THE FORM OF INFORMATION IN SCIENCE:
ANALYSIS OF AN IMMUNOLOGY SUBLANGUAGE

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THE FORM OF INFORMATION IN SCIENCE

Analysis of an Immunology Sublanguage

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PREFACE

DOES DISCOURSE HAVE A 'STRUCTURE'? HARRIS'S REVOLUTION IN LINGUISTICS

As a freshman back in 1947 I discovered that within the various academic divisions and subdivisions of the University of Pennsylvania there existed a something (it was not a Department, but a piece of the Anthropology Department) called 'Linguistic Analysis'. I was an untalented but enthusiastic student of Greek and a slightly more talented student of German, as well as the son of a translator, so the idea of 'Linguistic Analysis' attracted me, sight unseen, and I signed up for a course. It turned out that 'Linguistic Analysis' was essentially a graduate program – I and another undergraduate called Noam Chomsky were the only two undergraduates who took courses in Linguistic Analysis – and also that it was essentially a one-man show: a professor named Zellig Harris taught all the courses with the aid of graduate Teaching Fellows (and possibly – I am not sure – one Assistant Professor). The technicalities of Linguistic Analysis were formidable, and I never did master them all. But the powerful intellect and personality of Zellig Harris drew me like a lodestone, and, although I majored in Philosophy, I took every course there was to take in Linguistic Analysis from then until my graduation.

What 'Linguistics' was like before Zellig Harris is something not many people care to remember today. (The 'bible' of the subject – except at Penn! – was Bloomfield's *Language*, a knowledgable, scholarly, but deeply operationalist view of linguistics.) All of Harris's ideas were different from those that were being studied elsewhere: the idea of a 'transformation', later modified and made famous by Noam Chomsky, the idea of the autonomy of syntax, and the condensed mathematical notation which made it possible to represent a grammar in a few pages of what looked like equations. Since these three ideas have been taken over by 'generative grammar', it is important to be aware that Harris's view differs in important respects from that of the generative grammarians: For example, like the philosopher Nelson Goodman, Harris is deeply aware that any set of scientific phenomena admits

of more than one description. He is not one to insist that a particular 'description' of the grammar of, say, English, describes *the* grammar coded in the brains of English speakers – fashionable as that sort of utterly unsupported speculation is today. And like the late Roman Jakobson, Harris is interested in the syntax of whole discourses, and not just of individual sentences. Indeed, the major part of Harris's long and incredibly productive scholarly life has been devoted to the development of tools for the responsible study of what so many 'literary theorists', 'structuralists', etc., talk about *ir*responsibly – the structures that characterize different types of discourse.

The great aim of Harrisian 'discourse analysis' is to do this purely *syntactically*. But, like Chomsky, Harris of course hopes that syntactic regularities will be associated with semantic ones: not, however, with 'innate' semantic structures, nor yet with 'universal' ones, but precisely with structures which grow and change as the discourse studied grows and changes.

Paul Mattick has drawn an interesting parallel between Harris's work and the ambitions of the Logical Positivists.[1] The Logical Positivists thought that by rewriting scientific theories in the artificial language of Symbolic Logic they would be able to discover what their structure really was. (This enterprise flourishes today under the direction of Wolfgang Stegmüller at the University of Munich, for example). Harris believes that one can give a precise description of scientific discourse (and, of course, non-scientific discourse as well) *without* first having to rewrite it in an artificial language. The importance of avoiding such rewriting should be clear: even if the ancient Italian proverb that 'to translate is to betray' is an exaggeration, it is clear that every translation expresses the translator as much as it does the original; and philosophical 'reconstructions' of scientific theories have richly illustrated this fact. When we are given a description of the 'structure' of a physical theory by a philosopher the one thing we can be sure of is that some other philosopher will give a totally different description of that structure. And those philosophers who, unlike the Logical Positivists, have not even attempted any kind of precision in their descriptions of 'structures' of discourse have been even more unconstrained than the Positivists – and have, not surprisingly, disagreed with one another even more.

In this state of affairs, one possible response is to adopt the sort of subjectivistic ideology that is today, lamentably, sweeping Parisian intellectual life: to conclude not only that accounts of linguistic and conceptual structures must be subjective, but also, by some kind of incredible extension,

that *everything* human beings can think is subjective, is just a play with styles and with texts. Ultimately this view extends to a view of the human being: we are, we are solemnly told, just a play with mirrors, or (in another fashionable figure) 'centerless webs'.

This sort of pessimism mixed with irresponsibility is not new (a hundred years ago it was called the *fin de siècle* mood), and it is not destined to last. In the meantime, with unflagging brilliance and with unflagging energy, Harris has continued to pursue the task that even the Positivists thought impossible: to describe the structures of conceptual thought in a particular area with rigor and without first wholly rewriting those structures in the alien language of Symbolic Logic. The present volume, substantial as it is, is only a large 'pilot study' in this huge project. The idea that informs it is, like all of Harris's central ideas, breathtaking in its combination of simplicity and daring: to take a subfield of a particular scientific discipline and compare the structures of the texts in that subfield before and after a particular 'scientific revolution' in the subfield. The details look formidable at first blush – just as the papers on the grammars of various languages that I encountered as a freshman in Harris's notation looked formidable at first blush. But the reader who is serious about wanting to know if such a thing as 'structural analysis of discourse' is possible and who is willing to do a little work will find that the presentation is not as hard to follow as it looks, and that the payoff is large. This is a book every serious student of discourse, whether he comes from linguistics, from philosophy, from cognitive science, or whatever, will have to become aware of, and will have to learn to understand, at least in its central outline and key ideas. Bravo, Zellig! You have done it again.

HILARY PUTNAM

NOTE

[1] P. Mattick, Jr., "The Constitution of Domains in Science: A Linguistic Approach", in A. Fine and P. Machamer (eds.), *PSA 1986*, vol. I (East Lansing, 1986), pp. 333–341.

FOREWORD

This book presents a formal method for analyzing the word combinations in articles of a subscience, in a manner that gives the information in the science a more precise form, and may tell a good deal about the structure of the science itself. The method arises from the analysis of language as a mathematical system, and from the inherent correspondence between the form of language – under this analysis – and its information. The specific results obtained here arise from applying this method within the confines of a single area of science.

The field investigated here is in immunology: the search (c. 1940-65) to determine which cell produces antibody. Two different cells were claimed by different scientists; these were ultimately found to be different stages of the same cell-line. In analyzing the research articles, words were collected into classes on the basis of their occurring with each other, in regular ways in respect to other word combinations, in the sentences of the articles. The regular word combinations in these sentences were then found to fit into a closed set of word-class sequences. These word-class sequences are the formulas of the subscience, with each item of information having a stated form and location in the formula structures. The different views expressed in the articles, and the resolution of the controversy, were found to be represented by appropriately different formulas.

These formulas are thus shown to carry the information of the science. The structure ("grammar") of the formulas accords with the fact-structures of the science, i.e. with its objects and the relevant relations among them. The form indicates the content.

The purpose of the work presented here is to develop a formal tool for the analysis of science, and more generally of information. In respect to information, it has been found that a maximally unredundant description of the structure of language yields an approximate description of the information transmitted by language, and that this is all the more so within a science. In respect to the history of science, the formulaic representation of research done over a period shows, for example, changes in the way words for the objects of the science co-occur with words for the processes, changes which exhibit the actual development of the science. The analysis

presented here for the statements of a science suggests new approaches for the resolution of some of the recognized problems in philosophy of science and in philosophy of language. And the results of analyzing a sample of articles show that one can discover for each science a specific grammar adequate for it. In particular, one can distinguish by purely formal procedures certain contributing linguistic systems: one for the results and theory of the given science, an ancillary one for the procedures of investigation, a meta-science system, and also material from prior sciences which is included in various statements of the given science. This isolating of various special and well-structured languages of science makes possible new investigation into the structure and information of science, with obvious relevance to Carnap's search for a language of science, but with more complex inter-sentence connectives than Carnap envisioned. This work also establishes the existence of sublanguages within natural language, and raises the question of what relations can be stated among sublanguages.

The initial application of these methods, in the present volume, has been carried out on a small field, the early years of immunology, and primarily on its central research problem as noted above. Enough work was done, beyond analyzing the articles excerpted in the Appendices, to make it clear that the sublanguage arrived at here would, with occasional additions, be adequate for other articles of the period. Hence the special grammar developed in this volume appears to be appropriate not merely for the articles listed but for the whole field at that period. This early period, in a field which was still small at the time, was selected in order to test the method in a reasonably simple case. However, nothing in this method would make it less applicable to larger and more complicated sciences; it will only require much more work, and the development of computer support.

The method applied here does not claim to yield a complete picture or an interpretation of the course of a science: that may require knowledge from outside its research articles, and even outside the science itself. The method also does not claim to yield a full analysis of the conclusions and theories of the science: that would require, in addition to the present analysis of the individual sentences, also the analysis of long sequences of sentences in the articles (argumentation and "proof"). However, any such further investigations require first of all that we establish the specific sentence structures, i.e. the formula types of the science, and it is this that the method as used so far has yielded.

Viewed step by step, the processing shown here seems informationless and unimportant. It is indeed informationless, in that it moves only from the sentences of the articles to paraphrases of those sentences. But it follows a systematic path through the maze of paraphrases (including stylistically cumbersome ones). It thus reaches, in an objective and non-semantic manner, a maximal similarity among the sentences, as is seen in the Appendix tables. The alignment of the similarities exhibits what is constant among the sentences.

This constancy has a meaning: it yields those categories of information in which the sentences are jointly dealing – the categories of the given research problem and of the subscience.

A guide to the chapters of the present volume:

The immediate results are presented in the tables of Appendices 1 and 2, in which one can see how the sentences of the articles are rearranged onto the formulas. Since the methods used in this analysis are novel, they ar presented here in great, perhaps unreadable, detail. However, an introduction to the work can be obtained from Chapter 1, sections *1* and *2*, Chapter 2, sections *5-7*, and Chapter 3. A summary of the findings is given at the beginning of Chapter 1. Chapter 2 shows how the sublanguage of the immunological material was obtained, and Chapter 3 contains a brief discussion of how such analyses open the way for characterizing the structure of sciences and their interrelations. In Chapter 4, ways of using the sublanguage formulas to clarify and specify various informational relations are presented. Chapter 5 gives details of the transformations used in obtaining the sublanguage formulas; an overview of the transformations is given in section *1*. Chapter 6 presents the special sublanguages of laboratory procedures and of measurement. A slightly different form of analysis is employed in Chapter 7 to obtain substantially the same informational units from papers written in French; the French material had not been included in the analysis presented in Chapters 1-6. Finally, Chapter 8 presents a historical sketch of the search for the cellular source of antibody, by two workers in the field.

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CHAPTER 1

REDUCING TEXTS TO FORMULAS

1. SEEKING CANONICAL FORMS

This book attempts to show that certain analyses of how words combine, when applied to reports in a science, suffice to transform the reports into a sequence of formulas which represent the information contained in the reports. The methods do not depend upon the investigator's judging or classifying the meanings of words or sentences, or upon any specialized knowledge of the science. The words are identified not by their meanings but by the combinations into which they enter in respect to other words, within each sentence of the science material. At least in part, the methods could be carried out in computer programs applied to the articles as published, without pre- or post-editing.

The major results of the pilot investigation reported here, carried out on research articles in a particular research area of immunology, are:

– The science subfield has a reasonably small set of word-classes, and not many individual words per class (disregarding synonyms); the latter constitute the vocabulary which is sufficient for the science.

– The word-classes are combined into a few sentence-types, which are the fact-structures of the science.

– Each fact-sentence in the science can be written as a formula. Each formula consists of particular members of the word-classes in a particular sentence-type, possibly with modifiers (in stated classes) and under conjunctions and meta-science operators.

– The formulas can be used to codify, locate and process the information in a subscience. They can also be used for making a critique of the discussion in scientific articles, and in some cases of the course of the research.

– Preliminary results suggest that discussion in the science is constructed largely out of selections of fact-sentences, possibly with particular modifications, under particular hierarchies of conjunctions, and of course under various meta-science operators.

– The possibility of specifying all the structures above shows that such combinatorial methods suffice for discovering the special grammar of a

science, which in important respects represents the structure of the science itself: its objects and their relations. In so doing one can also specify the structural relation of the given science to its prior sciences, its subsciences, its success or sciences, and the like.

– The sequences of formulas in the articles in a given science can be looked upon as constituting discourses in a sublanguage of natural language, or alternatively as a new linguistic system structurally intermediate between natural language and mathematics.

The formulas thus obtained can be used to summarize the specific information in the given article, and any change in information. This can be a step in computer processing of the specific information in scientific reports. When these methods are applied to a number of articles in a subfield of science, the types of formulas characterize the information in the subfield – the entities with which the field deals and such relations among them as are studied in that field. In particular, the present investigation covers a problem in immunology and shows how the formulaic representations which are obtained for the various articles yield an organization of the successive stages of experimental results and conculsions as the problem developed. The formulaic representation makes possible an analysis and critique of the work and of the information in the science.

As to the terms used: a sublanguage is a proper subset of the sentences of a language, closed under certain grammatical operations of the whole language. That is, the result of these operations (e.g. transformations or conjunctions) operating on a sentence of the sublanguage, or on a pair of them, is again a sentence of the sublanguage. The sublanguage is characterized by particular word classes and sentence classes (word-class sequences) which are not necessarily classes of the language, and possibly by grammatical operations that are not distinguished as such in the language. A subscience for the purpose of the present discussion, is an aggregation of science reports characterizable by a sublanguage.

Both the methods and the results have had to be presented in some detail, but a general picture of this work and its conclusions can be obtained from Chapter 1, 1–2, Chapter 2, 5–7, and Chapter 3.

The methods used are mentioned immediately below, and discussed in Chapter 5. The specific procedures of analysis are introduced in *2*; details and problems of the analysis are presented in *3*.

The basis for obtaining the formulas of a science by grammatical transformations of its reports lies in the fact that the constraints on word-combi-

nations in a language create the sentences of the language and at the same time determine the information carried by each sentence (given the meanings of the separate words). Different sequences of different words and word-classes yield, in a regular way, correspondingly different information. In addition, in the writings within a restricted subject matter, it is found that there are additional constraints on the combinations of words. In the present book it is proposed to show how these subject-matter-specific constraints can be used to exhibit the objects and relations which are involved in the information of that subject matter. To do this we first establish word-classes in such a way that combinations of the classes, i.e. of one or another word of one class with one or another of another class, recur frequently in the material. Then, in each sentence of the material, we seek insofar as possible to divide the sentence into segments such that each segment contains one of the recurring word-class combinations and also is grammatically a component sentence of the original sentence. Finally, in each segment having a given recurring combination we seek the maximal alignment of the word-classes: we permute the word-classes, to the extent that is permitted by known grammatical transformations, so that the order of word-classes in the combination is the same in as many of the segments as possible. These ordered word-classes, which are transforms of sentence or component sentences in the orginal material, are the formulas of the subscience. Since all the segmentations and transformations mentioned above are paraphrastic, that is, do not change the meaning of their operand, the formulas are paraphrases of the original material, and can be considered as simply a canonical, inspectable, and processible form of the orginal material.

The work described here was done on the basis of formally established transformations, which are presented in Z. Harris, *A Grammar of Engish on Mathematical Principles*, Wiley-Interscience, New York, 1982 (hereafter GEMP). However, once it is seen that recurring formulas can be obtained via such paraphrases, it becomes possible to carry out a resonable approximation to this work on the basis of common-sense paraphrases, so long as the paraphrases are based on general English or science-writing practice, and not on any specific issues which are under investigation in the given articles. This informal approach is possible because it is controlled by an internal check, namely whether or not it can lead to a small set of formulas covering the articles.

2. Analysis of word combinations

If one wishes to find, in the writings of a science, a canonical form for its information, one could analyze a set of articles dealing with one problem or area during one period, and try to show by interpretation that their structure mirrors the information they contain. However, a clearer and more definitive test can be achieved if one takes a succession of articles in which is traced the known development of a research problem or field. In such an historical overview it would be known by hindsight what new methods, new results, and changes of understanding appeared at what time and in what articles. If a formal analysis of the articles, specifically a reduction for formulas, made independently of this developmental knowledge shows changes in the formulas at those points at which the understandings are known to have changed, it would be clear that a relation exists between the change in formulas and the change in understandings or information.

An adequate research problem of this kind was found in the work on the cell responsible for antibody formation. There had been a controversy, largely between American and European scientists, as to whether the lymphocytes or the plasma cells of the lymphatic system were responsible; it was finally resolved by finding that both cells produced antibodies, and by recognizing that these names were being used for different stages of the same cell-type. The problem of which cell produces antibodies does not today exercise the scientists in the field, having been largely resolved. Nor does it loom large in the recent history of the field, since the issues that have moved into central importance have been concerned rather with the process of antibody production. However, in the period of approximtely 1940-1965, the "which cell" problem was important in the field, and while the evidence that both plasma cells and lymphocytes produced antibodies was obtained directly by experimental techniques (e.g. plaque production, cf. paper 11 in the Appendix), the recognition that they could be stages of a single cell-development sequence was a by-product of increasing data on cell-morphology and its development (e.g. in papers 4, 10, 11, 12). The main reason for selecting this problem for the present investigation was the fact that it had a clear beginning (between paper 1 and the first lymphocyte and plasma-cell papers) and end (as summarized in the Yoffey and Bussard extracts, in Appendix 1, paper 14 and Appendix 2), with a controversy and resolution pinpointed as to time, so that one could hope for a clear con-

nection between the differences in sentential formulas as among papers, and the difference in information contained in those papers.

Fourteen papers in the areas were selected, on grounds given in Chapter 8 below. These are among the important articles in the field, from a 1935 paper which showed that antibody formation is located in the lymphatic system, through papers naming different cells as the producers of antibodies, and finally to electron-microscope papers that showed ongoing antibody production in plasma cells on the one hand and in lymphocytes on the other, and that discussed how the apparent conflict could be adjusted. In the course of this research the major new methods that came in at various time were the recognition of DNA-RNA involvement in production of proteins (in this case the gamma-globulin antibodies), the increased power of light microscopy, and finally the electron microscope.

We will see (in *1.3* of Chapter 3) that the formulas found for the 14 papers showed changes at the points at which there appeared the new methods and results, and that new kinds of discussion were necessitated by these. These changes in the formulas are of a kind that seems reasonable as a reflection of the known changes in information at these points.

The French papers considered in Chapter 7 were not part of the central investigation reported here. They were not selected for their relevance to the "which cell" problem, nor was their analysis used in judging the details and development of the formulas. Rather, they were selected as examples of research and review papers in a language other than English, to see if they exhibited the same gross formula structure as did the English texts.

2.1. Grammatical analysis

The selected articles were analyzed in the order of publication, beginning with the 1935 paper. In each article, the sentences were analyzed in the order in which they appear in the paper. This means in effect carrying out: first, a gross grammatical analysis of the sentence, determining for example the main verb of a sentence and its subject and object together with any modifiers of each of these; second, an undoing of any of the major transformations and zeroings (*3.3*) which have taken place in the sentence.

The gross grammatical analysis is determined by the classification of words as being arguments or operators, for example the class **N** (argument, mostly simple nouns, e.g. *cell*), $\mathbf{O_n}$ (operator on one **N**, e.g. *grow*), $\mathbf{O_o}$ (operator on one operator, e.g. *continue*) $\mathbf{O_{no}}$ (operator on **N** and **O**, e.g. *know*), etc., and the classification of affixes by how they change a word of

one class into another, e.g., **O** → **O** (tense operating on a verb to yield a verb), **N** → **N** (e.g. plural), **O** → **N** (e.g. *-ment* in *development)*, etc. A sentence consists of one or more operator-words, each of which requires as argument words of particular classes: in *The cell's growth continued, continue* is operator on *grow* (as its argument), *grow* is operator on *cell*, and *-th* is the **O** → **N** indicating that *grow* has become the argument of a further operator.

The major transformations, including zeroings, are defined on the gross structural components of a sentence *A*, and produce a transformed or reduced sentence *B* differing in word sequence from the given sentence *A*, but paraphrastic to *A* in meaning. On finding a transformed sentence *B*., e.g., *John buys and sells old books*, we must first recognize that it is the product of a transformation; in this case, the trace (i.e. evidence) is the lack of an object (i.e. second argument) for the first operator (e.g verb), *buys*, and the lack of a subject (i.e. first argument) for second operator, *sells*. Then we undo the transformation; that is, we reconstruct the "source" sentence *A* as it was before the transformation had taken place, in this case *John buys old books and John sells old books*, where *buys* and *sells* are operators and *John*, *old books* are the arguments of each of these.

There are two reasons for recognizing the transformations which a sentence has undergone. One reason is the simplification of the structural analysis of sentences. By finding in a sentence the trace of a transformation, we characterize the sentence no longer as a sequence of words belonging to particular classes, but as a transform of a source sentence which in turn is a simpler sequence of words belonging to particular classes. For example, *B* above need no longer be described as a verb (*buys*) appearing without its objects joined by *and* to a verb (*sells*) appearing without its subject, but rather as a transform (made by the zeroing of repeated subjects and objects) from a source sentence *A* which is two occurrences of verbs, each with its subject and object, joined by *and*. If we considered each complex sentential structure, e.g. *B* above, separately, we might find various convenient ways of stating its word-class sequence; for example, we could say that *B* consists of two verbs joined by *and*, with a common subject and object. But if we consider all the partially similar (and paraphrastic) complex structures, e.g. also (*C*) *John buys old books and sells old books*, or (*D*) *John buys old books and he sells them*, we find that the least redundant description for all of them together consists in saying that repeated words can be zeroed, or pronouned, in stated situations, thus producing from a single source-sentence *A* many reduced sentences such as *B*, *C*, *D*. In the last analysis, the word-class sequence characterizing the source sentence,

such as *A*, is the operator-argument relation (e.g subject-verb-object as above); all other sentences, such as *B*, *C*, *D*, contain this relation plus transformations.

The other reason for recognizing the transformations which a sentence has undergone is that the transformations are paraphrastic – more so or less so depending on how they are defined. The transformations alter, in a sentence, the position and form of words (even down to zero) without altering the information that the sentence carries, i.e. the informational relations among the words. It has been found that in the sentences of a discourse, and of a sublanguage, words (or word-classes) often repeat in a given grammatical relation in respect to other words. That is, each sublanguage has certain operator-argument structures of special word-classes – call it certain sentence-types – that repeat. We can try to maximize this by taking those sentences which contain a particular constellation of word-classes and seeking such transformation in each sentence as would put the words of the constellation in the same information (ultimately grammatical) relation to each other in each of the sentences.

The importance of these grammatical methods for an informational analysis of language material is two-fold.

First, these methods apply to all sentences. The major word-classes of the grammar are fixed for the language as a whole, so that the classification of a particular word in a sentence does not depend on the sentence in question. The structural analysis of a language applies to all its sentences. And the transformational reconstructions apply to all sentences which contain the traces of the transformation in question, the traces – and, in general, the domain – being specified a priori in the definition of the transformation. Thus these methods are not ad hoc to particular sentences, and cannot be adjusted to the particular interests of the investigator analyzing the articles.

Second, the analysis of each sentence is made of the basis of the relative positions of the classified words. No semantic criteria or subjective judgment is involved, so that the work can in principle be carried out by a computer program, even though considerable complexity is involved in so doing. (Grounds for all statements in *2.1* are given in GEMP.)

2.2. Sublanguage classes and sentence structures

After the successive sentences of an article have been analyzed grammatically, they are subjected to a further analysis, in respect to sublanguage

word-combinations. This work consists chiefly of forming classes of words which have the same grammatical relation to particular other words, e.g. the words **A** which appear (in Appendix I) as subject of *found in the lymph nodes after injection of an antigen.* These words **A** include *antibodies, agglutinin*, etc. Starting with this, we may then form a class **V** of operators *is found in, is contained in, is produced by*, whose subjects are **A** (e.g. *antibodies, agglutinin*). In this way we find that certain word-classes recur in a particular grammatical relation to certain others, e.g. **A** as subject of **V** with object or "complement" **T** (*lymph nodes, lymph, serum*). This creates a sentence type (structure), **AVT**, which is obtained at the same time as we set up (extensionally) the word classes **A, V, T,** since these are defined as occurring in respect to each other in the operator-argument relation which constitutes a sentence structure. The grammatical transformations applied previously will have strengthened this result, since for example a sentence *Lymph nodes produce antibodies* will have been recognized as a transform of *Antibodies are produced by lymph nodes*, hence as a case of **AVT**.

This method of setting up word classes in respect to their grammatical combinations is in principle the same as that used in finding the grammar of a whole language. When applied to the material within certain subject-matter language-uses it produces not the general word classes of whole-language grammar (**N, O_n, O_{no}**, etc.) but specific subclasses of these such as the **A, V, T** here. The restrictions on what words combine with each other in the material of a sublanguage are so strong that the major subclasses can be discovered readily. Aside from local problems discussed below, only a few nouns occur in these texts as subject of *is found, is produced by*, etc., and only a few operators (verbs, adjectives) occur between *antibody, agglutinin*, etc. and *lymph node, plasma cell*, etc. In all cases the criteria for classification were purely combinatorial and not semantic. The subclass **A** is the class of subjects of *is produced by the plasma cell* and the like, and not the class of words semantically close to *antibody*. Indeed, it will be seen below that *A* includes some words, such as *protein, gamma globulin*, which would not readily have been included on semantic grounds; and the subclass **V** of *is produced* includes, for example, *is secreted.*

2.3. Sublanguage subclasses

It would have been too much to expect that a few word-subclasses in various grammatical combinations would have sufficed without difficulty for the sentences of these articles. Difficulties were indeed met, but it was

possible to overcome many of them by defining further subclasses of the major word-subclasses. For example, there is a subclass **G** of words (*antigen, diptheria toxin*, etc.) which are subject of *is injected.* In a few places we find the word *dye* in the position of **G**, as in *when vital dyes are placed in superficial cuts they are drained by the lymphatics to the regional nodes* (paper 1, p. 800). Here *is placed in superficial cuts* is very similar to members of **J** (the subclass of *is injected*), while *is drained by the lymphatics to the regional nodes* is a member of the subclass sequence **UTT** (below). The subject of **J**, and of **UTT**, is **G**. However, *dye* is not found in other combinations into which G enters, in particular the main combination, **GJ:AVT** (e.g. *following injection of antigen antibodies are found in the lymph nodes*). We therefore put dye into a "no-antibody" subclass $\mathbf{G}_{a\sim}$ of **G**, and we have to say that the sentence structures **GJ** and **GUTT** hold for $\mathbf{G}_{a\sim}$ as well as for other **G**, but not when these sentence structures combine with a following **:AVT**. The advantage in this formulation is that words which occur in some but not all positions of a major subclass can be thus fitted in as a subclass of it. The cost is that the formulas for word-subclass combinations now hold not for all words in each subclass but only for (at least) some of those words. (For convenience, the major subclasses of a sublanguage will henceforth be called its classes.)

Whereas the classes listed in Chapter 2, 2, are inescapable, as being the most efficient for the sentences of these articles, some of the subclasses proposed are less well established, so that alternative subclassifications are not excluded.

It will be seen that while the word-class formulas (i.e. the sentence structures in terms of word-classes) change little as one goes from article to article in order of publication, the word-subclass formulas change appreciably. The former express the general types of information dealt with in these successive articles; the latter express the specific information presented in each article.

In the present investigation, the articles were first analyzed in terms of word-classes, with notations where some members of the word-classes were restricted in respect to members of the other classes with which they combined. A second pass through the articles was then undertaken, after we had some record of the kinds and amounts of such restrictions, and of the subclasses that would be required. In this second survey the formulas for the successive sentences were rewritten with subscripts indicating subclass.

2.4. The tables

In the Appendices the sentences of the articles are presented in a transformed shape, the transformations being those that would grammatically align the words of the sentence with words of the same class sequence in other sentences. Each transformed sentence has been obtained from the original sentence of the article by a priori established transformations (Chapter 5), or, in a few cases, by a special transformation which is discussed in the notes to that sentence (Appendix 3). In any case, each transformed sentence can be seen to be a paraphrase of the original, so that the meaning of the article has not been changed.

In addition, each sentence in the Appendices is represented by a formula, which is a sequence of class symbols, one for each successive segment in the transformed sentence. The formula thus merely maps the ordered words (with their modifiers) in the transformed sentence into the symbols for the class to which each of the words belongs. Where the word has been specified as belonging to a particular subclass of its class, the class symbol for the word is provided with a subscript indicating the subclass.

The major modifiers of a word (including those of quantity, time, negation) are indicated by superscripts on the class symbol of that word in the formula.

The tables published in the Appendices contain only a portion of each article. The portion was selected as follows: After the word-classes of an article were determined, all sentences which contained only one of these word-classes were dropped from further consideration, since they could not be used to show sentential relations among the classes. This applied to almost all sentences of the Materials and Procedures sections of these articles, and to a very few sentences in the other sections of the articles. The remaining sentences were analyzed in detail, down to their formulaic representation (except for the internal structure of the meta-science segments). Since the full publication of the fourteen articles and the three French papers with their sentence-analyses, would have imposed too great a burden on the present book, a selection from each article had to be chosen. What was selected was those sentences which were essential to understanding the experiment reported in the article and the conclusions drawn therefrom by the article. The selection was made purely on the basis of the content of the original sentences, without regard to their formulaic representations. Because the sentences that were favored were those dealing with the main subject of each article, it was found that the main

formulas of the article were relatively more frequent among these sentences than they were in the article as a whole. Other than that, the tables printed in the Appendix are similar to the tables obtained for the articles as a whole.

2.5. Validity of the procedures

The procedures used in moving from the original texts to the sequence of formulas differ from those used in many sciences, and their validity does not rest on statistical control as it does in much experimental work. Instead, the following considerations are relevant: The structural analysis (*2.1*) which ultimately describes a sentence as a partial ordering of particular operators and arguments is applicable to every sentence of the language. The reductions or other changes which describe a particular sentence as a transform of a particular other one are applicable to all sentences which contain the trace of that transformation. The paraphrastic effect of each reduction is a matter of interpretation, which can be verified once and for all in the case of each reduction separately. These properties thus hold for all applicable sentences, and therefore for the particular sentence in question.

There remains a difficulty, which in most cases can be overcome. Quite a few transformations are degenerate. That is, a given sentence may possibly be a transform of either of two different source sentences. Source A with reduction R_1, and source B with reduction R_2, may both yield the same word-sequence C. Given C, one can then reconstruct either A or B as source. When C occurs in a discourse, it becomes important to know which source was intended by the speaker or writer, for A and B may well differ in their informational effect in the discourse. If A would have greater word-repetitional similarities to the sentences around C than B would have, it may be presumed that A is the source for C.

Nevertheless, there may be some sentences in a text for which it is difficult to decide the "correct" source, i.e. the one meant by the author. In addition, there may be sentences which can be fitted into the neighboring word-repetitions only at the cost of ad hoc transformations which the reader may not accept. In all such cases the sentence can remain unanalyzed, or can be represented by formulas that do not fit in with the neighboring sentential formulas. It is important to understand, first, that this does not detract from the formulaic representations of the other sentences, and second that it does not destroy the formula-repetitions seen in the other sentences. The complete and partial similarities among successive sen-

tence-formulas are so great that the intrusion of unanalyzed sentences, or of sentences largely unrelated to these formulas, does not vitiate the overall result, e.g. that presented in Chapter 2. Furthermore, the result that has been obtained – so far, at least – is not a tight sequencing of formulas, based on some criteria for succession, such as could be affected by the intrusion of unrelated material. Rather, this result is simply the existence of formula-repetition and of partial similarities among neighboring formulas.

3. Details of the Analysis

3.1. Word combination within segments

The analysis begins with the successive sentences as they appear in each article. For each sentence we have to know the operator-argument relations among its words. If the work is to be done by hand, as in the present investigation, it suffices if we recognize these grammatical relations by virtue of knowing the language. In knowing the operator-argument relations in a sentence, we would know what is the subject and object of each verb or adjective, and what are the ordered secondary sentences (modifiers) on each word. This is tantamount to knowing all the source grammatical relations among the words of the sentence.

We then investigate, over the whole corpus of articles, how words cluster in respect to each other within these relations, e.g. which verbs have the same nouns as subject, or which adjectives or relative clauses modify the same nouns. No useful result will be obtained if we ask this question without the framework of specified grammatical relations, for example if we ask what words occur in the same sentence as *antibody* or what words occur next to it. But if we ask what words occur as operators with *antibody* as their first argument, we find (a) *is in, is found in, is contained in, appears in, is produced by, is formed in*, etc. And if we check the relation among these operators, we find that some papers have *is found in, appears in*, but also *is not produced by* or *is not formed in* as operators on the argument-pair *antibody, lymphocytes*; but no paper has both *appears in* and *is not found in* (or *is found in* and *is not found in*) on the same argument-pair (unless one operator reports the author's work and the other reports someone else's work). We then say that all of (a) above are in the class of operators on the pair *antibody, lymphocytes*, but that the last two members (*is produced by, is formed in*) are in a different subclass from the first four, because only

the last two of these can be (for the same arguments) under the further operator *not* in an article-section in which the first four are not under *not*. Such classification and subclassification has to be done for each word in respect to all the words which are arguments under it or operators over it, or co-arguments (i.e. joint arguments under the same operator); more rarely we may find that one word differs from another only in respect to words more distant in the partial order of operators in the given sentence.

We can now write each sentence not as a sequence of words but as a sequence of word-class symbols, with subscripts to indicate in which subclass the word belongs, and with superscripts to indicate the modifiers of the words. Any classification made at this point may be adjusted later, as further co-occurrence dependencies or regularities come to light; but at this stage we already have a good approximation to the final result.

Next, we check each successive sentence of each article, or a segment of the sentence (for example, up to a conjunction), or rarely a sequence of sentences, seeking repeating sequences ("formulas") of word-class symbols. Thus in paper 1, p. 783.1.7, (hereafter 'p.' will be omitted) we have *pathogenic bacteria carried on the lymph stream* and in 783.2.1 we have *antigens arriving by the lymph stream*, both of which we can represent as $\mathbf{GU^yT_\ell}$, where **G** is the class of antigen terms, $\mathbf{T_\ell}$ is used for *lymph* as a subclass of tissue words (**T**), **U** is for verbs whose subject is **G** with a second-argument **T** (or **C** for cell words), and superscripts **f, t, y** are respectively the prepositions *from, to, by* (with *on, along* as variants of *by*) introducing this second argument. When in the same paper we find (801.2.1) *the rapid lymphatic distribution of antigen* we have **G** and $\mathbf{T_{\ell'}}$, and we accept *distribution* as a **U** operator on the grounds given above; the reconstructed sentence might be *antigen is distributed rapidly lymphtically* (or: *along the lymphatic system*), represented by $\mathbf{GU^{iy}T_{\ell'}}$ (with superscript **i** for *rapid*).

In some cases, the decision as to the formulaic representation is more complicated. In paper 1, 796.4.3, we find *The nodes were equally inflamed.* Since the two preceding sentences distinguish *the lymph nodes from the side injected with that antigen* from *the nodes from the other side*, the referentially reconstructed *the* in 796.4.3 refers to these two, so that 796.4.3 can be referentially reconstructed to *The lymph nodes from the side injected with that antigen and the nodes from the other side were equally inflamed.* We have two ways of fitting this sentence into the elsewhere-established formulas. One is to use the reciprocal (reflexive) status of *equal* to transform 796.4.3 into *The nodes from the side injected with that antigen were inflamed equally with*

the nodes from the other side (GEMP 6.71); this could be represented as $\mathbf{T_nYT_n}$, where **Y** is the set of operators whose two arguments are necessarily of the same class, and $\mathbf{T_n}$ is *lymph nodes* (the references to *side* being superscript **B**, discussed below). The other possible formulaic representation is in two sentences connected by a conjunction: *The nodes from the sides injected with that antigen were inflamed, equally as* (or: *to an equal extent as*) *the nodes from the other side were inflamed.* This is represented as two $\mathbf{T_nW_f}$ sentences conjoined by *equally as* between them; the $\mathbf{W_f}$ is a subclass of **W**, which is the set of operators whose first (and usually only) argument is **T** or **C**. Since *equally inflamed* is quite different from the established members of **Y**, and since **Y** occurs virtually only with the pair **C**, **C** as its arguments (and never otherwise with **T**, **T**), it is better to use the two-sentence analysis here.

3.2. Obtaining repeating types of sentences

The goal of finding the greatest amount of regularities of word-combination in this material makes us seek, in each sentence of the articles, the largest repeating sequence of word classes, even though in some cases the longest formula has to be rejected, as in the case of $\mathbf{T_nYT_n}$ above. The sentences as printed in the articles repeat only rarely. Even if we represent the words by the symbols for word classes and subclasses, we do not get many repeating sequences. However, we can segment the sentences of the articles in such a way that many segments are class-symbol sequences which recur, as in the **GUT** sequences above. The recurrence is greatly enhanced if we permit each symbol to carry different superscripts, e.g. if the $\mathbf{GU^{iy}T_{\ell'}}$ above is considered a repetition of the $\mathbf{GU^{y}T_{\ell'}}$. Thus, we look for repetitions of particular operator classes or subclasses, with their arguments, allowing each of these words to carry various ordered modifiers. The modifiers are, grammatically, secondary-sentence operators on the given word. For example, many occurrences of *cell*, especially of *lymphocyte*, carry the modifier *large*. In many of these occurrences the *large* is clearly used to indicate a type of the cell and can even be taken as part of the cell name: $\mathbf{C^{g}_{y}}$ for what is called large lymphocytes as against lymphocytes in general. In a few cases the *large* is rather just a property of the cell, and could be given in a relative clause of *cell*: paper 7,11.3.3 has *Both the large cells and the smaller ones, the lymphocytes, do contain antibody*, where *the large cells contain antibody* could be derived from *the cells which are large contain antibody* from *the cells contain antibody; the cells are large.* A modifier (*large*) is simply the operator in a

secondary sentence, as here (after the semicolon above), with the host of the modifier (*cell*, here) being repeated as subject in the secondary sentence. The modifier may also appear in the primary (non-secondary) sentence, as in *A few of these...lymphocytes... were large* (paper 13, 453.1.2). When *large* is taken as a modifier it is written as a superscript, as in $\mathbf{C}_{\mathbf{y}}^{\mathbf{g}}$ (*large lymphocyte*); when it is taken as an operator it is written as $\mathbf{W}_{\mathbf{g}}$, a subclass of the word-class **W**, as in $\mathbf{CW}_{\mathbf{g}}$ (*the cell is large*).

In addition to the modifiers, there are certain other operators which are written as superscripts rather than in a separate formula. These are the local ("aspectual") operators on a verb, i.e. operators whose subject is the same as the one of the arguments of the verb on which it is operating (or is a classifier of that argument): for example **b** for *begin, start* as in *Antibody production starts at this stage*, derivable from *Antibody starts being produced...*, from *Antibody starts its being produced...* (paper 13, 470.3.3). We represent this sentence by $\mathbf{AV}_{\mathbf{p}}^{\mathbf{b}}$, with **A** for *antibody*, **V** for *produce, form*, and **b** as supercript on $\mathbf{V}_{\mathbf{p}}$ rather than as a verb in a new sentence. There is a particular set of operators which functions in these articles much as the aspectual operators do in English: this includes *have a role in, participate in*, etc., as in *The lymphocytes constitute a factor in antibody production* (paper 3, 122.1.1). These operators appear on $\mathbf{V}_{\mathbf{p}}$ (*produce, form, synthesize*), and if we compare the sentences containing $\mathbf{V}_{\mathbf{p}}$ under these operators with the sentences containing $\mathbf{V}_{\mathbf{p}}$ alone, we see that the arguments are the same in the two cases, but that there is a difference in respect to the metalinguistic segment over the $\mathbf{V}_{\mathbf{p}}$ (*2.2* in Chapter 2) and in respect to neighboring operators: we may find such two-sentence sequences as

$$\mathbf{AV}_{\mathbf{p}}^{\mathbf{r}}\mathbf{C}_{\mathbf{y}} \textit{ but } \mathbf{AV}_{\mathbf{p}}^{\sim}\mathbf{C}_{\mathbf{y}}$$

(*Lymphocytes have a role in the production of antibody but lymphocytes do not produce antibody*). Therefore, rather than treat these words as an independent operator-class, we treat them as local operators on $\mathbf{V}_{\mathbf{p}}$ and write then with a superscript **r**.

Another situation in which additional material can be included in a single repeating sentence-type is that of the repeating sentence-pair. For example, we find very many occurrences of sentences such as *Following injection of antigen, antibody was found in the lymph nodes*. The two component sentences are occasionally found one without the other, and in fact there is a certain background presence of antibody in the lymphatic system and blood which is not in response to infection or injection of antigen. However, in these articles the great bulk of occurrences of the two component

sentences are paired, connected by *following, thereafter*, etc., as above (although the *injection* component may be zeroed). Therefore, rather then consider each component a separate sentence, with a conjunction (*after*, etc.) between them, we write a single double-sentence formula **GJB:AVT** (e.g. *Antigen injection into the footpad is followed by antibody appearance in the lymph node*), while those cases where the components appear separately are written as **GJB** alone or as **AVT** alone.

The conjunctions between sentences (more precisely, between rows in Appendix 1) have much less repetitive regularity in respect to the sentences which are their arguments than do the various word-classes inside a sentence-type formula. In saying this, we take the colon which represents *following, after*, etc., as an intra-formula word-class. Therefore, to the extent that we are able to represent a sentence or sentence-segment of an article by a single sentence-formula rather than by a sequence of smaller sentence-formulas connected by period, *wh-* (which introduces a relative clause, i.e. a secondary sentence), or conjunctions, we obtain a better record of the co-occurrence regularities of the words in the articles. In addition to this, there are related informational reasons for maximizing, in particular ways, what is to be included in a sentence formula. The main objective is to get maximal information into the confines of a single formula because within a formula the information is explicitly organized by its sublanguage "grammar." A related objective is not to leave out of a formula (together with any conjunction on it) anything which would seriously alter the information in the rest of the formula.

By the main objective, we would favor keeping modifiers in a sentence segment X as superscripts on a word in the formula of X rather than reconstructing them grammatically into a relative clause, i.e. into a secondary sentence connected to X by the *wh-* conjunction. For example, in *Suspensions of various killed organisms were employed* (paper 1,794.5.2), we would write the whole sequence before *were employed* as **G** (with *suspensions* and *killed*, which are not in special word-classes of the sublanguage, as modifiers), rather then transform the sentence first into *Various organisms which were killed, which were in suspensions, were employed* and then into three conjoined sentences *Various organisms were employed; the organisms were killed; the organisms were in supensions.* (In the last form, *in suspension* and *killed* are the operators in their respective formulas, and would have to be put into sublanguage classes.)

However, if the modifier contains members of the formulaic word-classes, it is reconstructed into a separate conjoined sentence. For ex-

ample, in *They (the large cells) synthesize antibody specific for the antigen which stimulated their development* (paper 9,66.4.3), we treat *wh-* as the conjunction which introduces secondary sentences (the semicolon in the above examples); hence we transform the sentence into *They (the large cells) synthesize antibody specific for the antigen; the antigen stimulated their development*, which would be represented by the two formulas $\mathbf{G^wJ{:}A^GV_pC^g}$ and $\mathbf{G{:}C^gW_p}$ connected by *wh-*. (Here the **w** superscript indicates which word is carrying the following *wh-* sentence as modifier; the $\mathbf{G^wJ{:}}$ – read *after injection of antigen* – is reconstructed from the *specific for the antigen*, which is a modifier (superscript **G**) on **A** and refers to the injected antigen; $\mathbf{V_p}$ is *synthesize*; $\mathbf{W_p}$ is *develop*; $\mathbf{C^g}$ is *large cells*; the colon, which usually represents *thereafter* or the like, but also various causal verbs, here represents *stimulate*. Some words may appear in one sentence as a modifier written as a superscript, and in another as a full operator. For example, *mature* (written as superscript **m**) appears frequently as modifier on *cells*, especially on plasma cells; but we also find *when the plasma cells reached maturity* and *when the cells were fully mature*, which are $\mathbf{C_zW_m^b}$ and $\mathbf{C_zW_m^+}$ (paper 6,154.3.3,4).

A second situation in which we can maximize the information carried in a single formula is seen in the case of the comparative. Grammatical analysis decomposes comparative sentences into two sentences neither of which contain a comparative, plus a sentence which contains a comparative operator (*is more than*) and which can be reduced to the comparative *-er*: *I am taller than John* from (a) *I am tall to a degree which is more than the degree to which John is tall.* However, it is possible to get the comparative word or suffix into the first component sentence by making an artificial, ad hoc, transformation form (a) to *I am taller* and *John is tall* with *than* conjoining them. This has been done in many of the comparatives in Appendix 1.

Just as we try to maximize the information carried by a single formula, we try to minimize the occurrence of formulas which carry almost no information. For example, in paper 3,128.3.1, we have *Lymphocytes act an antibody producers.* Here *as* could be taken as a conjunction between the two sentences: *Lymphocytes act*, and *Lymphocytes produce antibody*. However, *lymphocytes act* carries virtually no information, even though *act* operating on *produce* affects the meaning. Hence we treat *act*, written as superscript **r**, as a local-operator modifier of *produce* in a single formula $\mathbf{AV_p^rC_y}$.

We turn now to the subsidiary objective of not leaving out of a formula anything which would alter its information. A major example of this is the restrictive relative clause: the case when a sentence is said about a given

argument only when that argument is under a particular modifier. For example, given (a) *This raises the question whether the "primary response" exists as such on a cellular level* (paper 9,67.3.5), where we know from other material that *primary response* is the same as *response to primary injection*, we obtain a formula **GJ^{1}:AVC**, representing (b) *To | a primary injection, | response exists as such | on a cellular level*, where the superscript **1** represents *primary* as modifier on *injection*. If this modifier were taken out, as being the operator in a secondary sentence (a relative clause), we would have two sentences: (c) *To an injection, response exists as such on a cellular level* (**GJ:AVC**) plus a conjoined (d) *The injection is primary*. But (c), without (d), is certainly not being posed as the question of (a) or of (b). True, we could say that in any sentence we don't know what is being said or asked until we add any conjoined sentences which may be present. But it is preferable if, in the course of connecting the formulas through their conjunctions, we do not present in one formula wrong or unintended information which has to be corrected in later formulas. It would be better if the formulas were such as to be only additive informationally in respect to preceding ones.

To achieve an informationally additive (and not correction-requiring) character for the formulas is not always easy. To do this, we would have to tie to each formula the degree of assertedness stated about the sentence – e.g. whether it is being asserted, or said to be possible, or questioned, or negated, etc. In the present set of tables we have usually done this in the case of negation, where the tilde ~ appears after the operator (or elsewhere in the formula, if needed). But many indications of assertedness are stated in the meta-science (**M**) portion of a sentence (as in the word *question* above), and the mechanisms for seperating these indicators from the **M** have not yet been fully worked out. This does not detract from the formulas as records of what kinds of information are presented in these articles; but the assertion-markers of a formula will have to be derived from the **M** and from the relation to neighboring formulas, if we are to use the present formulas as a record of the specific information given in the articles.

One other consideration should be mentioned as to how much should be represented by a single formula. When a word in one formula refers to a word in another, the apparatus to indicate the reference is complex and is not indicated in the present set of tables. (The development of such an apparatus depends upon further investigation into the textual distance, and other sublanguage restrictions, between the referent and its antecedent.) However, if a word in a formula refers to another in the same formula, it is easy to indicate this because the words which are part of a formula have

a priori fixed positions. The chief example of this situation in the present material appears in such terms as *regional lymph nodes* and *lymph nodes on the injected side*, which refer to the region or side of the injection. When the injection sentence GJB and the response sentence $\mathbf{AVT_n}$ are included in the same formula, we place a superscript **B** on $\mathbf{T_n}$ to refer to the **B** (body-part, body) of the injection. This gives an additional reason for including these two sentences within one formula $\mathbf{GJB{:}AVT^B_n}$.

3.3. How much transformation?

Grammatical transformations in the set of sentences are mappings from one subset of sentences onto another, which preserve the original operator-argument relations (even if in derived manner), and hence the meanings, within each sentence. In order to achieve repeating sentence-types, written as formulas, it is necessary not only to segment many sentences into two or more, but also to transform certain sentences in such a way that their words will appear in the position that their classes occupy in the formula. For example, by the side of *antibody is found in lymphocytes*, $\mathbf{AV_iC_y}$, we would transform (a) *lymphocytes contain antibody* to *antibody is contained in lymphocytes*, again $\mathbf{AV_iC_y}$. In some cases, the work of transforming can be replaced by simply writing the word-class sequence of the sentence, or part of it, backward (indicated by an arrow): thus (a) could be written directly as *antibody* | *contain* | *lymphocytes*←, which has the order of $\mathbf{AV_iC_y}$. An example of this was seen in the $\mathbf{GJ^1{:}AVC}$ above (cf. also the use of arrows in Chapter 4).

Most transformations consist of reductions of those words which contribute little or no information to the sentence in which they occur. The most frequent are the reductions, to pronouns or to zero, of repeated words which have occurred elsewhere in the sentence or in preceding sentences. In the present work such pronouns and zeros have been replaced in some sentences by the antecedents which they are repeating. In other sentences the pronouns or zeroes (zero being absence of the expected word) are left standing, in order not to burden the tables with too much reconstruction. It is hoped that further work will establish more precise criteria for replacing a zero by the word which was zeroed.

In the tables, the transformed sentences which accompany each formula have been so presented as to differ as little as possible from the original sentence, just enough to make the rows in the table conform to one or another of the formulas. The result of minimizing the use of transfor-

mations is that we are left with a larger number of formulas. For example, there are rows such as *Antibodies are found in large number* represented by $\mathbf{AV_i^+}$, and other rows such as *Antibodies are found in large number in plasma cells*, or *Plasma cells contain many antibodies* represented by $\mathbf{AV_i^+C_z}$. These two can then be considered as variants within a family of partially-similar sentence-types. We could also have defined a transformation-like reconstruction among the variants, which would fill out the $\mathbf{AV_i^+}$ type to $\mathbf{AV_i^+C}$ (or to $\mathbf{AV_i^+C_y}$ or $\mathbf{AV_i^+C_z}$ according to what the neighboring rows show to be the antecedent of the zero after $\mathbf{V_i^+}$). It is easier to justify reconstructing this **C**, or to determine whether it is $\mathbf{C_y}$ or $\mathbf{C_z}$ in a given occurrence, when we compare a formula with neighboring formulas, than when we are calculating the grammatical structure of a sentence. Hence for many situations of zeroing, it is best to leave the reconstruction of what has been zeroed until after the given sentence has been represented by a particular formula, and after comparison with neighboring formulas is possible.

In some cases it is easy to see that several sentence forms are variants of one another. For example, we find *They (the cells) had basophilic cytoplasm* (paper 7, 3.5.5), which is represented by

$$\mathbf{C}\ \textit{have}\ \mathbf{S_cW_s}$$

(abbreviated to $\mathbf{CS_cW_s}$, where $\mathbf{S_c}$ is *cytoplasm*); but also *The slightly large nucleus of these cells showed a loosening of the central chromatin* (paper 13, 454.1.3), which is represented by

$$\mathbf{S_n^g}\ \textit{of}\ \mathbf{CW}$$

(abbreviated to $\mathbf{S_n^gCW}$, where $\mathbf{S_r}$ is *nucleus*). It is easy to consider **C** (*has*) **SW** and **S** (*of*) **CW** as variants of a single formula, the more so as a transformation betweeen N_1 *is of* N_2 and N_2 *has* N_1 is known in English (the subscript numerals here identify the nouns, written *N*). In other cases the relation between two partially similar sentence types is unclear, as for the many sentences written $\mathbf{GJ{:}AV_i}$, e.g. (a) *Antibody appears after injection of antigen* as against (b) *The antibody is specific to the antigen*, which is written **G:A**. Such a (b) appears usually together with an (a), as in paper 12,109.2.3. This combination of (a) and (b) can also be written $\mathbf{GJ{:}A^GV_i}$, as in paper 5,205.1.1, where the superscript **G** represents *homologous* (rather than *to the antigen*). If (b) can occur independently of (a), its operator (*specific to*, or the like) would have to be a new verb-like word-class (not conjunction-like, as is the colon), even though the sublanguage meaning of that operator is related to that of the colon conjunction.

The main transformations which have been used in segmenting and aligning the original sentences into the repeated word-class sequences represented by the formulas are listed below. A fuller discussion is given in Chapter 5.

(1) Zeroed arguments and secondary sentences: Since each operator requires stated word-classes as its arguments, the appearance of an operator without its argument permits us to reconstruct that argument, as in our occasional inserting of *of antigen* after *injection.* In many cases the papers report antibody appearance and other cellular responses without saying the implicit *after antigen was injected.* This last can be inserted in the rows of the table (i.e. in the transforms of the original sentences) and in the formulas, although such insertions have been made only when some word in the row referred to some part of the absent **GJB:** segment.

(2) Pronouns: As noted, pronouns and zeros (word-absences) have in some cases, but not always, been replaced by the antecedent word whose repetition they indicate.

(3) Nominalizations: When a sentence (or its operator) occurs as the argument of a further operator, it is in many situations "nominalized," i.e. it carries a "noun-like" suffix showing that it is being used as an argument; and when the verb is nominalized, its adverbs become adjectives. If we return the sentence to its free-standing form, these adjectives are returned to adverb form. Thus, *after peritoneal injection of antigen* is reconstructed to *after antigen is injected peritoneally.*

(4) Passive: If both a sentence and its passive, or other permuted form, occur in the text, one can choose either the active or the passive order of symbols for the formula, e.g. $\mathbf{AV_pC}$ for both (a) *Antibodies are produced by the cell* and (b) *The cell produces antibodies.* To fit (b) into $\mathbf{AV_pC}$ is tantamount to transforming it into the passive (a). In certain cases the passive presents ambiguities which can be resolved by appeal to the known argument-classes of the given operator. For example, we have (a) *Mice were injected intradermally in the right ear with 0.03 cc. of the paratyphoid bacterin* and *after intradermal injection of antigens* (ibid, 4.1, nominalized from *after antigens were injected intradermally*), and (b) *0.03 cc. of the paratyphoid bacterin was injected intradermally in the right ears of mice.* In conformity with many **GJB** (*Antigen was injected into animals*) sentences, we transform (a) into (b) (via *We intradermally injected the right ears of mice with 0.03 cc. of paratyphoid bacterin*), and represent it by the **GJB** formula.

(5) Secondary sentences: Single text-sentences which contain residues of conjunctional material can be expanded into two sentences, e.g. by filling

out the secondary sentence of a comparative from the primary, or by reconstructing a modifier (adjective, relative clause, etc.) into a secondary sentence. Some of the considerations as to when to do this have been mentioned above.

(6) Shifting modifiers: Modifiers of operators or of sentences can be moved from their position in a sentence to certain other positions, in a way that aligns the word-classes of their sentence with those of other sentences; e.g. in paper 1, 783.1.1 and 792.4.1. Less generally, even certain modifiers of an argument (a noun) can be shifted into the status of modifiers on the operator on that argument. For example, we can transform *The cytoplasm in active cells is basophilic* to *In active cells, the cytoplasm is basophilic*, and vice versa. These possibilities of transformation can be used to locate in similar position all modifiers which are similar in informational character. For example, most modifiers referring to time (*immediately, on the 6th day*, etc.) occur on the colon which represents *after*, etc.; we can then transform others, such as *early*, from the word on which they occur to the colon in their row. With greater difficulty we may be able to move quantifiers (e.g. *first*) from nouns (e.g. *antigen*) to the verbs which operate on those nouns: e.g. (a) *the first antigen was deposited* derivable from *the antigen which was first deposited*, from *the antigen which was first injected was deposited* (by "appropriate" zeroing of *injected*, cf. Chapter 5), which is represented by

$$\mathbf{G^{w}U|||wh|||GJ^{1}};$$

this analysis is supported by the fact that (a) is attached to a subordinate sentence *if a second injection is given a month after the first*, which involves $\mathbf{J^{2}}$. In particular *no* on nouns can be moved to *none* on verbs, as in *No antibody was found* transformed to *of antibody, none was found* (GEMP 7.13).

(7) Conjunction: More problems are met with in the transformations that enable us to include in the colon all the sentence material which we want to include there. For example, consider the hidden *wh-* conjunction in *The nodes on the side injected with paratyphoid bacterin became slightly larger* (paper 1, 792.1.2, derivable from *...on the side which was injected...*), which we transform into *The nodes became slightly larger on a side; paratyphoid bacterin had been injected on that side*, represented in inverse order by $\mathbf{GJB{:}T^{B}_{n}W_{g}}$. The *which* is decomposable into the *wh-* conjunction (written as semicolon) and the pronoun *-ich* (here replacing *that side*); the *wh-* occupies here the position of *and then, causing*, etc., as though we had *paratyphoid bacterin was injected in a side and then the nodes on that side became slightly larger.* Although the details of the transformation have to be

specified, the motivation for including this occurrence of the *wh-* conjunction in the colon conjunction is that this occurrence joins **GJB** to **TW**, and whatever does that has the status of the colon conjunction – indeed, joing **GJB** to **TW** (or **CW**) or **AVC** is the definition of the colon in this sublanguage.

(8) Special-domain transformations: There are a number of transformations involving particular subsets of operators, which have been used in the tables. One is between N_1 *has* N_2 and N_2 *is of* N_1 (above). Another expands sentences with reciprocal verbs into two sentences, as in deriving N_1 *and* N_2V from N_1VN_2 *and* N_2VN_1 (with V for verb, GEMP 6.71: e.g. *X and Y met* from *X met Y and Y met X*). Yet another decomposes certain transitive verbs into *cause* operating on the corresponding intransitive verb (N_1VN_2 into N_1 *cause that* N_2V, GEMP 6.8). We use this, for example, when we find *agglutinin-forming antigen* (paper 1, 792.1.1), which seems to come from *Antigen forms agglutinin*; but we would like to avoid a formula $\mathbf{GV_pA}$ which does not otherwise occur. We then transform *Antigen forms agglutinin* to *Antigen causes agglutinin to form*, which is a case of $\mathbf{G{:}AV_p}$ and is close to the existing $\mathbf{GJ{:}AV_p}$.

3.4. Summary of procedures of analysis

The word-classes of articles listed in Appendix I were established by observing how the words combined with each other within the framework of operator-argument grammatical relations. Sentence-type formulas of these word classes were found by seeking repeating sentence-making sequences of the word classes, aided by paraphrastic transformations which aligned certain word-class sequences with others. Once the formulas are obtained, some of them could be transformed into others, by tranformations which are more readily justified when we know what word-class combinations are common in this corpus than when we are simply recognizing the structure of an English sentence.

To a first approximation, this work can be done with very little grammatical specialization. It would be enough to state explicity what words in a sentence are the subjects and objects of what verbs (or of predicate adjectives or of predicate nouns), and what words in it are the modifiers (GEMP 5.3, 6.6) and local operators (GEMP 6.5) on what words. Within these relations one could seek the repeating word-combinations that would justify setting up word-classes, and the repeating word-class sequences that would justify setting up sentence-type formulas. The test of the analysis

would lie in finding a small number of formulas that repeat many times over. The reason that one can obtain good results even with a rather rough grammatical formulation is that the repetition of just a few formulas is so great that they are bound to be discovered even if some sentences are misanalyzed or left unanalyzed.

The precise grammatical analysis is needed if we wish to avoid having many variegated formulas in addition to the few repeating ones, and if we wish to see in detail what are the patterns of recurrence of formulas and how they make up the whole article and the whole area of research.

It should be mentioned as an aside that precise grammatical analysis is sometimes not possible because the sentences of the text are not in all cases perfectly grammatical. Slips of grammar enter into some long sentences, and the analysis then has to be made on the evident intent of the writer rather than on the actual form of the text. (an example is *its* for *their* in paper 1, 789.4.1).

3.5. Output

The output of the analysis of an article is a sequence of formulas. Each formula is readable as a sentence (in a language whose words are class symbols); it is a sequence of word-class symbols, with subscripts to indicate subclasses and ordered superscripts to indicate modifiers or local operators. Each formula represents all of the specific words (other than meta-science) in a text sentence, or in a segment (or sequence) thereof, and is a paraphrastic transform of that piece of the text. The sequence of formulas together with the conjunctions and meta-science segments on them, cover the sequence of text sentences in the article.

In the work done so far, and in the tables of Appendix I, certain kinds of meanings are not specified in the formulas: e.g. The specific time and quantity modifiers, such informationally complex words as *ratio*, the distinctions among semantically different negative words (e.g. in *deplete*, inadequately written $\mathbf{W}_i^{\sim}$ and *restore*, inadequately written $\mathbf{AV}^{\sim\sim}$ (as in *The antibody response can be restored*, paper 10, 303.1.1 and 2.2). This would have to be amended in further work.

CHAPTER 2

RESULT: FORMULAS OF INFORMATION

The articles and books in a science can be reduced to a sequence of formulas expressing the information. These formulas are the sentence-types of a specialized grammar of the reports and discussions in that science.

A grammar of a language is an efficient formulation of the restrictions of free combinability of its phonemes (or letters) and – more importantly – its elementary, most nearly indivisible, words within each sentence. To be efficient, it must seek the regularities in such restrictions, and state the non-regular restrictions as products of the regular ones. One might think that a grammar should state word-restrictions in respect to a whole discourse – article, conversation, or whatever was the language event within which the words occurred. However, it has been found that a discourse can be segmented in such a way that the main restrictions on word-combinability within one segment are not affected by those in other segments. Hence regularities of word-combinations are stated primarily within the confines of each of these segments, which are approximately what are called sentences. The restrictions are found to be of two kinds. One is the argument-requirement, which precludes a word's appearing in a sentence unless words of its required argument-class are present therein, even if in reduced (even zeroed) form. The other is the likelihood that a given word will appear as operator on particular words of its argument classes. Differently from the argument-requirement, this likelihood is only a graded restriction.

In the case of a corpus of articles in a subscience, we find restrictions on word-combination not only in respect to each sentence but also in respect to the subscience as a whole. The latter condition arises because the main sentence-types (though not the untransformed sentences of the articles) have the restriction of being heavily repeated, in each article and in the science.

1. META-SCIENCE SEGMENTS

The first result is that it is possible to separate out, on grammatical – i.e. co-occurrence – grounds, "meta-science" (in the sense below) sentences or portions of sentences. These are the segments marked **M** in the Appendix tables. In scientific articles, many sentences have an **M** segment, such as *It was found that...* , or *That... is clear.* It is possible to distinguish the **M** segment from the sentence of the science: first, because the science-sentence is in general an argument (subject or object) of the **M** operator (e.g. of *found* or *clear* above); second, because the science sentences are found to have a limited and precisely describably structure, much more so that the **M** segments. In particular, we begin by classifying in **M** those operators whose second argument is a sentence, and whose first argument (subject) is not identical with the subject of that sentence, e.g. *demonstrate* in *Rich demonstrated that the "acute spenic tumor cell"... was identical with the lymphoblast...* (paper 7, 14.3.2). By this criterion, **M** does not include *begin* in *The cells began to profilerate*, where the object of *begin* is *proliferate*, while its subject is *the cells*, which is also the subject of *proliferate* itself (the sentence being reduced from *The cells began their proliferating* or the like).

In our present material, the meta-science verb-class **M** is found to contain chiefly *find, study, observe, investigate, recognize, describe, report, conclude, consider*, and also many additional words such as *accept that, give an account of, ascertain, assume, call attention to, believe, communicate that, contend that, determine, discuss, doubt, examine, expect, hold that, know, mention that, note, retest, search for, see, state, use, view.*

When we investigate the sentences which are the arguments of **M**-verbs, we find that (aside from statable exceptions) they are built out of a limited vocabulary in limited grammatical relations to each other: the word-classes and sentence types of *2* and *6* below. This is the specific science-language grammar whose structure is given in *2* – *7* of Chapter 2 and discussed in *3.1* of Chapter 3. The fact that the residues under **M**, i.e. the science-language portions of the sentences in the papers here analyzed, are characterized by this limited grammar enables us to recognize other portions than **M** which are also not in the science-language. Some of these non-science-language segments are operators whose arguments are science words but not science sentences. Others deal with matters of the science, but do not operate on science-language sentences. We consider the latter first, in respect to their grammatical characterization and to their meaning vis-à-vis the science.

Given **M**, we find that the subjects of **M** verbs are a particular set of nouns, **N′**, which includes *workers, students, investigators* (these being derived from **M** words), *we*, and capitalized words not usually listed in dictionaries: the names of scientists. Given **N′**, we then find that its members appear also as subjects of another set of verbs, **M′**, whose second argument (object) is a noun of the science-language rather than a science sentence. **M′** includes *use, examine, obtain, extract, excise, separate... from*: e.g. *We excised small pieces of red pulp.* Here we should include *use this technique* (or *method*), and the like. Problematic members of **M′** have **N′** as subject but usually no object, as in *work* (*on*), *experiment* (*on*). The words *table, Fig., article, paper* may be assigned to **M′**, if we reconstruct their occurrences as being from **N′** *made a table* (*of antibody titers*, or the like), and **N′** *wrote a paper about...*. There are also whole sentences which may contain **N′**, **M′**, or science-language nouns, but not science-language sentences, e.g. *The sampling problem for electron microscopy becomes very great* (in paper 12, 113.5.5). All these segments have been marked **M** in the tables, although the term "meta-science" may not be precisely appropriate for them.

To return to the operators on science-language sentences: There are many verbs, adjectives, and nouns which have the grammatical status of operators whose first and only argument is a science-language sentence. Such verbs are: *emerge, result, appear, may be* (as in *It may be that...*). Such adjectives (with *is*): *possible, probable, likely, significant, clear, evident, logical, true.* Such nouns (with *is*): *fact, thesis, theory, problem, case, not the case, data, evidence, factor, difficulty, development, subject of confusions, point at issue, matter of semantics.* All of these may be assigned to a new class **M″**. Some of them may be thought to be part of the science-language sentences, since to say *S is a fact*, or *S is not the case*, is the same as the assertion or denial of *S* in the paper. On the other hand, one can say that each science-language sentence in the paper carries a meta-science operator of the writer's asserting (or denying, or stating the improbability, etc., of) that sentence.

Meta-science operators on a sentence can also appear as modifiers of it, the latter being a transformation of the former: e.g. *In the present study, cells have shown pleomorphism* can be derived from *Cells have shown pleomorphism; that cells show pleomorphism is (found) in the present study* (where *is (found) in the present study* would be **M**).

There are some occurrences of **M** verbs where both subject and object are science-language sentences. Such are *demonstrate, show, indicate, suggest, confirm, point to.* These occurrences are similar to conjunctional verbs between science-language sentences such as *cause, accord with, support,*

speak in favor of, represent, mean that, by means of, is a result of, is a condition for, is consistent with, is corrected by, is borne out by. The purely conjunctional verbs do not occur with **N′** as subject. Other verbs, such as *demonstrate*, can also occur with **N′** as subject, as in *Rich demonstrated that* S_1 above. There is a transformational relation to the conjunctional status (as if one said *Rich demonstrated* S_1 *on the basis of some* S_2, whence S_2 *demonstrated that* S_1), but this is not always the case.

The procedures sketched above suffice to separate out, within the sentences of the articles, grammatically characterizable meta-science segments from a residue which is the science-language and is grammatically characterizable by itself. Separating these may involve complex transformations, which can be avoided if we allow some occurrences of meta-science words to remain within the science-language sentences. For instance, in *Peripheral lymph flow is far more rapid than is generally supposed* (paper 1, 783.1.2) we have a comparative with **M** in the second part: roughly *Peripheral lymph flows with a rapidity which is more than the rapidity of lymph flow which is generally supposed.* However, we can consider this occurrence of *supposed* as a word for quantity rather than **M**, and leave *is generally supposed* in the science sentence as though it meant *a moderate degree* or the like; this if the environment shows that *supposed* is not being used here to refer to actual supposing by scientists. Somewhat similarly, in *Some endoplasmic reticulum was demonstrable* (paper 13, 453.3.1) we can derive *demonstrable* from an underlying sentence such as *It was possible to demonstrate that some endoplasmic reticulum was present*; alternatively we can consider that *demonstrable* here did not refer to actual demonstration but was a rough synonym for *present* in *Some endoplasmic reticulum was present.* And *found* appears here both as **M** and as a synonym of *present* in the science sentences (e.g. in paper 1, 798.3.4).

In particular, science sentences can be filled out to conform to the sentence types worked out in *6* below by transforming certain kinds of modifiers from the M segment into the science sentence under that **M**. Thus we find (1) *Workers who examined the primary response were at first led to believe that the lymphocyte was responsible* (paper 9, 62.2.3). In terms of the word classes of *4*, *responsible* is merely a superscript on a word of the $\mathbf{V_p}$ class; hence *the lymphocyte was responsible* does not suffice for any sentence type of *6*. However, (1) could be derived from (2) *Workers who examined the primary response... believed that the lymphocyte was responsible for the primary response*, where *for the primary response* would have been zeroable as a repetition, yielding (1). Here, the *lymphocyte was responsible for the*

primary response is a case of a $GJ^1{:}AV^r_pC_y$ sentence type (section *6*). The reconstruction (2) of the zeroed segment is supported by the continuation of (1) in the article, which is *because of its very great predominance in antibody-containing suspensions made from once stimulated lymph nodes.* The sentence-types in this continuation are:

$C_yW_i^{+\,+}T_n^{wsw}$

AV_iT^s

GU^1T_n

representing

$C_yW_i^{+\,+}T_n^s$: *The lymphocyte had very great predominance in lymph node suspensions.*

AV_iT^s: *Antibody is contained in suspensions.*

GU^1T_n: *(Antigens) stimulated lymph nodes once.*

The conjunction *because* is understandable here only if *once-stimulated* is matched by *primary* in the first argument of *because.*

Every **M** segment is a grammatically constructed (i.e. argument-requirement-satisfying) chain of **M**, or **M**′, or **M**-type conjunctions (above), either operating on one or more science sentences or else occurring as a separate sentence. The sentences of the articles are composed entirely of the following: **M** segments, conjunctions, and science-language sentences. There are differences among the **M** segments, depending on the kind of science sentence on which they operate (e.g. observation sentences or conclusion sentences). However, those differences, as also the properties of conjunctions, relate to the structure of sentence sequences, and fall beyond the scope of the present book.

2. Word classes

In principle, word classes in a closed corpus of texts are established by characterizing each word-occurrence by its "co-occurrents," i.e. the words to which it has a grammatical relation in a sentence, and then putting into one class those word-occurrences which have the same co-occurrents, or nearly the same. The possibility of forming classes depends on how the word-occurrences cluster with respect to their co-occurrents. In the present

corpus of articles, it was found that the subject-verb-object (or subject-predicate) relations sufficed to partition the word-occurrences into a few classes. The noun classes were easy to distinguish on the basis of their occurrences with other nouns and with verbs or adjectives; they are given in detail below. The operator classes (chiefly verbs) were defined chiefly in respect to the noun classes which appeared as their arguments, i.e. their subjects and objects. Since they are more complicated they are only introduced below, with the detailed membership given in 5. The classes listed below are drawn only from the sentences presented in the tables of Appendix 1. In the articles, the sections on Materials and Procedures contained words of a few additional classes, which are not included here. Words are listed in order of appearance; parenthesized numbers indicate the article in which the word first appears in this corpus.

First, two classes, defined in respect to each other, can be set up for a set of nouns which occur as object of any of a particular set of verbs: The noun set is **G** (*antigen*), including (1) *antigen, bacteria, diptheria toxin, paratyphoid organisms, B. enteritidis, B. prodigiosus, ch. spirilla, typhoid vaccine, staphylococcus, bacilli;* (2) *sheep erythrocytes;* (3) *pneumococcus, sheep blood cells;* (4) *horse serum, s. typhi;* (5) *influenza virus, viral protein, cellular agents, agent;* (9) *antigenic material, organisms, diphtheria toxoid;* (10) *tetanus toxoid*; (12) *horseradish peroxidase;* (13) *antigen bearing red blood cells, SRBC.* The verb set is **J** (*inject*), including (1) *inject, incision, utilized, introduce, employ, vaccinate;* (3) *immunized*; (4) *sensitized, administered, deposited;* (5) *received injection*; (6) *received*, (9) *stimulation*; (10) *challenged with.* In most cases **G** is the subject of the passive of the **J**, as in *Paratyphoid bacteria was injected on one side.* For a few inverse members of **J, G** is the "object" – with *by* or *with* – of the passive **J**, as in *These animals were challenged with tetanus toxoid* (paper 10, 306.5.2) There are also a few nouns which can, on the grounds of their larger sentence-environment, be put into **J** unaccompanied by **G**: such as *scratch, puncture wound* in paper 1, 783.1.1 In many sentences, **GJ** is followed by a preposition plus noun (or an equivalent single word) such as *in these animals, in rabbits, on one side, intravenously, subcutaneously, intradermally.* These have been marked **B** ("body-part").

Words of **G** are also found, though much less frequently, as subjects of certain verbs marked **U** (or of the passive of certain inverse members of **U**). In **U**, whose general meaning is "move," are included (1) *travels, there exists a ready route for, has a path*, etc. There are certain preposition-plus-noun combinations which follow **U** whether **U** is active or passive. The prepositions are in most cases *from, to, along, by*, and the nouns are (1)

lymph nodes, blood stream, lymph stream, ear, blood; (4) *red pulp, follicles, white pulp*. These nouns can be put into a class **T** (tissue); these and many additional members of **T** appear in other combinations too (below). Before **U** the class **G** includes a new member $\mathbf{G_f}$ (section *3*): *infection* (paper 1). Examples of **GUT** and **GU** are: *Antigen arrives by the lymph stream* (ibid. 1.7), where no preposition-plus-noun is added. **U** differs from **J** in that it may be followed by up to three **T**, each with a different preposition (*from, to along* and their synonyms), as in the transformed sentence (ibid. 1.5): *The infection has a path between the lymphatic capillaries of the skin and the entrance of the larger channels into the blood stream, along which path stand the regional lymph nodes* (where *between... and* is equivalent to *from... to*).

We next consider the co-occurrents of the word *antibody*. This word is the subject of a large set, marked **V**, of verbs, such as *appear in, are formed by*. Since they fall into several subclasses, these verbs will be discussed in the listing of subclasses (*3*). The subjects of **V** are marked **A**, and include (1) *antibody, agglutinin, bacteriolysin, antibody protein*; (2) *hemolysis*; (7) *immune globulins*; (13) *anti-ferritin, anti-peroxidase*. Many **V** are followed by a preposition (usually *in*) plus a noun of the class **T** (especially in paper 1) or of the class **C** (*cell*, in later papers). The main **T** words after **AV** are (1) *lymph nodes, serum*, but also e.g. *the ear tissue*, (2) *lymph*; (3) *adipose tissue*; etc. **C** words after **AV** are (1) *collections of lymphoid cells*; (2) *lymphocytes*; (3) *plasma cells*; etc. The **T** and **C** words also occur in other combinations (below), and will be listed in their subclasses (*3*).

As to the other combinations into which **T** and **C** words enter: There are rare constructions in which two words of **T** are the two arguments of an operator, e.g. *The lymph stream passes through the glands* (paper 1, 783.1.7) and the more common construction seen for example in *the lymph follicles in the spleen* (paper 4, 12.4.2). Much more common, and different, are the constructions in which the first argument is one of a specified set of words which are names of cell types, as in *lymphocytes present in the fat of the renal sinus* (paper 3, 128.8.2), *Cells of characteristic appearance occurred in the reaction centers* (paper 4, 1.3.4), *Lymphocytic hyperplasia becomes organized into the characteristic follicular structure* (paper 5, 204.2.2), *the chronic drainage of cells from a thoracic duct fistula* (paper 10, 303.2.1). The subject position here is occupied by **C** words, but not by **T** words; and the second argument is always **T** and not **C** as it is in respect to **Y** verbs, below.

The verbs in the **C–T** (and rare **T–T**) sentences above are marked **W**. These are two-argument members of **W**. There are also sentences in which **T** or **C** appears as subject of a one-argument operator such as *develops,*

multiplies, is inflamed, which are also marked **W** (but intransitive). The two-argument and one-argument **W** fall into several subclasses.

There are also, in the later articles, **W**-type sentences in which the subject is not *cell* or *plasma cell*, etc., but *the nucleus*, *the cytoplasm*, etc., where *the* is a referential for *of the cells mentioned*. We find, for example *the cells had a nucleus which...* and also *The cytoplasm (of the cells) was fine* (paper 11, 164.4.5). Thus we have *In the smaller lymphocytes a small amount of endoplasmic reticulum was found* (ibid. 5.2), a transform of *The endoplasmic reticulum in the smaller lymphocytes was in small amount*; and *The cells had a nucleus which was more abundant in chromatin* (paper 4, 1.3.7), tranformable into *The nucleus which the cells had was more abundant in chromatin.* If *nucleus, cytoplasm, nucleolus, Golgi area*, etc. are put in a class **S** ("intracellular structures"), then all of these sentences have as subject the sequence: **S** *of* **C**. The operators in these sentences are in most cases intransitive (i.e. require no second argument). They can be included in the class **W**, in subclasses which depend on the two-noun subject: **S** *of* **C**. These subclasses of **W** differ from those which depend on **C** or on **T** as subject.

The class **C** appears in one other environment: as both subject and object of a class **Y** of two-argument operators (3) *are related to*; (4) *are classified as*; (7) *is identical with*; (9) *has as member*; (13) *have some points of similarity to*. **T** words do not appear as subject and object of **Y**.

The above word classes have been established in respect to the following recurrent operator-argument combinations: **GJB**, **GUT**, **AVT** and **AVC**, **CWT**, **TW**, **CW**, **S** *of* **CW**, **CYC**. These combinations enter into a further combination, namely the frequent **GJB:AVC** and **GJB:TW**, where colon represents *is followed by* and the like. The common text form is not

GJB *is followed by* **TW**,

but rather

GJB. *Thereafter* **TW**.

and

after **GJB**, **TW**.

An example is *On the first day... after the last injection... in every instance the nodes on the injected side... were greatly enlarged* (paper 1, 789.1.2-3).

It should be stressed that word-classes are established by the combination into which they enter, not by any semantic properties. For example, the $\mathbf{G_f}$ subclass occurs in the positions of **G**, i.e. before **U**, as above, and before **J**. It also occurs in the position of **GJ** together, i.e. before **:TW** (as

in end of section *6*) $\mathbf{G_f}$ includes (1) *infection, plague*; (6) *lymphatic leukemia, plasma cell myeloma*; (7) *chronic infectious diseases, hyperproteinemic states.* But this does not mean that $\mathbf{G_f}$ represents disease. Indeed, other disease names are found not in the position of $\mathbf{G_f}$ but in the position of **AV**. This is seen in (1) *Lymphatic leukemias are not associated with hyperglobulonemia* (paper 6, 164.6.2), which fits best into the $\mathbf{G_f}$**:AVC** sentence type, especially considering the components of the word *hyperglobulonemia*, which are $\mathbf{A_g V_i^+ T_b}$ (for the symbols, see below). One could even consider *lymphatic leukemia* as $\mathbf{G_f U^t T_{z'}}$, and *plasma cell myeloma* as $\mathbf{G_f U^t C_z}$ (diseases reaching tissues). Then (1) would be $\mathbf{G_f^w}$**:AVC** followed by $\mathbf{G_f U^t T_{z'}}$, where the **w** indicates that $\mathbf{G_f}$ *leukemia* is carrying a (reduced) relative clause *which is lymphatic.* In accord with this analysis, *Rabbits were immunized... and this resulted in a marked degree of hyperglobulonemia* (paper 3, 121.1.2) is a case of **GJB:**$\mathbf{A_g V_i^+ T_b}$.

There is a sharper example of how the criterion is how word-occurrences combine, rather than which words are identical or what is their meaning. This is seen in the class of operator-phrases, marked **I**, whose first argument is **C** and second **B**, with a third argument, also **B**, in some cases. The words are: (10) *inject into... from*, as in the transformed component-sentence *Small lymphocytes were injected from other rats* (3.3.2.2), *Thoracic duct cells were injected into rats from normal non-immunized rats* (314.3.3); (14) *introduce*, as in *The lymphocytes were introduced in the afferent vessel of another node* (579.2.5). These **I** occurrences are not included in **J** (which contains other occurrences of *inject, introduce*) partly because here the first argument (of the passive) is **C** and not **G**, although the distinction is not always obvious since **G** can contain *cells* as in *sheep red blood cells.* Another distinction between **J** and **I** is that **I** can have *from* **B** (in addition to *to* **B**) as second argument, something which is excluded when the subject is **G**. Thus we have two sentence types: **CI** *into* **B** *from* **B**, as against **GJB**; although the words of **I** appear also in **J**.

A final noun-class is **D**, which includes (6) *nucleic acids*, *DNA*, *PNA* (*RNA*). This class differs from all other noun classes in respect to word-combinations: it occurs both in **AVD** and in **DVC** (see section *6* below).

Finally, there is a class marked **:** (colon) of conjunctions and of verbs. Both arguments of a colon are sentences. The first sentence, before colon, is **GJB**, in a few cases **GUT** (or **GUC**) and **CIB**. The sentence after colon has **V** or **W** as its operator. **GUT** and **CIB** may also appear as second sentence, after **GJB:**. In the following list of the members of colon, an arrow after a member means that that member precedes rather than follows **GJB**.

For example, *after*← indicates that *after* precedes **GJ** in *After the reinjection,... it was possible to observe the occurrence of cells of characteristic appearance* (paper 4, 1.3.4); and *to*← precedes **GJ** in *the response to a second intravenous injection of toxoid* (paper 10, 306.4.2). In contrast, *produce* without arrow indicates e.g. *Diptheria toxin was utilized to produce local inflammation* (paper 1, 792.1.1). The colon class includes (1) *wh*-conjunctions and pronouns ←, *after*←, *with, to*←, *following*←, *produce, call forth, induce, result in, upon*←, *in*←; (2) *yielded*; (4) *conditioned*; (5) *prior to*←, *specific to* ←; (9) *outcome of, detonates, results after*←; (10) *gave*; (12) *to trace*; (14) *give rise to, is stimulus to.* Although the colon words are grammatically conjunctions and sentence-connecting verbs, they differ in these articles from the other conjunctions in that they connect the two members of a very frequent sentence-pair: **GJB** and **CW** (or **TW**, or **AVC**). There are in addition many other conjunctions, which connect various sentences (including the above pair-sequence as a unit, e.g. **GJB:CW**) to others. While these other conjunctions are noted in the tables, they are not represented in the formulas, because their subclassification depends on an analysis of long sentence-sequences, which is not part of the present study.

These, then are the gross word-classes that can be distinguished by their co-occurrents in the material here investigated. In certain gross classes (**G, J, U, A, Y**), many members can co-occur with almost any member of the co-occurring classes (e.g. *antibody* in **A** can occur before any **V**), while other members (such as *plaque* in **A**) can occur only with particular members of the co-occurring classes, or with particular members of the co-occurring classes, or with particular grammatically-farther words. We put such words into a subclass: e.g. *plaque* in $\mathbf{A_q}$. There are other gross classes (**V, T, W, C, S**) in which virtually all the words are restricted as to co-occurrents, and thus are members of one subclass or another. In such classes, any word that is not thus restricted has the meaning of a classifier or a pronoun for the restricted subclass words.

3. Word subclasses

The subclasses are marked by a subscript after the class symbol. The different words in a subclass are in effect synonymous in respect to the given articles; that is, the semantic differences between them are immaterial to the research discussed in these articles.

G has a subclass $\mathbf{G_{a\sim}}$ for foreign substances that do not call forth antibody response. Differently from **GJ**, the $\mathbf{G_{a\sim}J}$ is not followed by **:AV** (but by $\mathbf{:AV_i^{\sim}}$). Members are, e.g., (1) *dye substances, diphtheria toxin. Infection*, *disease*, and some related words form a subclass $\mathbf{G_f}$, noted in section *2*.

U has a subclass $\mathbf{U_i}$ expressing the antigen's stopping at a tissue or its presence in the cell: (1) *is arrested in, is held by*; (4) *accumulates at, is found in*; (9) *presence of.* There is a subclass $\mathbf{U_d}$**:** (4) *perish in.* We find a $\mathbf{GU_d^k{-}T_t}$ sentence-type in the transformed *Thymus has an insignificant phagocytizing capacity toward antigen* (paper 4, 12.4.2). There is also $\mathbf{U_p}$**:** (5) *multiply*, in *eliminates the question of multiplication of the agent* (paper 5, 204.2.7); and $\mathbf{U_s}$ *sensitize.*

The class **T** has a few non-specific members, which have in most occurrences the status of a classifier (see below): (1) *tissue, site, organ*; (4) *places.* The other words that appear in **T** position are assignable to distinct subclasses on the basis either of the **W** subclass with which they occur or of the neighboring sentences to which they are conjoined. One subclass is:

$\mathbf{T_b}$ (1) *blood, serum, vascular, circulating*; (12) *humoral.*

Subclasses referring to lymph tissue are:

$\mathbf{T_n}$ (1) *lymph nodes, lymph glands*;
$\mathbf{T_l}$ (1) *lymph, lymph stream.*
$\mathbf{T_{l'}}$ (1) *lymphatic plexus, lymphatic capillaries, lymphatics, lymphatic tissues;* (2) *lymphoid tissue*;
$\mathbf{T_{l''}}$ (5) *interstitial fluid, lymph supernatant.*

Subclasses of other tissues containing antibody-forming cells are:

$\mathbf{T_t}$ (3) *thymus*;
$\mathbf{T_k}$ (3) *adipose tissue of the renal sinus, fat of the renal sinus, pelvic fat*;
$\mathbf{T_p}$ (3) *retroperitoneal adipose tissue, retroperitoneal fat.*

Subclasses naming tissue structures are:

$\mathbf{T_s}$ (1) *spleen*;
$\mathbf{T_d}$ (4) *red pulp of the spleen*;
$\mathbf{T_f}$ (4) *white pulp of the spleen, lymphatic follicles, follicular tissue*;
$\mathbf{T_m}$ (4) *Malpighian bodies, periphery of the lymph follicles*;
$\mathbf{T_x}$ (9) *cortex*;
$\mathbf{T_u}$ (9) *medulla*;

$\mathbf{T_r}$ (1) *germinal centers*; (4) *reaction centers*;
$\mathbf{T_h}$ (10) *thoracic duct fistula.*

Subclasses of tissue not containing antibody-forming cells:

$\mathbf{T_v}$ (1) *liver*;
$\mathbf{T_c}$ (2) *muscle.*

In **W**, whose one or two arguments are **T**, **C**, or **S**, a few general properties are named: (1) *size, appearance*, (3) *weight, have histological features*, (11) *have morphological features.* Otherwise, there is a host of subclasses, each characterized by particular arguments. The major ones (for the others, see *5*) are:

$\mathbf{W_a}$, whose argument is **T** or **C**, contains (1) *reaction, are affected, involved*; (3) *active*; (9) *response, biological event*;

$\mathbf{W_f}$ has only **T** as argument: (1) *painful, inflamed, hemorrhagic*; in this context *normal* is $\mathbf{W_{f\sim}}$ (where the tilde means *not*).

$\mathbf{W_g}$ after **T** is (1) *enlarged*; after **C** or **S** it is (4) *large*, with $\mathbf{W_{g\sim}}$ standing for *small*; after S it is also (12) *extensive.*

$\mathbf{W_{c'}}$, only after **T**, contains (1) *rupture, open*; it occurs in particular sentence-sequences.

The most frequent operator on the pair **C, T** is $\mathbf{W_i}$, whose first and second arguments are mostly **C** and **T** respectively (or **T** and **C**, in the case of words marked "inv," for "inverse"): chiefly (3) *infiltrate, found in, present in, present in*, $\mathbf{W_{i\sim}}$ *free from* (inv, *the lymphatic tissue investigated was free from plasma cells*, 128.3.3), $\mathbf{W_i^+}$ *predominant*; (4) *met with, localized in*, $\mathbf{W_i^+}$ *abundant, contain* (inv), *abundant in* (inv, in *the pieces of red pulp were abundant in plasma cells*, (5.1.1), *in, have number* (11.1.5); *content*; (5) $\mathbf{W_i^+}$ *hyperplasia*; (7) *consist of* (inv); (9) *scattered*; (10) $\mathbf{W_{i\sim}}$ *depleted of* (inv), $\mathbf{W_{i\sim}}$ *are lacking*; (12) $\mathbf{W_i^-}$ *few, scanty*, etc.; (13) *occupy.*

$\mathbf{W_p}$ also has **C** as subject, in many cases with a second argument **T**: (3) *proliferate, -poietic*; (4) *formation, development* (11.2.3), *production*; (5) *multiply*; (7) *output, -genesis.*

$\mathbf{W_c}$ has mostly **C** as subject, but with no second argument: (1) *change* (where the subject is still **T**); (4) *transition, develop*; (5) *become organized*; (9) *differentiation, changing character, course of events*; (11) *pleomorphism*; (13) *adaptations, different*; (14) *sequential changes.*

A related subclass with one argument, **C** or **S**, is $\mathbf{W_m}$: (6) *reach maturity*, (7) *well-developed.*

Somewhat less common is $\mathbf{W_u}$, whose first argument is **C** (rarely **T**) and **T**: (1) *flow, pass through* (with **T** subject); (6) *leave, separated from*; (14) *held up in, enter, settle in, migrating throughout, reach.* Inspection of the neighboring sentences shows that $\mathbf{W_i}$ deals with the presence or absence of cells in tissue, while $\mathbf{W_u}$ deals with their motion.

A very few words can be put in another subclass, $\mathbf{W_d}$, with **C** as subject: (4) *disintegrate*, or **T** as object: (10) *damage.* And $\mathbf{W_o}$: (7) *mitoses.*

In addition, there are several subclasses, each with a particular subset of S as subject. Chief among these are:

$\mathbf{W_e}$ (4) *eccentric*, and $\mathbf{W_{e\sim}}$ *round*, with subject $\mathbf{S_n}$ (*nucleus*);
$\mathbf{W_s}$ (4) *red*, (7) *basphilic, pyroninphilic, bright* with subject $\mathbf{S_c}$ (*cytoplasm*);
$\mathbf{W_r}$ (11) *rough* with subject $\mathbf{S_r}$ (*endoplasmic reticulum*);
$\mathbf{W_t}$ (13) *electron-opaque*, with subject $\mathbf{S_n}$.

Finally, there is a subclass $\mathbf{W_\ell}$ of laboratory prodedures, whose object is **C** or **T**, such as (7) *seperate by sedimentation*, (1) *excise, tease.*

As to **C**, the following major subclasses can be distinguished:

$\mathbf{C_\ell}$ (1) *lymphoid cells*;
$\mathbf{C_y}$ (1) *lymphocytes*;
$\mathbf{C_r}$ (2) *reticulo-endothelial cells*; (4) *reticulum cells, reticulo-endothelial elements*;
$\mathbf{C_z}$ (3) *plasma cells*, (13) *plasmacytic*;
$\mathbf{C_b}$ (9) *hemacytoblasts, blast forms*;
$\mathbf{C_h}$ (10) *pyroninophilic cells*;
$\mathbf{C_m}$ (13) *macrophages.*

In **S**, there are few classifier words serving for all subclasses: (11) *structural units.* The other words are in subclasses on the basis of the W subclasses whose subjects they are:

$\mathbf{S_c}$ (4) *cytoplasm*;
$\mathbf{S_n}$ (4) *nucleus*;
$\mathbf{S_u}$ (7) *nucleolus*;
$\mathbf{S_m}$ (11) *mitochondria*;
$\mathbf{S_g}$ (11) *Golgi apparatus, Golgi bodies*, (13) *Golgi area*;
$\mathbf{S_r}$ (11) *endoplasmic reticulum*, (12) *ergastoplasm*;
$\mathbf{S_b}$ (11) *ribosomes*;
$\mathbf{S_p}$ (13) *perinuclear space.*

In the class **Y**, whose two arguments are both **C**, a few subclasses can be distinguished; the main **Y** words were given in section *2*. The major subclass is $\mathbf{Y_c}$: (4) *differentiate from*; (11) *differ from, show pleomorphism in respect to, show a progression of development through*; (13) *are transitional between.*

With the superscripts **f**, (*from*) and **t** (*to*), presented below, different words appear:

$\mathbf{Y_c^f}$ (3) *descend from*, (4) *originate from*, (9) *arise from*, (10) *is precursor of* (inv), (14) *is derived from*;

$\mathbf{Y_c^t}$ (4) *develop into, transition to*, (12) *results in*, (14) *gives rise to, produces.*

We now consider the subclasses of **A**. These are:

$\mathbf{A_a}$ (5) *substance*;

$\mathbf{A_p}$ (5) *protein*, (13) *protein-like material*;

$\mathbf{A_g}$ (7) *beta and gamma globulins, plasma globulins*;

$\mathbf{A_q}$ (11) *plaques*, (14) *hemolytic plaques*, (13) *hemolytic antibody plaques*;

$\mathbf{A_r}$ (13) *rosette.*

The main **A** words were listed in section *2*.

Finally, the class **V**. The most frequent subclass is $\mathbf{V_i}$: (1) *found in, contained in, appears in, positive, demonstrable, in, accumulates, titer in*; (2) *storehouse* (inv, i.e. *lymphocytes as storehouse for antibody protein*), $\mathbf{V\tilde{}_i}$ *negative*; (4) *amount in*, (5) *of*; (6) *quantities*; (9) *intra-, stained for* (inv); (11) *actual finding within*; (12) *distribution, identity in, reveals* (inv); (13) *occur in.* The other major subclass is $\mathbf{V_p}$: (1) *formation, production*; (3) *source*; (5) *primary site*; (6) *synthesis*; (7) *multiplying*; (9) *development*; (11) *cell in center of plaque* (individual cell producing antibodies), *cells at edges of plaques* (cells not producing antibodies).

It should be clear that $\mathbf{V_i}$ and $\mathbf{V_p}$ differ from each other not merely in meaning but in some word-combinations. For example some papers write $\mathbf{AV_pC_z}$, but not $\mathbf{AV_pC_y}$; indeed, some of them have an $\mathbf{AV_p\tilde{}C_y}$ sentence. A subclass which is a classifier for both $\mathbf{V_i}$ and $\mathbf{V_p}$ is $\mathbf{V_a}$: (9) *reaction.*

Three subclasses cover the remaining relations of antibody to cell or tissue:

$\mathbf{V_u}$ (1) *taken out, seep through, drained from*, (4) *extracted from*, (5) *distributed, pass through, received*, (13) *absorbed, coated with* (inv);

$\mathbf{V_s}$ (11) *secreted*;

$\mathbf{V_t}$ (13) *storage.*

with (inv);
$\mathbf{V_s}$ (11) *secreted*;
$\mathbf{V_t}$ (13) *storage.*

4. Word Modifiers and Local Operators

Many occurrences of the central words of a sentence, i.e. those that are members of the gross classes and subclasses above, carry modifiers (such as *large* preceding a noun, or *primarily* following a verb) or local operators (such as *begin to* preceding a verb) which are indicated here by superscripts on the central words. Only a few combinations of central words make up the sentence types of section *6*, and they can occur without the modifiers and local operators. When these latter occur, it is only in local grammatical relation to central words, or to other modifiers and local operators on the central words. In the grammar of the whole of English, the modifiers are transforms of operators in secondary sentences (i.e. those joined by *wh-* to the primary): e.g. *Some large lymphocytes contained antibody* from *Some lymphocytes contained antibody; the lymphocytes were large.* And a local operator is derived from an operator on a sentence: e.g. *The cells begin to differentiate* from *The cells begin their differentiating* (where *They differentiate* is a sentence under *begin*). However, in the language of the texts here investigated, these words have the special property stated above, which makes them ancillary parts in the sentence-types of the science rather than constituents of new types of sentence. Whereas a subscript on a class symbol indicates the (subclass) choice of words in the given occurrence of the gross class (e.g. $\mathbf{A_p}$ for *protein* as against **A** for *antibody*), the superscripts indicate added words before or after the central word. In some cases, however, the added meaning indicated by the superscript is carried by a new word choice in the gross class, rather than by an added word. This happens especially in the superscripts for negation (e.g. $\mathbf{V}^{\sim}_{\mathbf{i}}$ *free from*, equivalent to *not containing* (as against $\mathbf{V_i}$ *containing*), quantity (e.g. $\mathbf{V}^{\uparrow}{}_{\mathbf{i}}$ *rise*), equivalent to *increased presence* as against $\mathbf{V_i}$ *present*), and direction (e.g. $\mathbf{Y}^{\mathbf{t}}_{\mathbf{c}}$ *develop into*, equivalent to *change into*, and $\mathbf{Y}^{\mathbf{f}}_{\mathbf{c}}$ *derived from*, equivalent to *change from*).

In the tables in Appendix 1, from which the vocabulary above is drawn, there are superscripts on operators, on nouns and on conjunctions. Those on operators include – in rough semantic characterization – negation,

quantity, aspect (e.g. *begin to*), direction, and some which are particular to the verbs of these texts. They are:

~	for *not, un-, in-, abolish, fail to, cease, depress*, and word-replacements meaning negative or opposite;
~ ~	for *to restore, to reverse or correct (unresponsiveness)*;
+	(also on nouns) for *much, so, rapid, marked, enormous, strong, high, pronounced, rich, massive, constantly, several, intensive, extensive, numerous, predominant, mainly, considerably, great, large numbers, significant numbers, in profusions, brisk*;
-	for *few, little, low, small numbers, no large amount, sparse, minor, paucity*;
↑	for *increased, rise, growing*;
↓	for *decrease, recede, fall, decline, diminish, subside, smaller*;
>	for *more (than), higher concentration, -er, exceed*;
> >	for *maximal, peak*;
<	for *less*;
f	for *from, of*, also in *efferent*; **t** for *to, into*, also in *afferent*; **y** for *by, along, on, through*; **ft** also for *between... and* (i.e. *in the interval from... to*).

In what may be called the aspectual meanings there are:

b	for *begin, start off on, reach, initiated, induction*;
s	(on verbs) for *stop, end with*;

and the important **r** for *have role in, participate in, relate to, factor in, act as, regulate, concerned with, correspond, possible, importance in, responsible for, instrumental, dependent, associated with, contribution to, mediated, play a part in, of significance for.*

Distinct from this is **k** for *have capacity.*

On the colon, which is the only conjunction included in the sentence-formulas, there is one class of modifiers, marked **t** and written for convenience as a subscript instead of a superscript; for example

$:_t$	for *three days after, on the 12th day after, until the 7th day following, shortly after.* Time indications found elsewhere in the sentence are transformed if possible into being placed on the colon, just as quantity and negation modifiers on a noun are transformed if possible into being placed on the operator on that noun.

There is also:

e for *early, first*, chiefly on verbs;
i for *rapid.*

A special modifier on verbs is

v for *in vitro, in culture.*

There are also frequency superscripts on **J**:

1 for *primary, single, sensitizing, one*;
2 for *secondary, re-, booster, two*;
3 for *repeated, hyper, further.*

On nouns the superscripts are:

g for *large, extensive, distended*, with $\mathbf{g}\sim$ for *small*;
m for *mature, well-developed*;
c for *changing, developing, differentiating, transitional, variation, intermediate*;
k for *capacity for*;
a for *active*;
d for *disintegrating*;
x for *extract of*;
s (on **T**) for *suspension of*;
/ for *line, category, family, class.*

There are finally two gramatically different superscripts, both involving reference. A capital letter indicates a reference to the occurrence of that letter as a gross class in the same formula.

One superscript is **G**. Thus $\mathbf{GJ{:}A^{G}V_{i}}$ can represent *After an antigen is injected, antibodies to that antigen appear.* And $\mathbf{GJB{:}AV_{i}T_{n}^{B}}$ represents *After antigen is injected in the left ear, antibodies appear in the lymph node on that side* (where *the left ear*, is equivalent to the *ear on the left side* as in paper 1, p. 792).

Superscript **B** represents *regional, of the injected side, neighboring, local, the sole draining, homologous, homolateral*;

$\mathbf{B}\sim$ is for *the uninjected side, opposite, heterologous.*

The other exceptional superscript is **w**, placed on a symbol whose word carries a relative clause that is not included in the same formula but is represented by a seperate formula following. This separate representation of a relative clause is used when the clause is itself a sentence type of the

texts. For example, *Pathogenic bacteria carried on the lymph stream are often arrested in the glands through which this stream passes* (paper 1, 783. 1.7) is represented by a sequence of three formulas: $\mathbf{G^{w}U_{i}T^{w}_{n}}$ for *Pathogenic bacteria are often arrested in the glands*, followed by

$\mathbf{GU^{y}T_{\ell}}$ for *Pathogenic bacteria are carried on the lymph stream*,

and

$\mathbf{T_{\ell}W_{u}T_{n}}$ for *This stream passes through the glands.*

The two superscript **w** in the first formula indicate that the symbols to which they are attached are hosts to two relative clauses which come from the two next sentences (listed in the order of the two **w**).

In contrast, a relative clause which does not contain a separate formula is simply represented by the appropriate superscript or subscript on its host symbol. For example, *There are considerable differences of opinion concerning the changes which occur in the primary and secondary response to an antigen reaching the node* (paper 14, 583.3.1) we can transform in part to *the changes which occur in response to an antigen's primary and secondary reaching of the node*, which is $\mathbf{GUT_{n}{:}CW_{c}}$ (where *changes which occur in response* is $\mathbf{W_{c}}$).

5. Summary of word classes

The sentence-segments **M** which operate grammatically on the science-sentences state the scientists' views or actions in respect to matters described in the science sentences.

M verbs: e.g. *observe, doubt.*
N′: e.g. *investigators, personal names.*
M′: e.g. *examine, extract, prepare a table of.*
M″: e.g. *probable, significant; problem.*
M conjunctions: e.g. *indicate, is a condition for.*

There are occasional problems in separating grammatically the meta-science segment of a sentence from the science-sentence.

The gross word-classes are: (the sample member given below is a classifier or main member of the class):

G	*antigen*
J	*is injected*
B	e.g. *in rabbits, subcutaneously*

U	*travels, is distributed to*
A	*antibody*
V	*is present in*
T	*tissue*
C	*cell*
W	*have histological features*
S	e.g. *nucleus, cytoplasm*
Y	*is called, is identical with*
I	*is injected into . . . from*
D	*nucleic acid*
:	*thereafter*

Conjunctions between formulas are not considered to be parts of the formulas and are not listed here.

The subclasses of nouns, itemized in section 3, are:

$\mathbf{G_{a\sim\sim}}$	*dye*
$\mathbf{G_f}$	*infection, disease*
$\mathbf{A_a}$	*substance*
$\mathbf{A_p}$	*protein*
$\mathbf{A_g}$	*Beta and gamma globulin*
$\mathbf{A_r}$	*rosette*
$\mathbf{T_b}$	*blood*
$\mathbf{T_n}$	*lymph nodes*
$\mathbf{T_\ell}$	*lymph*
$\mathbf{T_{\ell'}}$	*lymphatic system*
$\mathbf{T_{\ell}*}$	*lymphatic capillaries*
$\mathbf{T_{\ell''}}$	*lymph supernatant*
$\mathbf{T_t}$	*thymus*
$\mathbf{T_k}$	*adipose tissue of the renal sinus*
$\mathbf{T_p}$	*retroperitoneal adipose tissue*
$\mathbf{T_s}$	*spleen*
$\mathbf{T_d}$	*red pulp of the spleen*
$\mathbf{T_f}$	*lymphatic follicles, white pulp of the spleen*
$\mathbf{T_m}$	*Malpighian bodies*
$\mathbf{T_x}$	*cortex*
$\mathbf{T_u}$	*medulla*
$\mathbf{T_r}$	*germinal centers*
$\mathbf{T_h}$	*thoracic duct fistula*

$\mathbf{T_v}$	*liver*
$\mathbf{T_c}$	*muscle*
$\mathbf{T_i}$	*ileum*
$\mathbf{T_j}$	*packed cells*
$\mathbf{C_l}$	*lymphoid cells*
$\mathbf{C_y}$	*lymphocytes*
$\mathbf{C_r}$	*reticulo-endothelial cells*
$\mathbf{C_z}$	*plasma cells*
$\mathbf{C_b}$	*blast forms*
$\mathbf{C_h}$	*pyroninophilic cells*
$\mathbf{C_m}$	*macrophages*
$\mathbf{C_w}$	*white cells*
$\mathbf{S_c}$	*cytoplasm*
$\mathbf{S_n}$	*nucleus*
$\mathbf{S_u}$	*nucleolus*
$\mathbf{S_m}$	*mitochondria*
$\mathbf{S_g}$	*Golgi bodies*
$\mathbf{S_r}$	*endoplasmic reticulum*
$\mathbf{S_b}$	*ribosomes*
$\mathbf{S_p}$	*perinuclear space*
$\mathbf{S_t}$	*chromatin*

B and **D** have no important subclasses here.

The subclasses of operators (verbs and adjectives, even if nominalized) are distinguished by their arguments (subjects and objects). Thus $\mathbf{U_i}$:**G—C** indicates that words of the $\mathbf{U_i}$ subclass occur with words of the **G** class and words of the **C** class as arguments. Entries with leftward arrows indicate that the order of arguments is right-to-left; for example, *contain* ←, as a member of $\mathbf{U_i}$, has a member of the class **C** as first argument and a member of the class **G** as second argument: *cell contains antigen.*

U:	**G—**	**G—T**	**G—C**
	route	*reaching*	*stimulated*
	travels	*stimulate*	*stimulus*
		stimulated by ←	*has been processed by*

U_s: **G—C**
sensitization to ←
sensitized
exposure to ←

U_s^t: **G—C**
uptake by
encounter with ←
interaction with ←
contact with ←
contact by ←
adherence to

U_i: **G—T**
found in
arrested in
hold ←
detected in
content in
concentration in
distinguish in
accumulate in

G—C
contain ←
presence in

U^t: **G—T_n**
are carried to
distributed to
seive out ←
reaching

U^y: **G—T_s**
are carried on
arrive by

G—T_b
absorption by

G—T_s
distribution of

U^f: **G—T_e**
escape from

U^{fty}: **G—T_s·$T_b$$T_n$**
has a path between...
and... along

U_d: **G—T_d, G—T_f** *perish in* **G—T_t** *phagocytizing capacity for* ←

U_p: **G—** *multiplication of* ←

V: **A—, A—C, A—B** *response*

V_p: **A—T_n** *formation in* / *formed by* / *production of*← **A—C** *form* / *produce*← / *synthesis of* ← / *are the source of* ← / *resulting from multiplying* **A—SC** ←*formed in* / *synthesis of* / *production in* **A_q—C** *in the center of* ← / *at the edges of*← (= $V_p^{\sim}$) / *occur in* ←

A_q— *size of* **D—** *multiplication* / *production* / *formation*

V_i: **A—T, A—C, A—SC** *in* / *found in* / *appear in* / *detect in* / *was demonstrated in* / *visible in* / *present in* **A—SC** *is restricted to* / *filled with* ← / *is free of* ← (= $V_i^{\sim}$) / *are nonreactive for* ← (= $V_i^{\sim}$) **D—C** *in* / *contents of* / *presence in*

contain in
within
distribution in
associated with
occurs in
intra-
contain ←
positive for ←
as a storehouse of ←
content of
was stained for ←
were negative for ← ($= V_i^{\sim}$)

V_i^y: **A—T^f** *occurred over* | **A—C** *detected around* *distribution between* | **A—SC** *present throughout*

V_t: **A—S_r**
have deposits of ←
deposition of ←
storage of ←
stores ←

V_s: **A—C_y, A—C_z**
secrete ←
secretion by
release of

V_a: **A^G—C**
reaction on the surface of

V_u^f: **A—$S_rC_z^m$** *escape from* | **A—C** *extracted from* *was derived from* | **A—$T^{s'}$** *liberation from* | **A—T_b** *concentrations from*

V_u^t: **A—T_n** *drained to* | **A—C** *absorbed to*

	drained into *absorbed to*	*coat passively with* ← *adherence to*	
V^{ft}_{u}:	**A—T_n,** *taken out of... by* *taken up from... by*	**A—TT_b** *being received from by*	**A—TC_y** *concentrated from... by*
V^{y}_{u}:	**A—T_n** *passing through*	**A—T_b** *seeped through*	
V^{t}_{u}:	**A^a—C^g_y~C** *is transferred to*		
W:	**T_n—** *size and appearance*	**SC—** *state of* *continuity of* *appearance of*	
W_a:	**T—** *reaction* *action* *activity in* *active* *affected* *histologically involved*	**—C, C—T** *reacting* *reaction* *active* *event* *course of events* *fate of* ← *response*	
W_c:	**C—, C—T** *differentiation* *change* *stage of development* *change takes place in* *changing character in* *changes in* *development*	**S_rC—, S^vC—** *differentiation* *developmental change* *development of* ← *have further increase in number, length and width* *organization* *developing* *complex*	

W_c^t: C_y—T_f
becomes organized into

$W_{c'}$: $T_{\ell'}$—
rupture
open

W_g: SC—
large
prominent
extensive
large and honeycombed

C—
enlarge
large

T_n—
enlarged
large
swollen
enlargement of
hypertrophic

W_q: S_nC—
electron-opaque

$W_{q\sim}$: *electron-lucent*

$W_{g\sim}$: SC—, C
small

W_m: SC—
distinct

maturity

C—
mature

C—T
maturation process in

$W_{m\sim}$: C—
primitive
immature

W_i: S—SC
in
had ←
with ←
constituent of
occupied
associated with ←
ringed with ←

S—
in
occupied by ←
of
containing ←
present in
was found in
displayed by

C—
present
detectable
appearance
encountered
occurrence
occurring
were met with

	were found lining	*volume in*	*content*
	bordering		*diffuse*
	contents of ←		
	C—T		
	present in	*detected in*	
	in	*were found in*	
	scattered in	*were met with in*	
	of	*were contaminated with*	
		←	
	appear in	*containing* ←	
	fixed in	*persist in*	
	within	*showed infilitration of*	
		←	
	consisting of ←	*infiltration in*	
	occurrence in	*infiltration of*	
	$\mathbf{T}_{\ell}$**—**$\mathbf{T}_{\ell'}$		
	in contents of ←		
	$\mathbf{T}_{\ell'}$**—**$\mathbf{T}_{j}$		
	caught among		
	contain ←		
$\mathbf{W}_{\tilde{i}}$:	**C—T**		
	free from		
$\mathbf{W}_{p}$:	**C—**	**C—T**	
	multiplication	*formation of colonies in*	
	development	*clusters scattered in*	
		profusion throughout	
	perpetuates itself	*form colonies in*	
	- poiesis	*aggregates may possi-*	
		bly constitute	
	- genesis	*generate* ←	
	formation of ←	*genesis in*	
	proliferation of ←	*development in*	
	production of ←	*development in*	

	S_rC—	S—C	T_m—B
	well developed	*develops*	*were well developed in showed proliferation of* ←
	T_r—T_f		
	proliferation in		
W_o:	C—		
	undergoing mitotic division		
	dividing		
	divides		
	mitotes were found		
W_u:	T_{ℓ}—		
	flows		
W_u^f:	C—T_n		
	transferred (from)		
	output from		
	output of ←		
	leave from		
$W_u^{f\sim}$:	C_z^m—T_n		
	would be held up in		
W_u^t:	C—T_n, C—T_b, C—T	C—T	
	entered	*deposition* ←	
	settled in		
$W_u^{t\sim}$:	T_{ℓ}^f—T_b		
	was prevented from reaching		
W_u^y:	C—T_n		
	pass through		
	migrating throughout		

W_u^{ft}: $C_y^{g\sim}$—T_bT_ℓ
circulates between blood and lymph

W^f: C—T_h, T_ℓ—T_h
drainage from
emerged from
loss from

W_e: S_nC—
eccentrically situated
having eccentricity
eccentric, showed deep indentations with the chromatin in part condensed
indented
pushed to one side and indented

$W_{e\sim}$: S_nC—
intact
round, with evenly dispersed chromatin

W_w: S_rC— S_cC—
distended *broadened*
widened
sparsely and consistently widened
dilated

$W_{w\sim}$: S_rC— S_cC—
narrow, rare *narrow*
flattened
with a constant narrow distance between the rows of ribosome bearing membranes
narrow and of constant width
narrow

W_n: S_cC—
fine and granular, with most organelles confined to the larger pole of the cell

W_y: S_rC—
oriented in more or less parallel lamellae
a parallel orientation
having regular circular lamellae

$W_{y\sim}$: S_rC—
apparently random orientation
no organization into lamellae was apparent

$W_{b'}$: S_b—S_cC
randomly distributed

$W_{b''}$: S_b—S_cC
were clustered in polyribosomes in
in clusters in

W_r: S_rC—
rough, having single narrow channels
rough

W_s: S_cC—
red
typically red
stained moderately red in Unna-Pappenheim (methyl green pyronine), and light blue in Giemsa
flourescent
basophilic
pyroninophilic (basophilic)

S_uC—
pyroninophilic, conspicuous

C—
basophilic

W_f: $T_{\ell'}$— - *angitis*

T_n—
inflamed
hemorrhagic
inflamed
edema

W_{ℓ}: **T_s—$T_s^{I,II}$** **T_f—T_s**
separated by means of, to be cut from
sedimentation into
were subjected to differential sedimentation
to separate them, if possible, into

T—
were excised
was collected externally
examination
examined for weight and
histological features

C_yT_{ℓ}—, C_y—
were centrifuged, washed in saline and
then divided into 2 portions
labelled with thymidine
labelled
lysed
suspended in normal rabbit serum and cultured
in a roller tube for 48 hr.
lysed in distilled water

C_z^m—
identified on electron microscopic radioautography

S_cC—
spun down

W^f_{ℓ}: **C—T**
preparations from
were separated from
withdrawn from

Y: **C—C**
to be considered *of*
were typically *are same as*

are closely related to
are
are in
found to be in
classification into
typical of
were considered
were called
classified as
could constitute
had some points of similarity to
appearance is indistiguishable from that of
was identical in its ameboid movement with

independence of (= $\mathbf{Y}^{\sim}$)

identified as
contained some morphological features both of
may represent
of the morphological classification of
include
appears to represent
have shown pleomorphism of
resembles morphologically
can be assigned to

being differentiated into
is according to our nomenclature

were regarded as
with the morphological characteristics of
distinguish from (= $\mathbf{Y}^{\sim}$)

S—S
being distributed as
appear as
may be
is in the form of
are

A—A
is
must be
identified as

$\mathbf{Y_c}$: **C—C**
transitions between

$\mathbf{Y_c^f}$: **C—C**
formed from
derived from
descend from
adaptation or differentiation from
differentiating from
is a precursor of ←

arise from
considered as the stem cell for ←
originated from

Y_c^t: **C—C**

development into	*develop into*
give rise to	*produces*
production of	*generating*
differentiation, resulting in	*the mature member is*
transition into	

Y_c^y: **C—C**

shown a progression of development through

Y_c^{ft}: **C—CC**

bridge the gap between... and
morphological indications of a transition between... and
transitional between... and

Y_c^{yt}: **C—CC**

differentiate through... to

Y_c^t: S_r^y—S_r^r

a transition to

Y_i:

C—C	$S_r^s S_c$—$S_r^s S_c$
are known to include	*intermingling with*
found among	
among	
in	

Y_p: A_r—**A**

the involvement in formation of

J and **I** have no subclasses here.

The superscript modifiers and local operators are listed in section *4* above.

The approximately 100 symbols in sections *4* and *5* together with quantity words (e.g. *3 days*) to specify the values of **t** on colon, suffice to express the information in the papers here analyzed. Their classification and combinability provide a grammar of the restricted language of the subscience. All that is missing here is the set of conjunctions, and the details of the

meta-science segments which operate grammatically on the science sentences.

The question might be raised whether a scientist in the area would be able to construct the same vocabulary list without having to go to through the analysis of the word-combinations. In part, certainly. But reducing the wealth of English verbs used in the papers to the particular list of **U**, **W**, **Y**, **V**, subclasses would be by no means obvious, even to a worker in the area. It is also questionable whether the impressions gained from research experience would suffice for classifying phrases collected here into the superscripts, especially in the case of such a complex semantic function as that filled by the superscript **r** (*having a role in*). The scientist using the words grouped under **r** is expressing his view of the status of cells in antibody production. A check on how these words co-occur with the subjects, objects, and neighboring sentences of $\mathbf{V_p}$ indicates whether all these words are being used for the same unspecified status, or whether certain words differ from others in respect to what status is meant.

There are several important relations within and between word-classes. For one thing, for certain classes and certain sentence types, there are classifiers, i.e. words whose meaning is that of all members of the class or type. Thus *cell*, *tissue* serve for any **C** and **T** members, respectively. In *antibody response*, the word *response* can refer to either $\mathbf{V_i}$ or $\mathbf{V_p}$ and is thus a classifier of these; but *immune response* refers as classifier to $\mathbf{AV_i}$, $\mathbf{AV_p}$, or $\mathbf{CW_a}$ (or $\mathbf{TW_a}$), as noted in Chapter 4. *Site* in these papers refers to the particular **C** (or **T**) such that $\mathbf{AV_pC}$, i.e. to the locus of antibody production.

There are various relations of a class to its members. Many noun subclasses have only one member here: e.g. *muscle* $\mathbf{T_c}$. Some subclasses have a few members whose differences in meaning is important elsewhere but is not relevant in the present articles: *antibody*, *agglutinin* in **A**, or *blood*, *serum* in $\mathbf{T_b}$. Some classes have members whose meaning difference is relevant to the given area of science, but not to the arguments and conclusions in this set of articles, i.e. in respect to the site of antibody formation. One example of this is **G**, as between the different antigens tested; and in **B**, as between the different locations of injection, or the different animals. In many articles the experiment was intended to see if any antibody production differed for different **G**, or **B**. Hence the differences would be important for any survey of the field. But once the results showed no difference in site, the variety of **G**, or of **B**, become irrelevant to the sentences about site. We see here how the grammatical structure of research articles can bring out results which would stand out less clearly in,

for example, review articles or textbooks. Another example is seen in **A**, as between *bacteriolysin*, *hemolysin*, *anti-ferritin*, etc. In addition, some subclasses contain synonyms: these are few in the noun classes (e.g. *node* and *gland* in $\mathbf{T_n}$, *antibody* and *antibody protein* in **A**, *sheep erythrocytes* and *sheep blood cells* in **G**). But synonyms are many in some operator subclasses such as $\mathbf{V_i}$, $\mathbf{V_p}$, $\mathbf{W_i}$, and the colon (even though not all the words in each subclass are synonyms in English). Finally, some subclasses have words some of which are synonymous even in general English while others are slightly – but importantly – different semantically in English but not here: so in $\mathbf{W_f}$, **Y**, and the superscript **r**.

There is also a relation, which may be called dependent synonymity, in which a subclass has a particular member when its operator or argument subclass has a particular member. For example, *cells in the center of plaques* indicates cells which are producing antibody: it can be written $\mathbf{A_qV_pC}$, while *cells producing antibody* is written $\mathbf{AV_pC}$. Similarly, *cells at the edges of plaques* is $\mathbf{A_qV_p\tilde{}C}$. A slightly different situation of this kind is seen when the words of a class differ according to the different prepositions which operate on them: e.g. **U**, which can be represented by "move," has *arrested in*, etc., for "move into" ($\mathbf{U^i}$), *reach* for "move to" ($\mathbf{U^t}$), *escape from* for "move from" ($\mathbf{U^f}$). In the whole language, such complementary members are found among sounds (in the "conditional variants" of phonemes), but hardly ever among words, because the ranges of meanings and of combinations among words are too complex. But in the restricted content of a subscience we can find such complementarity of use as in the case of the *plaques* above.

There is not enough material here to show how many words are fully synonymous in respect to this research area. In the cases where words are synonymous in respect to their combinability and meanings in these articles, the synonyms can be replaced by a single word. Thus each subclass can in principle be reduced to a single member which would be the English – or French, etc. – representative of the symbol; in case a subclass contains several non-synonymous members, it can be replaced by several subclasses.

The possibility of finding synonyms is increased if words that are grammatically equivalent to a sequence of more basic words are factored into (i.e. replaced by the sequence of) those other words. For example, in *Wesslen obtained thoracic duct lymph* (paper 14, 577.1.3), we cannot, on one hand, easily extract a known sentence-type since *obtain* does not take *lymph* as subject; hence this is not a science-language sentence. On the other hand, if we leave *obtain* in the meta-science portion the *lymph* has no

operator. However, if we factor *obtain* into *establish the presence* or the like, we would have *Wesslen established the presence of thoracic duct lymph* which is a meta-science operator (*establish*) on a $T_{\ell}WT_{h}$ sentence (*lymph is present in duct*).

There are many homonyms, that is cases where the same English word appears in two or more different classes. Thus, *produce* appears frequently in $AV_{p}C$ (*Lymphocytes produce antibody*), but also seemingly one in $CY_{c}C$ (*lymphocytes' secondary response, which would presumably be chiefly the production of plasma cells*, paper 14, 583.3.4). Here the word *produce* has two quite different meanings.

There is also a synonymity-homonymity among operator subclasses, which is indicated by the appearance of the same subscripts in different operator classes. Thus we have V_{i}, W_{i}, U_{i}, and V_{p}, W_{p}, U_{p}; and U, V_{u}, W_{u}; also W_{c}, Y_{c} and superscript **c**; and W_{d} U_{d}, and superscript **d**; and W_{g} and superscript **g**; and V_{a}, W_{a}, and superscript **a**. Use of the same letter indicates that some (but not all) of the words are the same (e.g. *is found in* in V_{i} and W_{i}) and that the meanings are close, although they are not identical (due to the different classes of argument). If a single word is chosen for each subclass, the words chosen would be somewhat different because of this meaning difference (perhaps *appear* for V_{i} and *occur* for W_{i}), so that the homonymity disappears. Indeed, if the subclass symbols are used instead of English words, the symbols, e.g. V_{i} and W_{i}), exhibit both the semantic closeness, in the **i**, and the grammatical and semantic difference, in the V versus W. Within the richer – English – vocabulary actually used, the homonymity (e.g. *is present in* in both V_{i} and W_{i}) means that our classification has to be carried out on word-occurrences in respect to their environment, not on words. That is, not *is present in* but a particular occurrence of it is in V_{i}. But if the symbols (rather than the words) are looked upon as the real vocabulary of the science, sufficient for its reports, then we avoid both homonymity and synonymity in the total symbol (e.g. V_{i}) but not in its components (e.g. **i**).

6. SENTENCE TYPES

In *2–4* the words of the articles investigated here were classified in respect to their combinability, above all in their immediate operator-argument relation. Hence, the operator-argument relation of these word classes was being organized at the same time as the classification. Each operator-argu-

ment combination forms a sentence: *secrete* operating on the pair *lymphocytes, antibody* forms (1) *Lymphocytes secrete antibody.* When the words are mapped onto their classes, the sentences are mapped onto sentence-types, e.g. **CVA** for (1). The 14 gross classes of section *2* combine into only a few sentence-types, each consisting of an operator-argument relation among particular word classes. Among these sentence-types there are cases of several different combinations of the same word classes, in which the combinations are paraphrastic to each other and can be considered variants of each other: the difference is then statable as a sublanguage transformation. The sentence-types (with parentheses indicating omittable segments) are:

GJ (B) e.g. *influenza virus injected in rabbits.*
$GU^{y_t}TT$ e.g. *Pathogenic bacteria carried on the lymph stream are often arrested in the glands* ($G^{w}U^{t}T_{n}$, $GU^{y}T_{\ell}$).
$CI^{ft}BB$ e.g. *thoracic duct cells injected from normal non-immunized rats into rats.*
AVC (and **AVT**) e.g. *Antibody is formed in the lymphocytes.*
CWT e.g. *Plasma cells were usually not detected in the lymph follicles* ($C_zW_i{\sim}T_f$).
TW e.g. *The nodes are inflamed.*
CW e.g. *lymphocyte disintegration.*
SCW e.g. *The cytoplasm of the large cells is basophilic.*
CYC e.g. *These cells obviously originated from reticulum cells.*

In addition, there is a conjunctional operator which pairs certain of these sentence-types into a macro-sentence type, namely:

GJB: response sentences (i.e. sentences whose operator is **V**, **W**, or Y_c below)
GJB:GUT
GJB_1:$CI^{ft}B_1B_2$ (more fully **GJB_1: AVC^{B_1}: $CI^{ft}B_1B_2$**)
GUT: response sentences
$CI^{ft}B_1B_2$: response sentences (of B_2)

Many **AVC** sentences appear as **CVA** (*Plasma cells produce antibody*), with the verbs of **AVC** being passives of those in **CVA**, or vice versa. The

AVC variant is used here because it is simpler to transform **CVA** to **AVC** (e.g. the above to *Antibody is found in lymphocytes*) than **AVC** to **CVA**. The subscript numbers on **B** above are to distinguish the two bodies in **I** sentences: donor and recipient of transferred cells (paper 10). Some **CWT** sentences appear as **TWC** (with inverse **W**). **SCW** sentences appear in several paraphrastic arrangements. There are few **G:A** (*antibody specific to an antigen*) sentences which cannot be sharply distinguished from **GJ:AV** (*antibody formation is specific to the antigen injected*). There are also several **AYA** sentences e.g. *Antibodies are globulins*. And there are a few cases of **DVC** and **AVD**, too few to establish these formulas as the best form for those sentences.

Subscripts, by definition, do not affect the sentence-types except in rare cases (e.g. $\mathbf{Y_c}$, or the referential $\mathbf{B_1}$, $\mathbf{B_2}$). Superscripts do, if they occur characteristically in certain sentence-types: e.g. **ft** after **I**, or **t** (though written as subscript) after colon, or quantifiers in sciences in which quantity relations are persuasively important.

In part, these sentence-types fall into families: **AVC** and **CVA**; **GJ:AV** and **G:A**; and all the **W** sentences together. Furthermore we note that almost all **AVC** sentences, most of the **CWT**, almost all **TW**, **CW**, **SCW** and almost all $\mathbf{CY_cC}$, as also most **DVC**, appear only after **GJB** plus colon (even if the **GJB:** has been zeroed) or after **GUT** or **CIB** plus colon. These restricted-occurrence sentences are called here response sentences, as above. They refer to the immune responses to the **J**, **U** and **I** events. Indeed, there are individual classifier words that can occur in place of these sentences, whether **V**, **W**, or $\mathbf{Y_c}$: *response*, and more limitedly *reaction*.

Another kind of family of sentence-types is seen in the case of *infection*, which was classified in section *3* as $\mathbf{G_f}$. For example, *the reaction of lymph nodes to infection* (paper 1, 783.1.6) would be represented by $\mathbf{G_f{:}T_nW_a}$, with *to* (and *in*, below) represented by colon. However, in *the occurrence of plasma cells in chronic infectious diseases* (paper 7, 2.6.1), the *in* accords less with *disease* as noun (where *in* would mean "inside," and the formula would be $\mathbf{G_f{:}C_zW_i}$) than with *disease* as a nominalized sentence, equivalent to *the occurrence of a disease*, the formula being then $\mathbf{G_fJ{:}C_zW_i}$. The latter is seen in *When such infection occurs the lymph nodes become enlarged* (paper 1, 783.1.6) as $\mathbf{G_fJ{:}T_nW_g}$. Indeed, the first example above can be taken as transformed from *the reaction of lymph nodes to occurrence of infection*, $\mathbf{G_fJ{:}T_nW_a}$. $\mathbf{G_fJ}$ does not occur as an independent sentence (as **GJB** does), but $\mathbf{G_f{:}TW}$ and $\mathbf{G_fJ{:}TW}$ are in a family with **GJB:TW**.

The colon-pairing of sentences can be combined into an envelope of colon-pairings, in the sentence-sequences

GJB:GUT: response sentence
GJB_1:CIB_1B_2: response sentence of **B_2**

Any sententially whole portion of one of these sequences can represent a macro-sentence, i.e. a row in the tables of Appendix 1.

The sentence types, plus the constraints on how the subscripts and superscripts occur in them, are the grammar of the science-language proper. In addition, the texts of the science have conjunctions and meta-science segments operating in the science-language sentences.

7. Sentence formulas

The sentence types are the recurring sequences of word-classes. Given a particular sentence, we can insert into its type formula the subclass and superscript symbols which represent the specific words of the sentence: e.g. $\mathbf{AV_sC_y^{g\sim}}$ for *Antibody is secreted by small lymphocytes.* If the various words represented by the same subscript or superscript are locally synonymous, i.e. if their meaning difference is irrelevant to the given sentence, then the type formula plus the subscripts and superscripts constitutes a sentence formula which is informationally identical with the given sentence. The formula can then be considered not just a representation of the structure or information but an actual transcription of the information in the individual sentence. In the articles analyzed here, this situation can be achieved in respect to all material in the fact sentences of the sciences except for numerical modifiers of time and quantity. Numerical data cannot be summarized, unless we know that only certain cuts – groupings or differences – of the numerical information are relevant. In many sciences in which quantity relations are important, it is possible to find transformations that enable the quantity superscripts to be located at fixed points of the formulas, as the time symbol **t** was restricted here to the colon. In some cases, also, it is possible to find that only certain ranges or contrasts of quantity are relevant, so that symbols are needed only for these, rather than for specific quantity mentioned in each sentence. Aside from the numerical values represented by the time and quantity symbols, the only (but essential) information in the articles which is not included in the sentence formulas is, first, the conjuctions between them (together with the hierar-

chy, i.e. the operator-argument relation, among the conjunctions themselves), and, second, the meta-science operators and modifiers on the sentence.

The sentence formulas can be seen in the tables of Appendices 1 and 2, where each row is a macro-sentence preceded by its formula.

Not only the sentence types recur frequently in the articles, but also the specific sentence formulas. (The actual sentences recur less frequently because of the use of paraphrastic devices – synonyms and transformations.) In many cases a particular sentence formula repeats several times within a paragraph, the difference between repetitions lying in the time and quantity words, or in the conjunctions and **M**-operators.

The fact that the sentences of an article can be replaced by their sentence formulas means that informational and other processing can be carried out on the sequence of formulas, in which it is practicable, rather than on the much more varied original sentences, in which it is impracticable. The validity of the formulas as transcriptions of the original sentences can be seen by comparing the formulas of a given article with the formulas of the summaries of that article which are given in the introductory section of various papers in the series. The methods of obtaining the least redundant description of word-dependence leave room, in certain situations, for small differences in analysis, leading to somewhat different subclass and sentence formulas in different independent analyses of the same articles. However, this could not alter the general result that only a few word classes and a few sentence types suffice to determine sentence formulas which organize the information contained in the article, in a form available for formal analysis and processing.

CHAPTER 3

FROM STRUCTURE TO INFORMATION

The special structures of sublanguage and discourse, within language, are of interest because their informational interpretation is different and sharper than the informational interpretation of the whole language. Since the problem of identifying the antibody-producing cells has been resolved in the papers investigated here, we know in retrospect how the papers differed in respect to their information about this problem. This difference can then be compared with the papers' differences in grammatical structure, to see if there is a controlled method of making an informational interpretation of the grammatical structure of sublanguage material. It will be seen in section *1* that differences in word classes and in sentence formulas appear where there are known differences in information or in opinion. This correlation suggests that one can indeed judge the information on the basis of the structure, and it indicates how the structure points to the information. Any relations established in such controlled conditions should prove applicable in less controlled situations, such as in investigating ongoing research, where our informational judgement about an article is less definite (see section *2* below).

1. DIFFERENCES IN STRUCTURE AND DIFFERENCES IN INFORMATION

1.1. Course of the information

We note first the main information presented in each paper in respect to the site of antibody formation. Paper 1 showed that this takes place in the lymphatic system and more particularly in the lymph nodes. Paper 2 showed that lymphocytes were involved. Paper 3 argued that the plasma cells of the lymphatic system, and not the lymphocytes, were the antibody producers. Paper 4 presented results in the same direction, together with evidence that the plasma cells are the end stage of a development of reticulum cells which go through lymphoblast stages, but, it was claimed, not through lymphocyte stages. Paper 5 is an example of those articles

which point to lymphocytes as antibody producers. Papers 6 and 7 support the plasma cell results and argue against lymphocytes, paper 7 noting the stages at which plasma cells are antibody producers. Papers 8 and 9 find antibody in individual plasma cells, in internal structures studied in paper 12. Paper 10, in the course of a different research problem (concerning donor cells injected into a second animal), showed that small lymphocytes are not an end cell but develop further, and that they are essential to initial antibody production. Papers 11 and 13 show individual small lymphocytes, as well as plasma cells, producing antibody, and argue that plasma cells are descended from lymphocytes. And paper 14 surveys the whole investigation sketched above.

During the 35-year span of these articles, various scientific developments aided in the obtaining of further results, and are reflected in the word-classes and sentence types of these and contemporary articles. Chief among the developments were: greater detail in intracellular structure, seen from paper 4 and on; the role of nucleic acids in protein production, seen in papers 6 and 7; the electron microscope, used in the later papers.

1.2. Changes in word classes

Only few new word classes were introduced in the course of these papers, mirroring the informational developments. **C**, which is hardly mentioned in paper 1, becomes one of the central classes in all following papers, as the research narrowed from "which organ or tissue" to "which cell". **D** appears briefly from paper 6, when tests for nucleic acid were used in order to indicate antibody production. **S**, for intracellular structure, appears first, in this material, in paper 4 (only for *nucleus* and *cytoplasm*) and then increasingly from paper 7 and on.

Of subclasses, we find $\mathbf{C_y}$ (*lymphocyte*) from paper 2, $\mathbf{C_z}$ (*plasma cell*) from paper 3, and $\mathbf{C^I}$ (*individual*, or *single*, *cell*) from paper 8. $\mathbf{Y_c}$ (*cell-change*) begins briefly in paper 3, frequently in papers 4, 7, 11, 13, 14. **S** subclasses become numerous in later papers.

1.3. Changes in sentence-types

The changes in sentence-types reflect even more closely the changes in information. Paper 1 has **AVT** (the antibody being found in an organ), whereas the middle papers have **AVC**, which in many cases is composed of a sequence of $\mathbf{AV_iT_x}$ and $\mathbf{C_xW_iT_x}$ (i.e. antibody is found in a tissue $\mathbf{T_x}$

which is rich in a certain type of cell C_x), whence the conclusion is AV_pC_x (C_x produces antibody). Finally, the later papers have **AVC** without intermediate reference to a particular **T**. Similarly, the earlier papers have **TW**, for *tissue reaction*, while the middle papers have **CW** as well.

As soon as there is evidence of immature and mature plasma cells, and of stages of "blast" cells preceding them, CY_cC sentences appear. There are formulas for short-range changes between near stages, as in $C_y^bY_c^tC_z$ (for *lymphoblasts developing into plasma cells*), and formulas for long-range changes, as in $C_zY_c^fC_r$ (for *plasma cells being descended form reticulum cells*). At about the same time, the unsubscripted **Y** (for *is called, is same as*) appears. Such **CYC** sentences could have occurred in earlier articles, since the **Y** does not require any special experimental results, in contrast to Y_c which requires evidence of changes and stages. However, in the absence of knowledge about changes there was less need to name various stages, and to note that a name given by one scientist indicated the same cell or stage as some other name given by another. What we see in these **Y** and Y_c formulas is that the recognition of cell-change and the naming of cell-types went hand in hand. The cell changes were recognized as differences between somewhat arbitrarily selected stages, and the stages were reified by cell-type names; the untoward effect was that the subjects and objects of Y_c and of **Y** were treated grammatically as different things – cells – in the science, rather than as a development of one thing – a cell line.

An example of how a somewhat different research problem is reflected in the sentence-types is seen in the donor-research in paper 10, where there appear $CI^{ft}B_1B_2$ sentences (for injection of cells from one, usually sensitized, animal B_1 into another B_2) in order to see if the second animal will respond by forming antibody. The relation of this part of the paper 10 research, and of this sentence-type, to the problem studied in these papers is seen in the fact that $CI^{ft}B_1B_2$ can be fitted in between GJB_1: (for *antigen injected into the first animal*) and $:AVB_2$ (for *antibody in the second animal*). Other such cases are seen in paper 2 (not in the section included in Appendix I), and in various papers included in the present report.

An interesting informational situation in these papers is the presence of both the assertion and denial of a particular sentence. In this material, AV_pC_y (*Antibodies are produced in lymphocytes*) appears in paper 5 and other papers of the time, and in papers 11, 13, 14, whereas its denial $AV_p\tilde{}C_y$, or AV_pC_Y under negative meta-science **M**, appears in several papers, e.g. *The experiments clearly refute the idea of antibody production by mature lymphocytes* (paper 7, 15.9.1); *Antibody is not produced by small lymphocytes*

(paper 10, 317.1.1). In contrast, we have: *A number of these cells (small lymphocytes), with the characteristic small lymphocyte morphology, are also antibody producers* (paper 14, 587.5.2). The status of this confrontation, with respect to the neighboring sentence types, will be discussed below.

1.4. Critique of the sentence-types

We now consider the course of the information in terms of the main sentence types in the results-section and conclusions-section of each paper. First we have as results $\mathbf{AVT_s}$, (paper 1), then both $\mathbf{AV_iC_y}$ (antibody presence, papers 2,5) and $\mathbf{AV_iC_z}$ (papers 3,4,6) in circumstances that suggest $\mathbf{AV_pC_y}$, $\mathbf{AV_pC_z}$ (antibody production in those cells). The $\mathbf{C_z}$ papers (3,4,6,7,8,9,12) argue against $\mathbf{AV_pC_y}$, partly because the small lymphocytes ($\mathbf{C_y^{g\sim}}$) were viewed as a terminal cell from having too little internal structure to support antibody production, but mostly because of the antibody abundance ($\mathbf{V_i^+}$) in plasma cells that was obtained after two or more injections of antigen ($\mathbf{GJ^3{:}AV_i^+C_z}$). In such conditions little or no antibody was found in lymphocytes ($\mathbf{AV_i^\sim}$). In addition, when the mature plasma cells were understood as the end of a cell development (paper 4) it was argued that $\mathbf{C_y}$ was not a stage in that development: *In these investigations plasma cells were found to originate from reticulo-endothelial cells.... On the other hand nothing has emerged which speaks directly in favour of the participation of the lymphocytes in the formation of antibodies* (paper 4, 12.3.1, 4.1), which is represented by $\mathbf{C_zY_c^fC_r}$ and $\mathbf{AV_p^r{\sim}C_y}$ (contrasting with frequent $\mathbf{AV_p^rC_y}$ in later $\mathbf{C_z}$ papers, admitting a $\mathbf{C_y}$ role). The role of plasma cells was then made certain by $\mathbf{AV_iC_z^l}$, i.e. by finding antibody within the individual $\mathbf{C_z}$ (paper 8).

On the other hand, it was shown that the small lymphocyte is not unchanging, but itself a stage in cell development: $\mathbf{C_y^{g\sim}Y_cC}$ (paper 10), 317.3.1); and in particular that it develops toward a plasma cell, as in the sequence $\mathbf{C_y^{g\sim}Y_c^tC_h^g}$ and $\mathbf{C_h^gY_c^tC_z}$ (where $\mathbf{C_h^g}$ is a "large pyroninophilic cell"; papers 10 and 14). Hence when there finally came definitive evidence of antibody production by small lymphocytes, it had to be understood that the development to plasma cells went through lymphocytes: $\mathbf{C_rY_c^tC_y}$ and then $\mathbf{C_yY_c^tC_z}$ (through blast cells $\mathbf{C_b}$, papers 11,13,14). The failure to state this earlier was due not to lack of the $\mathbf{Y_c}$ cell-development sentence-type, but to the exclusion of $\mathbf{C_y}$ from being a stage in the $\mathbf{C_rY_c^tC_z}$ development.

2. Formula-based critique of information

In the first place, the subclass symbols established by an investigation such as the present one determine the working concepts of the science at the time. This is the case when various of the words that are used are found to be synonymous for the science, e.g. *in*, *present in*, *contained in* as $\mathbf{V_i}$. It is much more importantly the case when words of clearly different meaning are used for the same event or relation in the science. A simple example is **U** (without superscript) for antigen reaching a cell, but also for the antigen stimulating the cell, and for the cell being sensitized by the antigen. In detail, these are different stages and aspects of an event, but at the level of the "which cell" research they all are used for the same type of event. A more complex example is seen in the many different words and grammatical forms that are classified as colon, i.e. that connect a **GJ** sentence to an **AVC** or a **CW** one. Severally, the words indicate time-succession, causation, subordination (*wh-*), modifier status. But together they indicate one relevant concept – not a range of meanings but a single meaning – for the relation between **GJ** and **AVC** or **CW** in this research, a concept for which there is no one English word but which is not within various sciences.

The formulas and their sequences can serve both for summaries of information and for critiques of the information. For example, in respect to the exclusion of $\mathbf{C_y}$ above no adequate grounds had been stated for the common view that the small lymphocyte was an end cell, something which was in any case refuted in paper 10. Nor were explicit grounds, i.e. appropriate sequences of formulas, stated for how much structure a cell (the $\mathbf{C_y}$) should be expected to have if it were producing antibodies. In the papers, as much information about ultrastructure was given as the microscopy made available, but there was little explicit information as to function of the ultrastructure; and indeed much of the ultrastructure served not for production ($\mathbf{V_p}$), but for storage ($\mathbf{V_t}$) which was not essential (in the lymphocyte stage) as long as cells were secreting antibody ($\mathbf{V_s}$) almost as fast as they were producing ($\mathbf{V_p}$). The small lymphocytes found producing antibodies (i.e. at the center of plaques, paper 11) did so while having little ultrastructure, though more than those at the edges of the plaques, which were not responding to the given antigen and so not producing antibody. In addition, analysis of the sentence-types in the various articles shows no grounds for certain views stated about single and repeated injections, such as *This raises the question whether the "primary response" exists as such on a cellular level, or whether the synthesis of antibody results only after the uptake*

of two doses of antigen by the same primitive cell of the proper variety, with some unknown but necessary intracellular event intervening (paper 9, 67.3.5). This would require the non-established claim $\mathbf{GJ^1{:}AV^{\sim}C}$ (no antibody after one injection) by the side of the established **GJ¹:CW** and **GJ¹:AVC** (cell-reaction and antibody after one injection). The amounts of antibody reported in $\mathbf{GJ^1{:}AV_iC_y}$ (paper 5) and $\mathbf{GJ^1{:}AV_pC_y}$ (paper 11) are indeed small, but this is to be explained by the fact that only a small percentage of the lymphocytes are of the proper variety to respond to a given antigen.

The discussion in *1* and *2* above was offered in order to show how the information and conclusions in an article can be surveyed in terms of the sentence-types used. When statements of the articles are represented in formulas belonging to a few sentence-types, it is easier to inspect the sequence of formulas in order to check the grounds (i.e. the preceding formulas) for each one of them. While the discussion above was entirely informal, one may hope that more orderly ways of using the formulas for a critique can be developed, though it is impossible to say in advance how far such a critique can reach.

Even in the formal discussion above it can be seen that the formula sequences which lead to hypotheses and conclusions are less complete, and so less adequate as arguments, than the tightly structured designs of experiment and the accompanying sentence-type sequences which lead to summaries of factual results. One general critique can be made of the data presentation itself. Although various morphologically different cell-types were recognized, from paper 4 and on, as being stages of development of a single plasma-cell line, neither this fact nor the arbitrariness of the boundaries between successive stages is reflected in the word-classes and sentence-types. Some stages were given the same kind of names as cell types were given: *plasmablasts*, *lymphoblasts*, *hemocytoblasts*, as well as *plasma cells*; and separately *lymphocytes*. Other stages were given modifiers on cell names: *large and small lymphocytes*, *mature and immature plasma cells*, *transitional cells*, etc. Only rarely is the characterization of a stage presented as a predicate on the cell which is developing through that stage. Such a predicate naming development is used in *The greatest rise in PNA concentration occurred when the plasma cells reached maturity. The highest figures of PNA were observed when the cells were fully mature* (paper 6, 164,3.3-4), which is represented by $\mathbf{D_rV_i^{\uparrow>>}}$ *when* $\mathbf{C_zW_m}$, followed by $\mathbf{D_rV_i^{>>}}$ *when* $\mathbf{C_zW_m^+}$. The $\mathbf{C_zW_m}$ (as against the usual $\mathbf{C_z^m}$ for *mature plasma cell*) was used here by the author because the process of maturation was being distinguished. It may seem like quibbling over notation, but had the

sentences about mature plasma cells, or small lymphocytes, or lymphoblasts, been stated about "plasma cells when mature" (or "individual reticulum cells at final developmental stage"), or "lymphocytes when small," or "reticulum cells during differentiation," respectively, then the sentences would have had to talk about the process of developing through one or another stage rather than about the named cell-types $\mathbf{C_z}$, or $\mathbf{C_z^m}$, etc. This would have afforded a more accurate formulation of cellular behavior, whether **AVC** or **CW**, as related to cellular development (itself a cellular behavior) rather than as something that happens to one cell-type as against another. Grammatically, it would mean, for example, that $\mathbf{C_z}$ or $\mathbf{C_z^m}$ would not be the argument of some particular **W** or **AV**, but that instead $\mathbf{W_z}$, or $\mathbf{W_{zm}}$ would be a predicate in a second formula conjoined to that particular **W** or **AV**.

Furthermore, treating the stages as predicates of a subject **C** would make the $\mathbf{C_1Y_cC_2}$ sentences into a case of the $\mathbf{C_1W}$ (development) type, with $\mathbf{C_2}$ (as stage names) taken as an adverb indicating the extent of the development $\mathbf{Y_c}$. The difference seems immaterial: between "development into" ($\mathbf{Y_c}$) a cell and "development up to" ($\mathbf{W_c}$) a stage. However, such precision in the statements makes them purer records of what the scientist has observed. Furthermore, such detailed reconsiderations of the formulas may help make it possible to get additional information out of the conjunctional and meta-science interrelations of the formulas. When the formulas are spare and precise representations of what is said, they constitute bare records of the perceived facts in the science, leaving the relations among the facts to be possibly visible in the relations among the formulas.

Clarification of the status of lymphocytes in respect to antibody production would have been furthered if the $\mathbf{AV_p \sim C_y}$ assertion ("lymphocytes do not produce antibody"), which does not quite follow from the preceding formulas, had not been made. After the early papers it became clear, not only due to paper 10, that lymphocytes could not be excluded from involvement in antibody production (in contradistinction to the $\mathbf{AV_p^r \sim C_y}$ quotation from paper 4 in *1.4*). This was represented by $\mathbf{AV_p^rC_y}$ (stating that $\mathbf{C_y}$ nevertheless had a role in $\mathbf{AV_p}$), which often accompanied the $\mathbf{AV_p \sim C_y}$. The understanding of what this role is, i.e. of the superscript **r**, would have been facilitated if it had been accepted that the $\mathbf{V_p^r}$ was not an alternative but possibly an addition to $\mathbf{AV_pC_y}$ (i.e. to actual antibody production by lymphocytes). Such understanding would have been the more important as the whole discussion of the cellular site of antibody production led to information-gathering and analysis of the mechanism of antibody pro-

duction, which was a matter not of such a vague conclusion as $\mathbf{V}_{\mathbf{p}}^{\mathbf{r}}$ but of the detailed observable response and development (**W**) of the $\mathbf{C}_{\mathbf{y}}\mathbf{C}_{\mathbf{z}}$ cell line after antigenic stimulation.

It is clear from the above survey that differences in sentence-types reflect differences in information or in opinion, and that critique of the sentence-types and of their sequences provides a critique of the information and opinion. More generally, the sentence-type structure of each article and of the set of articles is a good, and refinable, representation of the information therein. We can see both what is constant (i.e. the **GJB:C** *response*) and what is changing in the structured information. We can also see what is unresolved or perhaps awaiting resolution. Thus, as mentioned above, the ultrastructure within cells is described, but those descriptions are not fully used in the further sequence: the structures are presumably relevant to determining what cell produces antibody, but their relation to the mechanism of antibody formation is not treated explicitly. Furthermore, there is incomplete organization in the major sentence-types. In the position of

C *response* (after **GJB:**)

we have any one of **AVC**, **CW**, $\mathbf{CY}_{\mathbf{c}}\mathbf{C}$, with no explicit indication of how these are organized among themselves as followers of **GJB:**, i.e. whether certain subclasses of **V**, **W**, and $\mathbf{Y}_{\mathbf{c}}$ are ordered or simultaneous followers of **GJB:** rather than alternative followers. This is directly the question of the mechanism of antibody production, and it arises as soon as we look at the various forms of the main sentence-type above. The question of the **GUC** sentence type (antigen taken up by the cell) enters here also. We have

GJB:GUC

and

GUC:C *response*

and even occasional

GJB:GUC:C *response.*

Rather than leave this as an episodic structure we have to ask whether all

GJB:C *response*

sentences can be considered as reduced from

GJB:GUC:C *response*,

or whether there are specific kinds of formulas where this is the case.

3. SUBLANGUAGE PROPERTIES

3.1. Grammatical structure

Like all syntax, that of the science language consists of word classes and subclasses, and the sentence types which are produced by their operator-argument relations, together with any constraints on all these. This syntax is given in *5 - 7* of Chapter 2, with remarks on some of the major relations among the words of a class. There are intra-class relations among members, e.g. of classifier words to their classificands. There are also semantic relations among class members, e.g. the fact that the red pulp ($\mathbf{T_d}$) and the white pulp ($\mathbf{T_f}$) are both parts of the spleen ($\mathbf{T_s}$). Such relations may or may not come out in the co-occurrence analysis of any particular set of texts. The analyst may decide to use such outside knowledge if it is absolutely certain; this was not done in the present investigation, in order to show how far one could get on the basis of word co-occurrence alone.

There are also symbol-homonymities, when the same symbol occurs in different classes: as in $\mathbf{V_i}$, $\mathbf{W_i}$ and $\mathbf{U_i}$; or in $\mathbf{U}$, $\mathbf{V_u}$ and $\mathbf{W_u}$; or in $\mathbf{U_d}$ and $\mathbf{W_d}$. This is a situation unique to sublanguages. In whole languages, many homonymities are accidental phonemic identities among semantically unrelated words in different classes (e.g. *see* and *Holy See*). In well-organized sublanguages which have been reduced to a science language of symbols, the occurrence of the same symbol in different classes means that the same or closely-related concepts, which may be expressed by the same words, occur in different classes – that is, at different points of the system described in the science of language. The homonymous symbols thus indicate synonymities in the science language.

The English sentences of the articles, especially as transformed in the Appendix tables, constitute a science sublanguage of English, closed under transformations and conjunctions. The formulas into which they are reduced constitute a symbolic language for the science. Aside from the intra-class and inter-class relations in the symbolic science-language, there are various relations among the English words used in the English sublanguage. In the present sublanguage, each operator subclass, and a few of the argument subclasses, contain a few or many interchangeable synonyms. Superficially, the authors seem to be using the wealth of meanings in English vocabulary; but the restrictions on word-use show that in most subclasses the authors are merely drawing on that vocabulary for synonyms for the subclass in

question. If we disregard such synonyms, the subclass may then contain a single word.

There are also homonymities among the English words. Some of the words drawn from the English vocabulary were seen to be members of more than one subclass: e.g. *contain* in both $\mathbf{V_i}$ and $\mathbf{W_i}$. Even some technical words appear in two classes: the two-argument *is injected into* of **J** and the three-argument *is injected from... into* of **I**; note also *immunize* in **J** and *immune* in **A**. The sublanguage grammar then has to be stated in terms of word-occurrences as tokens (e.g. a particular occurrence of *contain*), not simply words as types.

The subclass assignment of word-occurrences makes it necessary to analyze certain occurrences of single morphemes as a sequence of two subclasses: thus *respond*, which in some occurrences is $\mathbf{W_a}$, is in others $\mathbf{AV_i}$ or $\mathbf{AV_p}$. Representing these occurrences of *respond* by a subclass sequence is tantamount to breaking ("factoring") the single morphemes (words) into two or more. The specificity of subclass combinations in the sentence types of the sublanguage makes it possible to factor certain other word occurrences into two classes, on syntactic grounds; such factoring is more difficult to justify in the syntax of the whole language. An example is *normal*, which is analyzed as $\mathbf{W_{f\sim}}$, hence factored into *non-depleted* or the like; as it happens, other occurrences of *normal* are $\mathbf{J^{\sim}}$, hence equivalent to *not injected* or *not immunized.*

The grammar has a few one-argument operator-subclasses (in **W**), and a few three-argument ones (in **I, U, V, Y**), but mostly two-argument ones (in effect, transitive verbs). Each operator subclass can be defined by a list of members (especially if it has only one, up to synonymity), or by its arguments or operators, and also by the range of meaning common to its members. The sentence-types have subtypes, for the various subclasses. Some sentence-types also fall into families, on the basis of how they combine with other sentences: e.g. those which appear after **GJB:** or **GUT:** or **CIB:** (these are most $\mathbf{Y_c}$, **V**, and **W** sentences), in the macro-sentence-type **GJB:GUT:CIB:** *response* family. Sentence-types can also be placed in a family on the basis of having the same classifier, such as *respond* for most **V** and **W** (and possibly $\mathbf{Y_c}$) sentences. In the articles, different major sections (e.g. "Procedures" versus "Results") and different experimental questions introduce different families of sentence-types.

Two types of word classes in the sublanguage cannot be organized so easily into clear-cut subclasses. These are quantifiers within sentence formulas, and conjunctions on pairs of sentence formulas. The quantifiers are

expressed in a wide variety of English words or phrases, and their environmental properties may not suffice to assign them to just a few superscript subclasses. For example, *nothing speaks in favour of* (in *1.4* above) is a weakened negation, not quite a denial; but it is not clear what kind of weakening modifier to attach to the negation in this case. To discover if there is a particular set of quantifiers and negative operators distinguishable in the sublanguage, with particular probabilities and other modifiers on them, would require a large body of material. The situation is simpler, at least in the present sublanguage, with respect to modifiers which indicate the amount of time; this is a class with many members operating on the colon (which itself means 'thereafter'). Most of the other superscripts indicate science-specific word-classes such as *mature*, where if there is more than one member it is usually qua synonym. This is apparently the case even for the many words and phrases indicated by the superscript **r** (*have a role in*, *participate in*, etc.). The classification of words by their combinations show that all the words listed in *1* of Chapter 2 have a common function here, and the list of English phrases shows the meaning of this function: meta-science. One would not necessarily have thought that these words would constitute a special class, or that this class, with its meaning, would be an entity in the information of this science. But the class is revealed by the analysis, and it was important for the course of the investigation, and even for the process of antibody formation.

As with the quantifiers, so with the conjunctions (except for the colon), much more material has to be investigated before we can say whether the various English conjunctions used here can be collected into just a few classes of conjunction-words in respect to the present sublanguage. The grammar of conjunctions is a matter of what sentence-types are connected by what conjunction-words, what differences there are between the formulas which are paired under a given conjunction-word, and what hierarchies (operator-argument relations) appear among conjunction-words. Conjunctions can occur on any sentences, including such as contain other sentences. Both in the quantifiers and in the conjunctions it is not as yet clear whether for the present sublanguage, or for all science sublanguages together, there is a specifiable set of subclasses of conjunctions, quantifiers, and meta-science. If so, the broader English vocabulary is being used merely as a source of synonyms; this would mean that there is an organizable logic of scientific discourse. If not, then the semantic differences among the English words used are being kept as an open-ended set of meanings in the sublanguage material, as they are in English.

Finally, whether certain words, e.g. *indicates*, are to be taken as sublanguage conjunctions or as that plus a meta-science operator may depend on how we describe the systemic properties of the meta-science language.

The separation into meta-science and sublanguage, the possibility of subclasses being defined not only by their co-occurrence (environmental) differences but also by semantic or other definitions (made in the metalanguage), and the existence of synonyms within a subclass, are all due to the science language being a sublanguage of a whole natural language, e.g. English.

3.2. Discourse structure

The science-language is characterized not only by the grammar of sentences, but also (to a lesser extent) by certain properties of discourse structure. As in all discourses, certain sentence-types repeat, the repetitions containing different subclasses or words in one or another of the word-classes of the sentence-type, or having different modifiers (superscripts). Local recurrences of sentence-types are visible in the articles surveyed, but the present material was not sufficient for finding larger recurrence-patterns, in terms of the successive sentence-types and of the conjunctions between them. As among the Procedures, Results, and Discussion sections of articles, there were differences not only as to some sentence-types, but also as to typical patterns of sentence-type recurrence. However, many Discussion sentences are simply Result sentences arranged under particular meta-science operators which are characteristic of the Discussion sections.

3.3. Information processing

Mechanized processing of the information in the articles, in principle by computer programs, is made in principle practicable by projecting the sentences of the articles onto the formulas. The formulas represent transformational reductions and expansions which are paraphrastic to the sentence of the articles. Since the transformations used were selected to yield maximal alignment of word-classes, in maximal similarity of sentence-types, the formulas constitute a normal form for the information which is contained in the sublanguage word-classes and their sentence-type operator-argument relations. Identical information, and more generally similar information, is thus located in the same word-class positions of the same

sentence-types. On this basis it is possible to summarize, and to organize in one way or another, the information in the successive formulas, and to compare formulas in different parts of an article or in different articles (in the extreme case, to see if one formula negates the other). It is possible to answer questions about the information (since we know where to look for it), and even to make certain critiques of the information or its treatment (of which section *2* is an informal and episodic example).

The more difficult task, which may indeed prove impossible, is to find a priori ways of operating on the formulas so as to obtain useful results: for example, to be able to characterize sequences of formulas (with given conjunctions and given kinds of differences between successive formulas) which are sufficient to justify the last formula as a conclusion or suggestion from the first formulas. Something in this direction is already visible in the articles, where we can ask on what explicit grounds a sentence is being asserted, by inspecting the preceding sequence of formulas and their conjunctional and meta-science material.

4. Further work

The investigation reported here was designed to see if the facts and conclusions presented in a subscience had a characterizable relevant structure. The material that was covered sufficed to show a fact structure specific to the subscience. But a larger corpus of articles is needed if we wish to discover the structural regularities of the meta-science segments which operate on the subscience statements, and of certain superscript (modifier) classes such as quantifiers, and of reference, and of sentence-sequences with or without conjunctions. In these latter cases we are dealing with word-classes, and word-class sequences, which are largely not specific to the given subscience alone. Furthermore, in the case of sentence-sequences, especially the longer ones in which one conjunction operates on another, we have necessarily in our texts a much smaller population than the population of single sentences, so it is not surprising that a larger corpus is needed if regularities are to be discovered.

In the meta-science material we include the indications that a statement is being asserted, denied, questioned, considered to have some degree of probability, and the like. In the system of conjunctions and sentence-sequences (which can have a cohesion even without explicit conjunctions) we include both such sentence pairs as comparatives, and also longer

sequences such as causal chains and sequences that lead up to a conclusion. In all of this, "sentence" and "statement" refers to sublanguage sentence-types or formulas, not to the original sentences as they appear in the articles, for only in respect to the sublanguage structures is there any hope of finding sublanguage regularities in the meta-science material, or in the placing of quantifiers, or in restrictions upon reference. Such restrictions, which have not been found for the language as a whole, may be discoverable here for the position or maximal distance (in terms of sentence-types and their types of sequences) of a pronoun in respect to its antecedent, also for the hierarchies of conjunctions which are found in argumentation.

A major further problem is opened up by the finding that the Discussion section of papers is composed not of new sentence-types of its own (so to speak, theoretical rather than experimental), but of sentences from the Result section arranged in particular ways leading to conclusions which are largely of the same sentence-type. This, obviously, is distantly reminiscent of mathematical proof, where sequences of particularly-structured true or false statements, stringently ordered, determine the structure and assertability of a concluding statement. For various structural and semantic reasons, nothing approaching the power of proof is available in natural science. But the fact that conclusion sentences in science are related structurally to sequence of result sentences.

Such structural properties in an adequate corpus of articles in the subscience can certainly be investigated, once its sentence-types have been established. When there is such a corpus, with each article represented by a succession of formulas, we can look for various kinds of regularities. For one possible regularity, given a sequence of formulas all of the same sentence-type, we can investigate the way the successive subclasses in one position vary, especially in respect to the successive subclasses in another position of the sentence-type. Another possibility is to investigate the sentence-type variation within paragraphs of different kinds, and to see how an article is, in some cases, composed of successive subarticles.

One can also investigate how the boundaries between subsciences are reflected in differences of sentence-types and of formula sequences: for example, how these differ in articles which deal with the same problem but which follow different experimental concerns, or which use new ideas and methods. Examples of such differences have been seen in the present survey, but any regularities can be discovered only by finding many more cases of each situation.

Quite a different problem is to analyze articles in the same subscience but in various languages, in order to see how the common sublanguage of a science frees itself from the grammatical pecularities of one language or another. Such work has been done in the present survey, in the analysis of French articles presented in Chapter 7.

When enough additional work has been done in formulaic representation of sciences, it should be possible to formulate a priori procedures for carrying out such analyses of science reports. It should also be possible, at least in part, to establish procedures for processing the information in the formula sequences, and for operating on sub-sequences of formulas in a way that makes it possible to inspect their information or the conclusions drawn from them. In particular, it may be possible to carry out such analyses in real time: that is, to organize and inspect and criticize the information in the articles of a given research problem while work on the problem is going on, in a way that can be of use to scientists still working on the problem.

5. Toward the Grammar of Science

The most general results concerning the combinability of words in language are: first, that sentences have an operator-argument structure, whose informational interpretation is the speaker's assertion (or denial or disjunction) of fact; and second, that connected discourse has patterned recurrences of component sentences or sentence-types, whose interpretation is the act of discussion. Within these constraints there are additional restrictions on word-combinability in each subfield of natural science and mathematics (i.e. in "hard science"). These further constraints are that the word-classes of the language of the given science are locally closed, i.e. the list of classes and subclasses and class members are closed at any one moment in any one small field, though immediately expandable with any expansion of the field. In almost all of these sciences the elementary argument (roughly, noun) classes are closed; i.e. there is a closed set of classes, many of them having a closed set of subclasses or members (chiefly technical terms), with new words being defined upon entry. And the operator and modifier (secondary operator) classes are also, though less obviously, locally closed, the use of many English words here being synonyms for one or another of the subclasses. Quantity words, and in some instances time or other general semantic categories, may not be closed in respect to the given science (e.g.

any quantity word may occur in a given sentence position in that science); but these words are in the closed vocabulary of arithmetic or some other science of general application, which is in this respect a prior science to the given science. In contrast, in many sciences the conjunctions – both in their vocabulary and in their restrictions (as to which can operate on which) – do not seem to be closed or well-organized in respect to the particular science. Pending further analysis we have to accept them as just part of English grammar within the science reports, and not an organized part of that science sublanguage or of any prior science (logic). In mathematics, however the conjunctions (the binary operators on propositions) and their restrictions are an integral part of the science language; and to a more limited extent they are part of the science language also in those sciences where certain sentence-sequences are expressed by, or have to accord with, a quantitative system, for example in mathematical physics, or in the formulas for chemical reactions. At the other extreme there are fields in which many of the operator classes and even some of the argument classes are open to the stock of English words, in their general English meanings and combinations, in the same way that the conjunctions seem to be in the papers covered by the present investigation. This can hold not only for such fields as history, which can be written with little technical vocabulary, but also for example in law, where technical vocabulary and sentence types are standard but where words and sentences from the whole language can apparently enter at will. In such fields it may be impossible to represent, in a general way, the word-combinations of the original sentences by a fixed set of word-classes and subclasses and a fixed set of sentence-types. This means that it may be impossible there to mechanize a complete representation of reports as sequences of sublanguage formulas.

It may be expected then that, in all fields with locally closed word-classes and sentence-types, facts are given in a specific syntactic structure, and each fact can be represented in a computable way by a formula belonging to one of a small set of sentence types, often under a meta-science operator. In many cases, conclusion and opinion statements are structurally similar to, but not always identical with, the fact statements; they may appear at the end of conjunctional sequences (of fact statements), whose structure is not yet adequately known.

These properties are not only empirical results in one science or another, but are to be expected wherever the "hard science" conditions are met. This is because it is a general interpretive result about language that to constraints on word-combination, once they have been described in an

unredundant manner, there conform specificities of information. In the whole of language, the partial-order constraint which creates the operator-argument relation (sentence) can be interpreted as due to the predicational constraints inherent in information; and when language is used in a universe with additional contraints – a science – the language has corresponding additional constraints. Thus the closed set of word-classes in a science, and the closed set of sentence-types and individual formulas formed out of these, carry unique kinds of information, the information of the given science.

Each science-language is a sublanguage of the whole of a natural language because if we operate on the special sentences or sentence-pairs of the science-language with the operations of the whole language (e.g. *and*, reductions, or other transformations) we obtain again a sentence of the science-language. In addition, the sublanguage for a given science in one language is similar to the sublanguage for that science in another language, so that its status as a sublanguage of English, French, or the like, is not its main characterization. Indeed, we can consider the science-language vocabulary to be not the English or other words gathered synonymously into the science-language subclasses, but rather those subclasses themselves, written as symbols outside any natural language. The individual sentences of the science-language are then the formulas themselves. In that case it is no longer necessary to look upon the science-language as a sublanguage of some natural language. It can be regarded as a new kind of linguistic system, used identically by scientists of whatever native language – even if each scientist pronounces or writes the symbols or words in a natural language, e.g. English, of his own. This science-language has its own vocabulary (the subclass symbols) in its own word-classes, occurring in its own sentence-types, under a more general system of conjunctions and meta-science material. It is a linguistic structure which has arisen in trying to represent the information and constraints met with in a given science. As a system it is in certain respects intermediate between natural language and mathematics.

The grammar of each science sublanguage is not a subgrammar of the grammar of its whole language, since it has entities (e.g. word-subclasses) and operations (e.g. conjunctional restrictions) which do not exist in the whole grammar. It also is not a pure abstract system (such as a whole grammar is), because its classes are not defined solely by an a priori relation defined on them; instead, its elementary arguments are collected into particular classes by their relation to particular operator-classes. These

particular classes can be defined, or their members listed, in the meta-language of the science-language, i.e. in the whole natural language. Such an outside metalanguage is not available for a natural language as a whole, where the words and their interrelations are defined within the same language itself.

All of this is not to say that all science information is in the language of science reports. Everything that is in discrete symbols (e.g. formulas), or can be reduced to such without ad hoc judgments (e.g. many charts and graphs), is includable in the language information. But pictures and the full range of a scientist's observations and sensings are not. Furthermore, there is no direct evidence that the information in science reports is the same as the structure of the science itself (whatever that precisely means). Nevertheless, the nouns in the noun-classes name the objects studied in the science, and the operators refer to the relations and events in which they are perceived to be involved. The classifications of nouns and operators express the regularities of particular operators relating to particular nouns; in addition, some classes, especially in the superscripts, reflect primarily the perceptions of the scientists (e.g. in the case of superscript **r**). While we may consider reality and its records to be continuous, without inherently relevant aspects, the existing sciences have succeeded in descriptions and predications of reality by selecting relevant aspects and finding largely discrete characterizations (in words and symbols) for the entities and relations. It is this that we analyze here.

In addition, problems arise because science reports may contain errors in observation or argumentation, perceptions and motivations that distort the objective facts, and poor writing that distorts the intent of the author. Also, the writing uses shortcuts that omit whole areas of detailed fact. Thus papers 11 and 13 speak of cells producing plaques and rosettes, though in fact the cells produce antibodies which in turn occasion (or "produce") the plaques and the rosettes: we have $\mathbf{A_qV_pC}$, but not $\mathbf{A_qV_pA}$ (*Antibodies produce plaques*); one might argue that instead we should have $\mathbf{AV_pC}$ (*Cells produce antibody*) and $\mathbf{A_qX_pA}$ or the like (a new sentence-type for *Antibodies occasion the formation of plaques*).

Nevertheless, the sentence-type (and sentence-type sequence) structure of the reports is similar, in ways that have yet to be made precise, to the structure of data and theory in the science itself. The similarity can be increased by filling out and regularizing the report structure: in the case of the plaques, by moving $\mathbf{A_q}$ and $\mathbf{A_r}$ into a new class **R**, and replacing, e.g., $\mathbf{A_qV_pC}$ by the sequence

$\mathbf{AV_pC}$ *and* $\mathbf{RX_pA}$,

where $\mathbf{X_p}$ is a new verb class containing *cause formation* and the like. Such filling out of intermediate steps makes the observational report approach more closely the mechanism of the science. Indeed, $\mathbf{RX_pA}$ appears on occasion. In paper 13, 471.1.2, we have *Thus a cell could be producing and secreting enough antibody to produce a rosette or plaque without containing, at a given time, enough completed antibody to be detectable even by the sensitive electron microscopic anti-ferritin method.* Here *to produce a rosette* is grammatically reduced either from *for the cell to produce a rosette* ($\mathbf{A_rV_pC}$) or more likely from *for the antibody to produce a rosette* ($\mathbf{A_rV_pA}$, or better $\mathbf{RX_pA}$). The latter is made more likely also on textual parallelism grounds by the material following: *the cell contains enough completed antibody to be detectable*, where again two sources such as above are possible, but *for the antibody to be detectable* (from $\mathbf{AV_i}$, *antibody is present*, under **M**, *is detectable*) is much more likely than *for the cell to be detectable* (which would be $\mathbf{CW_i}$ under the same **M**).

Given the structure of fact-sentences and meta-science material, and the construction of argumentation out of sequences of selected fact-sentences under hierarchies of conjunctions, we have thus reached what may be called a grammar of science. Somewhat as the most unredundant description of language structure conforms to the predicational information carried by language, so devising a grammar which is just sufficient for a science-language may conform to the structure of information reported in that science. Each such grammar is specific to one subscience, with particular word-classes and sentence-types, under conjunctions and under meta-science operators. But there are similarities among the grammars of related subsciences, and less so presumably among the grammars of all sciences – if no more than that all presumably have particular word-classes and sentence-types. Many sciences have much the same conjunctional apparatus and meta-science operators; but those of mathematics have a closed subset of these. What is common to all of the science grammars must be common to all scientific information, and what is specific to a science or a subscience reflects the special kinds and conditions of information in that science. The operator-argument structure of sentences and the recurrence structure of discourses are included in the grammar of science, but not as special characteristics of science since they are common to all of language and reflect the structure of all information that is expressed in language.

It remains here to ask what are the boundaries of a science when we speak of a science-language. It is simply as much of the science as can be described with the same word-classes and sentence-types, i.e. the same sublanguage. It is true that various parts of a single article in a science may involve different word-classes or sentence-types, e.g. the Materials and Procedures sections, and occasionally some portions of a Discussion section. We can nevertheless declare that an article is a single report and that all its parts will be described in a single grammatical system. However, as has been noted, articles in a subscience may contain different classes and sentence-types due to different research problems or techniques, even though they are otherwise grammatically similar to the other articles. The weight of similarity will still make us include the divergent articles in the same subfield.

One problem is to determine when a subscience has changed into a new stage, or even a new subscience. In any field, later articles may differ partly from earlier ones, but within a very similar grammatical representation. Only when important issues have been settled or dropped, or when the understandings or research-problems have changed materially, do we get appreciably different grammars in the later articles of the field. Hence the question of how long a science remains the same science is to be decided by the weight of similarity versus divergence in the grammars of earlier and later reports in that science.

A more difficult question is the boundary between related sciences, whether parallel as between molecular and population genetics, or serial as between laboratory and clinical research in medicine. In these cases the grammars are quite distinct, though with a few points of similarity. But there are many sets of smaller and more closely related subsciences among which the grammatical similarities are more weighty. In any case, comparing the grammars provides an objective method for judging the boundaries and relations between subsciences.

There are also other inter-science relations which can be seen in the grammatical structures. An important case is that of one field being a prior science to another. This relation appears in more than one form. One was noted above, when a seemingly open set of quantificational phrases, drawn from the closed and structured set of quantifiers in arithmetic and in logic, occupy certain positions in the sentence-types of a science. Another form is seen, for example, in sentences of experimental medicine, many of which are made by an operator (*affect*, *reduce*, *initiate*, etc.) on two arguments, one a procedure, drug name, etc., and the other a sentence of physiology (or

a name of a body-part): e.g. a procedure or a drug has some effect on an organ or a physiological event. Here the sentences which are the second arguments of the operator are in physiology, which is thus a prior science (i.e. an argument-sentence) to the experimental-medicine field.

CHAPTER 4

SUBLANGUAGE FORMULAS AS INFORMATION UNITS

PRELIMINARY CONSIDERATIONS

A concern central to any grammar of a language is that of distinguishing those combinations of its elements which constitute the observed sequences. Clearly, not all combinations of elements occur; in English, the phoneme sequence /ls/ does not occur after pause, the word sequence *by at here* is not an admissible sentence. This redundancy, or departure from equiprobability of occurrence of its elements, is crucial for characterizing language structure, i.e. stating those combinations of its elements which can occur as against those which cannot. Natural language cannot avail itself of any external metalanguage to designate its elements or couch its description; the very possibility of constructing linguistic elements rests on the non-occurrence of various combinations[1]. It follows that the description of the occurences of a language can only be given in the same language (as a natural language, e.g. English contains its grammar in English as one of its sublanguages) or in another (as a grammar of French in English). The grammatical description already makes use of the same kinds of elements and of their possibilities of combination which are to be defined. Insofar as language structure is descriptively the resultant of a succession of constraints on possible combinations,[2] it is essential that grammatical statement of each restriction not contribute to the redundancy it attempts to characterize.[3]

In other words, we seek a description which 1) is *economical,* giving descriptive standing only to formally identifiable features which are not eliminable, or otherwise reducible to other formal features via stated paraphrastic methods, and 2) is *efficient,* in that it does not contribute to the restrictions on combinations and, in so doing, give descriptive standing to what is only an artifact of method. It follows that the objective in discourse and sublanguage analysis is not merely to provide a grammatical description of a given corpus or use of language; the approach throughout is to replace more restricted forms by ones of wider combinability. This may require redefining the elements or generalizing the operations established in the grammar, a procedure called "regularization."

Instances of regularization abound in the analysis of language. In the area of morphology, morphemes, as the minimal meaningful phoneme sequences, may be redefined so as to admit of, e.g., the addition of zero morphemes, as in the past tense of *cut* or the plural morpheme of *sheep*. The zero plural morpheme in *Whose sheep are these?* is recoverable on the basis of formal features in its environment, here, number agreement of the verb. In the domain of syntax, the decomposition of *who, which, whose,* etc. into two elements, a connective *wh-* (itself a variant of the semicolon operator) plus a pronominal element, permits a simplified statement of sentence structure, e.g., *John saw a man who bought a car* is describable as a primary *NVN* sequence connected by *wh-* to a secondary *NVN* sequence.

In operator grammar, many of the restrictions and subclasses are eliminable – or rather, transferred to being particular domains of reductions which preserve the information in a sentence. The residual restrictions (stated in terms of the base sentences) are the operator-argument depenences in the entry of words into the composition of sentences, with the relation of an operator to its argument(s) being simply interpretable as a predication. The transferability of restrictions to the domain of reductions, which are demonstrably paraphrastic, means in effect that these restrictions did not add to the information of the sentence. Generally, regularization is admissible only when it can be shown that restricted elements can be replaced under conditions which are stateable *a priori* and, moreover, that the eliminated restrictions did not add to the information content of the occurring forms.

Regularization over a discourse is based on the observation that in a discourse (as opposed to a 'random' collection of sentences), words in particular positions recur in respect to other recurring word (-sequences). The regularization consists in setting the sentences of a discourse into maximal similarity with one another. Here we proceed by determining how the predicational (or: partial order) constraint – which governs language in general – is satisfied in the corpus under analysis. The formulas provide a general statement of the dependences which constrain the combination of words. This is achieved by representing these dependences in a chosen alignment (normal form sequence) of the respective word classes. The transformational methods described in Chapter 5 help to establish a set of a few sentence structures in which the greatest number of occurring sentences can be 'housed'. Regularization reduces differences among the occurring sentences (word combinations) by showing them to be instances of one or more of a small number of common forms. As these transformation-

al methods are paraphrastic, a statement of the residual restrictions on word combinations – those not eliminable by regularization – provides a formal expression of the information content of the occurring sentences. It is in this sense that we claim the formulas give an informational representation of these sentences.

Some theories of the semantics of natural language proceed from a supposition contrary to that advanced above. These approaches to meaning in a natural language L are "translational" in that they require the resources of a prior metalanguage L″ of expressive power strong enough to characterize each sentence of L in unambiguous terms and pair it with its metalinguistic equivalent in L′. Here, the operative assumption is that the meaning of a sentence can be given by stating the conditions under which it is true. More particularly, the procedure takes the form of assigning semantic values (*true,false*) to the sentences of L by means of semantical rules formalized in L′. In the case of a language or theory utilized in the course of an ongoing inquiry, the assumption of a prior language and a prior interpretation is not to the point. Such assumptions make the labor of scientific inquiry wholly gratuitous. Indeed, in view of the experimental finding that certain cells termed "plasma cells" are further developmental states of certain 'other' cells termed "lymphocytes", one should be wary of positing any simple and direct correspondence between linguistic entities and their purported real world or semantical counterparts. A requirement to be placed upon any plausible account of the semantics or meaning of the language of a particular field of science is that it should take cognizance of the grammatical processes by which the resources of a language are adapted for the expression of new meanings, i.e. how the language changes in response to new experimental findings. But on the fixed interpretation view of semantics, the lesson is lost that new meanings arise in grammatically specifiable situations and are the product of a particular experimental (and so discourse or sublanguage) environment.

In *1* of Chapter 3, it was shown in what way the formulas obtained by the analysis are to be regarded as informationally representative: the formula structures changed in ways corresponding to known changes in methods and results within the subscience. The first two sections of this chapter present various details regarding the structure of the formulas – their linear form (*1*), and the interpretation and significance of the superscripts (*2*). The status of the formulas as informational units makes possible a number of investigations of the organization of information in these articles. For example, the term *response* is employed as a classifier of

various sublanguage sentences, where its classificand sentence(s) in each occurrence may be grammatically determined *(3)*. The next section *(4)* presents the correlations among operators (sentences) classified by *reponse* in respect to their role in "argumentation". Questions can then be raised – in terms of the formulas – concerning the detailed nature of the response, for example, the relations between cellular and ultrastructural functions and change. Finally, we consider here the possibility of operators such as *change* acquiring classifier-status in the later ultrastructure articles. Details of the use of particular word-set homonymities (e.g., the occurrence of *immunized* in the J word class, and of *immune* in A) provides an illustration of the development of science terminology *(5)*. Alternative analyses available for particular sentences may point to instances in which related sciences impinge upon the subfield or new results are at hand *(6)*. Further, the process of ongoing change of meaning can be identified even where the new meanings are still unstable or not yet fixed; this is the case, for example, with the class of terms designated as the *r* modifier *(7)*.

1. Normal Form Linearity: Projection and the Use of the Arrow

Once a word sequence which is all or part of a text sentence S_i has been segmented into word subsequences, i.e., the members of the established word classes and the local operators upon these (if any), a mapping [4] can be defined which projects each subsequence of S_i (perhaps present in only zero form) onto its position in the conventionally fixed linear order of word subsequences as they appear in the tables. The image of this mapping, the projection of S_i, is in "normal linear form". This term is used to characterize both the linear order of word subsequences within the units (i.e., elementary sentences) under the projection of S_i, as well as the linear order in the case of the conjunction by : of two or more elementary sentences – the "macro-sentences" of Chapter 2, section *6*.

As an illustration of the former use, the word sequences *antibody production by lymphocytes* in S_j, *the production of antibody by lymphocytes* in S_k, and *lymphocyctes' production of antibody* in S_l, are all represented in the projection (*of* S_j, S_k, S_l) by the same left-to-right normal linear form:

[of] antibody | ['] [the] production [by] | lymphocytes [←]

which receives the formulaic index $\mathbf{AV_pC_y}$ mirroring the linear order. Here, the single vertical bars indicate the segmentation of the analyzed word sequence of S_j (S_k,S_l) into the various subsequences of the established word classes and subclasses. The square brackets – adopted only for illustration of this example – enclose the actual variation of morphemes in the three sequences, while the bracketed arrow is a scanning instruction to read the segments of the projection right-to-left so as to obtain the linear order of the words in the text (see below). With the use of the leftward pointing arrow [5] and one of the relinearization transformations of chapter 5.2, this projected form yields three readings corresponding to $S_{j,k,l}$

i) *antibody production by lymphocytes* corresponding to S_j

ii) *of antibody the production by lymphocytes* corresponding to S_k

iii) *lymphocytes' production of antibody* corresponding to S_l

Similarly, the elementary sentence types are assigned a normal form linear order in the projection which places the word sequence indexed as **GJB** (or as **GJ** or **J**) to the left of the special conjunction marked off by double vertical bars and indexed by colon. To the right are positioned the various "response" sentences. To give a simple example, the word sequence *after the second injection of antigen plasma cells massively proliferate in the spleen* in S_i is projected in normal form as

iv) antigen | the second injection of || after ← || plasma cells | massively proliferate | in the spleen

Corresponding to the order of the normal form, this projection receives the formulaic index $\mathbf{GJ^2{:}C_zW_p^+T_s}$. In this case, following the convention that there are no other scanning instructions for the projection (see "Reading Instructions", in Appendix 1), the row is read beginning with the material indicated by the rightward arrow and a reading of the projection is obtained which captures the linear order of words in the text sentence.

Adopting the normal form linearity convention enables us to identify as instances of one sentence type, those word sequences containing words established as belonging to the same word classes, independently of the linear order of the words (*modulo* sublanguage transformations) as they actually occur in the text. Examples i) – iii) above show that the normal form word sequence represented by AVC assimilates word sequences otherwise representable as **VAC** and **CVA**, while iv) regularizes a word

sequence representable by

$$:J^2GC_zW_p^+T_s \text{ as } GJ^2:C_zW_p^+T_s.$$

In general there are three cases to be considered in positioning the words of a text sentence in normal form sequence. In the first, no departure from the linear order of the word sequence occurring in the text sentence is involved. This is the case in i) and iii) above. Note that the left-pointing arrow (stating "read segments right-to-left from this point") merely allows the linear order of the text to be replicated in the normal form sequence.[6]. In the second, only changes in the linear order of the word sequence as it appears in the text sentence are involved – this is seen in ii) above. These changes are restricted to those effected by the relinearizing transformations discussed in Chapter 5.2. Finally, in the third case, there are changes (either reductions or their reconstruction) in the actual phonemic shape of the word sequence. These are the remaining sublanguage transformations of Chapter 5 and summarized in Appendix 3.

2. Local Operator Modifiers

The environments which serve to distinguish the members of the various (gross) word classes and subclasses serve also to isolate and characterize the different local modifiers operating upon them. These operators are "local" in the sense that they do not introduce an independent subject into the sentence. Semantically, the local operators restrict, specify or otherwise modify the reference or meaning of their host (i.e. argument). Syntactically, they are derived via a secondary sentence conjoined by *wh-*. They are indicated in the formulas if there is a formal basis for their identification, that is, recurrence and a distinquishing environment. In the formulas, they are symbols superscripted to the right of the major (nominal or verbal) category symbol.

While these modifiers can be decomposed into secondary sentences, in the present work decomposition was adjusted to the objective of maximizing the informational (i.e., grammatical) relations representable by a single formula or some conjunction of these. In practice, this meant decomposition of modifiers was usually implemented only where it was required to obtain an instance of an existing sentence type.

2.1. Modifiers of argument (noun) categories

Among the modifiers of certain nouns (members of the **S, C, T** classes) are included words of the **W** class which, in other of their occurrences, are the main (highest or latest entering) operator upon the noun. Occurring as main operator, they are, together with their noun argument, an elementary sentence. We find *large* occurring as the main operator on *the cells* in *the cells were large* (from 4,1.3.5.), a $\mathbf{CW_g}$ instance of the **CW** elementary sentence type. Under the condition that a further operator enters the sentence upon that noun, they become modifiers or adjuncts of the noun (which becomes their host). For instance, *large* occurs as a local modifier of *cells* in *the presence of large cells (in these cultures)* (from 7,12.2.1) where *cells* is under the higher operator *presence (in)*. The modifier *large* is included in the noun segment of the projected sentence (here as a left modifier); in the formula, the subscript indicating the **W** subclass to which the word belongs is written as a right super-script to the noun word class symbol, $\mathbf{C^gW_iT^u}$.

Similarly, *mature* occurs (intransitively) as the main operator on *the cells* in *the cells were fully mature*, $\mathbf{CW_m^+}$ (from 6,164.3.4). However, *mature* is a local modifier of *plasma cells* under the higher operator *found to be present* in *mature plasma cells were found to be present in large numbers* (from 6,164.5.3), which is indexed $\mathbf{C_z^{m}W_i^+}$.

Noun modifiers which are not of the W class are regularly reconstructed as secondary sentences. Notable among these are occurrences of the hyphenated compounds *antibody-producing*, *plaque-forming*, *rosette-forming* as modifiers of *cells*. Despite the semantic property which these share with other modifiers, viz., that of serving to 'name' their host under the conditions of a higher operator upon that host (thus the latter two receive abbreviation as *PFC* and *RFC*), these have in all cases been transformationally decomposed via *wh-* into a secondary sentence appearing as a lower row of the projection. For example, *rosette-forming cells... had the same cytoplasmic components* (from 13,453.2.1) is reconstructed as *cells... had the same cytoplasmic components* with appended secondary, *which cells are forming rosettes*. (For details of this decompounding see chapter 5.3.)

With the exceptions (discussed below) of (a) the special, referential, case of nominal superscripts attached to nominal categories, i.e., $\mathbf{A^G}$ and $\mathbf{T^B}$, and (b) the quantifiers, all of the symbols superscripted to nominal categories are either **w** (marking the *wh-* relative clause) or carry the subclass designation of a **W** operator. This is the case even if the **W** operator does not

occur in the body of the texts as a main operator (in the situation of there being no later entering operator on its host), and so does not, with its argument, comprise an elementary sentence type. Thus, *lymphoblast* (in 11,164.4.3), *plasmablast* (in 13,470.2.1), indexed $\mathbf{C}_{\mathbf{y}}^{\mathbf{b}}$, $\mathbf{C}_{\mathbf{z}}^{\mathbf{b}}$ respectively, are roughly derivable from *lymphocyte/plasmacyte in the blast stage of development* which, if it occurred, would receive the index $\mathbf{C_yW_b}$ / $\mathbf{C_zW_b}$. Similarly, *afferent lymph* (as in 7,2.2.6) receives the index $\mathbf{T}_{\nwarrow}^{\mathbf{t}}$ from *lymph flowing to* (or: *entering*) *the lymph node*, $\mathbf{T}_{\nwarrow}\mathbf{W}_{\mathbf{u}}^{\mathbf{t}}\mathbf{T_n}$.

In cases where there are two modifiers of a word, these are represented in the formula by writing the superscripted symbols designating the category of the modifiers in the order of their entry upon the host word and seperated by a comma. For the host word *lymphocytes* in *cells typical of small, inactive lymphocytes occurred only in rosettes of uninjected animals* (from 13,451.5.1), the order of modifiers is given by the intermediate form *cells typical of lymphocytes which are inactive occurred...; said lymphocytes are small*, indexed $\mathbf{C}_{\mathbf{y}}^{\mathbf{a}\sim,\mathbf{g}\sim}$.

2.2. Referential superscripts

The **G** in $\mathbf{A}^{\mathbf{G}}$ and **B** in $\mathbf{T}^{\mathbf{B}}$ indicate cases of local operators (rather than modifiers) upon the host nominal category. In each, the superscript represents a word of a designated word class which is the second argument of a (possibly zeroed or reduced) transitive verb and which has referential relation to its respective counterpart occurring in an environing **GJB** (or **GUC/T**) sentence. With $\mathbf{A}^{\mathbf{G}}$ this verb is *specific to* which has a word of the **A** class and a word of the **G** class as its ordered arguments. On the basis of the referential relation between the two **G** occurrences, we can reconstruct the **GJB** sentence together with the conjoining **:** operator (which may also be reconstructed on other grounds). Thus *no antibodies to influenzal virus were found... in lymph nodes* (from 5,204.2.5.) is from *no antibodies specific to influenzal virus were found... in lymph nodes* which is represented by $\mathbf{GJB{:}A^{G}V_i{\sim}T_n}$, where **GJB** represents the reconstructed (from a previous occurrence) sentence *influenzal virus was injected into the foot pad of rabbits*.

$\mathbf{T}^{\mathbf{B}}$ indicates an operator of the $\mathbf{W_i}$ subclass (*present in, from*, etc.) selecting *tissue, body*. Here again the superscript indicates that the body term is referential to an occurrence of a body term in a conjoined **GJB** sentence. This notation is especially helpful in the analyses of paper 1 where some findings presented are based upon the different contents of agglutinin in

lymph glands on the injected as opposed to the uninjected side of the animal. In many of these cases, the **GJB** sentence is conjoined by *wh-* in the colon position, as in *no agglutinins were demonstrable in the extract of the nodes on the side injected with diptheria toxin* (1,792.3.4) which, upon transformation, is represented by $\mathbf{GJ^{2}B{:}AV_{i}{\sim}T_{n}^{B}}$.

2.3. Modifiers of operator categories

Right superscripts to the categories **W, V, Y, U, I, J** indicate modifiers of either the operator itself or of a possibly zeroed modifier of that operator. These include:

(a) the quantifiers and adjectives specifying amount operating upon (often zeroed) broad selection quantity nouns which occur in a *PN* phrase modifying the verb. In these cases, the superscript represents a word which does not directly operate upon the verb but on a word in a phrase modifying the verb. For example, *an increase in the total number of lymphocytes in the efferent lymph from that node* (from 5,204.2.1) is represented by the formula $\mathbf{C_{y}W_{i}^{\uparrow}T_{\not{n}}^{f}T_{n}}$. Here ↑ represents the operator *increase* upon the phrase *the total number* which, as a modifier (in nominalized form) of the $\mathbf{W_{i}}$ verb *(present) in*, does not receive explicit representation in the formula on the grounds that these modifiers have high likelihood of occurring in this position (i.e., under an "appropriate" operator such as *increase*, cf. chapter 5.3).

(b) Words operating upon the operators of (a). These are the various forms of the comparative, *more (than)*, *-er (than)*.

(c) Prepositional indicators marking the argument requirement of a given subclass of verbs. For instance, the superscripts **f** and **t** in the formula $\mathbf{C_{y}^{g}I^{ft}B_{2}B_{1}}$ represent the prepositions *from*, *into* marking the ordered arguments $(\mathbf{B_{2}},\mathbf{B_{1}})$ of the **I** verb *inject* e.g., ... *by injecting small lymphocytes from other rats of the same highly inbred strain (into such rats)* (transformed from 10,303.2.2).

(d) Preverbs, discussed below.

In addition there are ordinal or other ordering modifiers of aspectual time modifiers of an operator (i.e., of a sentence). These include, e.g., *first*, *second*, *primary* on members of **J** and, in several instances, on members of **U**, as well as *first*, *early*, and the like on colon (chapter 5.4).

These local operators do not occur independently of their verbs and, by this fact, are not candidates for elementary sentences. To take the example given in chapter 1.3.2 *lymphocytes act as anitbody producers* (from 3,128.3.1) is not decomposed into two sentences conjoined by *as*, *lymphocytes act* and *lymphocytes produce antibodies* since *lymphocytes act* does not otherwise occur as an elementary sentence. By taking *act as* as a local operator upon the verb *produce*, these two sentences can be collapsed into a single structure which is given the formulaic index $\mathbf{AV}^{\mathbf{r}}_{\mathbf{p}}\mathbf{C}_{\mathbf{y}}$, with superscripted **r** representing *act as*.

A list of the different operators which receive representation as right superscripts to a verb category is given in Chapter 2, section *4*. It remains only to note several details regarding the employment of a certain class of these O_{no}.

2.3.1. Preverbs

Among the local operators are two distinct groups of O_{no} operators; the first consists of the aspectuals e.g., *begin*, *stop* (superscripted as **b**, **s**) while the second is the class of words and word sequences indexed by the **r** superscript. Both of these groups may be considered as preverbs (in the sense of GEMP 6.50) in that they have the preverb property of the high-likelihood of their first argument being either the same as the subject of the sentence which is their second argument or in a relation which selectionally restricts this subject. On these grounds, the subject of the argumented sentence is often obligatorily zeroed as redundant: e.g., *the lymphocytes began to proliferate in significant numbers* (from 6,164.4.1) is reduced from *the lymphocytes began their proliferating in significant numbers.*

In other occurrences, the aspectual O_{no} may have a second argument which is not the verb itself but a modifier of the verb such as *increase.* This happens, for example, when the higher subject is a nominalized sentence, as is *antibody content* in *the antibody content had begun to increase* (from 4,1.3.4). Here, the nominalized higher subject is not agentive, i.e., *antibody content* is not interpretable as being the agent of its own increase. In these cases a derivation through *state* or some other noun-like operator on a sentence can be given; the example cited, for instance, can be derived from *antibody content had the state of antibody content's beginning to increase* (GEMP p.302).

2.3.2. The r operator

This class of O_{no} occupies a special place in the present corpus, both with respect to the semantic qualification they impose upon the assertion of the sentence which is their second argument and as regards their standing as metascience classifiers or variables (*7*). Grammatically, they are distinquished from the other O_{no} by the fact that a different selectional relation obtains between their first argument, the higher subject, and the subject of the sentence which is the second argument, viz., these are related but it is unlikely that they are identical. Thus, *the lymphocytes constitute a factor in antibody production* (from 3,122.1.1) is not readily interpreted as 'the lymphocytes constitute a factor in their producing antibody', unless some distinction can be drawn between those lymphocytes that constitute a factor and those that produce. An idea as to the nature of this selectional relation can be gathered from the observation that the nominalized verb (almost always a member of $\mathbf{V_p}$) in the argumented sentence usually has a strong nominalizing suffix (e.g., *-tion* in *production*). This suggests that *antibody production* in the above example is obtained from a weaker *-ing* nominalization, e.g., *the situation/process of something's producing antibody*, which, under the O_{no} becomes *antibody production* with the appropriate nominalizing O_{no} *situation/process* reduced to the *-tion* suffix. The indefinite *something*, as subject of *produce*, is employed in the reconstructed form only to suggest that the subject of *produce*, whatever it is, has a particularly close relation to the higher subject of the O_{no}, *the lymphocyte*, a relation which permits the subject of *produce* to be zeroed on grounds of low information. Whether this subject is specific, e.g., *the lymphatic system* or more general, e.g., *the body*, etc., it can be viewed as something in which lymphocytes either are included or from which lymphocytes cannot be seen as completely distinct.

3. The Classifier 'Response'

The specialized vocabulary of this subfield of a science includes words, such as *response*, which occur as classifiers of certain sentences and, perhaps, ordered sequences of these. Classifiers can be distributionally distinquished as occupying the grammatical position of their classificand. The semantic relation of a classifier to its classificand is largely definitional; the precise statement of the definitional relation, however, may only be fully

specified in a prior science or as 'background knowledge', and assumed as 'tacit' in the subscience under investigation. As a shorthand or means of abbreviation, classifiers naturally find a wide employment in the science language as a species of pro-form, referring to and occupying the grammatical position of, their classificand sentences, i.e., as 'replacements' of them. Since the precise conditions governing the employment of classifiers – specifying, e.g., the sentences which are their intended referends in each occurrence – are but rarely stated in the text of a scientific report (an exception is paper 8,49.1.3, cited below), their usage may initially seem inherently ambiguous. Despite some recognizable (and perhaps intentional) indeterminacy in usage, it is in many cases possible to identify formal criteria, i.e., differences in grammatical environment, which distinguish the classificand sentence. In so doing, we are able to represent an occurrence of a classifier word in the formula as the word class sequence (elementary sentence type) of its classificand; as mentioned in Chapter 3.3.1, this is equivalent to "factoring" the classifier morphemes into those of its classificand.

That *response* classifies various sentences characterizing a process or sequence of events is clear from sentences such as (8,49.1.3): *The response consists of cell multiplication, cell differentiation and the concurrent synthesis of a specific protein, antibody* (representable as: *concurrently* $\mathbf{CW_p}$, $\mathbf{SW_c}$, $\mathbf{AV_p}$). In other sentences, it is apparent that *response* classifies a particular sentence and not a conjunction of sentences, e.g., (9,67.4.1): (*the appearance of*) *the plasma cell family is a specific response to antigenic stimulation* where *reponse* operates directly on the $\mathbf{C_zW_i}$ structure. On the other hand, *response* has occurrences, as in *antibody response* (from 10,306.5.2) where it 'replaces' the operator of its classificand sentence, and refers only to a sentence of the **AV** type. A general diagnostic for determining the intended classificand of *reponse* in many of its occurrences was found to be based upon the following considerations.

First, the range of usage within particular articles may be restricted (although such restriction is usually not explicitly stated) to classifying only one type of sentence. In paper 10, for example, nearly all occurrences of *response* have *immune*, *hemolysin*, *antibody* as (left-modifier) cooccurrents. Since these latter are all members of the word class **A**, which otherwise occur as arguments only of operators of the **V** class, [7] the classified sentences are of the **AV** type. Treatment of the remaining occurrences of *response*, e.g., (10,306.4.1): *no response that could be measured by the tanned red cell hemagglutinin technique*, can all be assimilated to the clear **AV** cases

or can be resolved on more indirect grounds (e.g., treatment as referentials, rarity of other candidate classificand structures such as **CW**, **CYC** within the wider grammatical environment).

In some articles the usage may more or less be directly stipulated, often in an initial sentence, as in the example from paper 8 cited above or the following one from paper 4 (1.2.2): *Characteristic of the so-called secondary response is a more rapid onset of the reaction and a more prolific formation of antibodies* transformable into *a more rapid onset of the reaction and a more prolific formation of antibodies is characteristic of the so-called secondary response* where *response* classifies both **CW** and **AV** sentences. Given a stipulation of this kind in a particular text (which is not revised or otherwise modified in that text), it is then possible to analyze a text sentence containing a **CW** structure and the postulated **AV** one, e.g., (4,1.2.3): *In a previous paper the present writer, taking advantage of the more extensive reaction connected with the secondary reponse ...*

There are also papers where, although the intended reference of *response* may vary in its different occurrences, certain differences in immediate (i.e., operator-argument) and wider (i.e., under a conjunctional relation) grammatical environment serve to specify a classificand sentence for each occurrence. For example, its occurrence under **r** operator (see 7), which in our corpus is restricted to the $\mathbf{AV_p}$ – environment, indicates an $\mathbf{AV_p}$ classificand: (9,67.2.2) *the cell type responsible for this limited response.* In (11,167.6.1) the immediate and wider grammatical environment independently determine the same classificand: *Various attempts have been made in the past to find a role for the two cell types in antibody formation, the lymphocyte perhaps being involved in the primary response and the plasma cell in the secondary* where not only the occurrence of *response* under **r** (*being involved in*) but also its occurrence in a wider environment containing an $\mathbf{AV^r_pC}$ occurrence, (*a role for the two cell types in antibody formation*), justify the factorization of *response* as $\mathbf{AV_p}$.

There are also occurrences of *response* where no particular sentence type or subclass designation can be inferred from the grammatical environment, either immediately or otherwise, and where there is no textual support for a particular assigned factorization. In these cases, the use *response* can be taken as to refer to a process of largely unspecified events which occur subsequent to antigenic stimulation.

4. Correlations Between W and V Operators

The present work does not include a detailed analysis of the different conjunctions or conjunctional operators (with the sole exception of :) on elementary sentences. Some preliminary observations can nonetheless be made, which in addition to illustrating the recurrence of certain patterns of sentence sequences across several of the articles, also call attention to significant correlations between (sentences containing) **W** operators and (sentences containing) **V** operators. The interest in drawing attention to these aspects is two-fold: to exhibit a bit of the characteristic structure of argumentation in terms of which inferences were drawn as to the cell type producing antibody and secondly, to give an illustration of how the intervention of new techniques, i.e., electron microscopic observations of antibody-producing cells, present a further dimension in the reported course of events constituting the cellular response to antigenic stimulation.

A conspicuous feature of these 14 articles is that the various conclusions regarding cells thought to be antibody producers were in many cases based upon establishing correlations and connections of different kinds – sequential, temporal, causal – between the two main types of "response sentences" i.e., those with **V** and those with **W** operators. Before the wide employment of electron microscopy (papers 11-13) or sophisticated fluorescence techniques for detecting specific globulins within individual cells under light microscopy (papers 8-9), the 'paradigmatic' form of the **W-V** correlation in these papers was in establishing a relation between histological changes in the cell population in a section of a particular tissue (**CWT**) and the titer (concentration) of antibody in extracts of that tissue ($\mathbf{AV_iT^x}$) as determined by various staining techniques. Paper 3, for example, is concerned to establish the relation of plasma cells to the production of antibody ($\mathbf{AV_p^rC_z}$) by determining, in hyperimmune animals (**GJ^{3}B**), the antibody contents in extracts of pelvic or renal fat tissues ($\mathbf{AV_i\ T_k^x}$). The tissue extracts were found to exhibit a strong proliferation of, or were rich in, plasma cells ($\mathbf{C_zW_p^+T_k^x}$, $\mathbf{C_zW_i^+T_k^x}$). The authors note (121.1.3) that the degree of plasma cell proliferation ($\mathbf{C_zW_p}$) appears proportional to the concentration of antibody protein ($\mathbf{AV_i}$) and that tissues such as thymus ($\mathbf{T_t}$), known to importantly lymphocytopoietic ($\mathbf{C_yW_p^+T_t}$), contained little or no antibody ($\mathbf{AV\text{-}_iT_t}$, $\mathbf{AV_i\tilde{}T_t}$) after hyperimmunization (128.6.1; 128.7.1). Moreover, the cell population was only 10 per cent lymphocytic in antibody-containing renal fat tissue whereas this tissue was rich in plasma cells ($\mathbf{C_yW_i^-T_k^w}$ $\mathbf{AV_iT_k}$ and $\mathbf{C_zW_i^+T_k}$; 128.8.2). Concluding, they state that (129.1.1) they

have not found indications of production of antibody by lymphocytes but that both earlier and present results point to plasma cells as the producers of antibody (AV_pC_z). In its essentials, this argument is duplicated for the case of splenic tissues (T_s, T_d, T_f) in papers 4 and 7.

As the research problem which is the subject of these articles was resolved by the finding that a single cell line (but with lymphocytic and plasmacytic stages) produced antibody, the individuation and naming of the various cell stages which could be distinguished was of prime importance. Given this outcome, the names of the various stages, rather than designating truly 'different' entities, are perhaps less misleadingly thought of as abbreviating certain characterizations of the morphologically different stages. With the advent of new techniques (e.g., plaque formation), individual cells could be identified as antibody-producing – even if, (somewhat paradoxically, in light of the previous assumptions that an antibody producing cell must demonstrably contain antibody) they could not be identified as antibody-containing. Under the electron microscope which greatly heightened the threshold of observation, examination of these antibody producing and secreting cells gave new detail to the morphological description of cellular ultra-structure. In this way it becomes possible to see that a cell's transition into another cell can, in fact, be more accurately depicted as consisting in specifiable changes along a number of distinct ultrastructural parameters. Thus the grammatical characterization of this transition ($C_1Y_c^tC_2$) is, in effect, a sort of short hand or "classifier" of the various degrees and kinds of ultrastructural changes (**SW**). We have here the basis for reducing the Y_c operator to some conjunction of C_1**SW** sentences, with C_2, as appended meta-scientific designation for the conjoined CSW sentences (as suggested in chapter 3.2).

The accompanying chart (Table 1) presents the basis for such a correlation with data from the 3 electron microscopy papers (11-13) in our sample. The rows with Y indicate the different cells as named in the 3 articles; these range from the small lymphocyte ($C_y^{g\sim}$) and lymphoblast (C_y^b) on the left to the mature plasma cell (C_z^m) on the right. The top half of the table specifies histological change (**W**) across eleven ultrastructural features. All symbols here are interpreted at the end of this volume.

Most notable are the changes in the three endoplasmic reticulum rows, marked S_r, S_r^h (channels of endoplasmic reticulum) and S_r^s (cisternae of endoplasmic reticulum). For example, we can see that the endoplasmic reticulum of the small lymphocyte ($C_y^{g\sim}$) is characterized as rough (W_r) in paper 11 while that of the medium-sized lymphocyte (C_y^{g-}) is similarly

Table 1

S_r—S_c														$W_i^>$	
S_b—S_r	W_i^+		W_i^+		W_i^+				W_i					W_i^-	
S_b—S_c	$W_i^>$		$W_i^>$	$W_i^<$	$W_i^>$	W_i^+	W_i^+	W_i^+			$W_i^\downarrow$				
S_r^s								W_i^-				W_w		$W_w^\uparrow$	
S_r^h					$W_{w\sim,y\sim}$	$W_{w\sim}$	$W_w^{\Delta,-}, W_y^>$				$W_c^>$				W_y
S_r	W_r	$W_{w\sim}$	$W_{i,w}^-$	W_r	$W_{i,r\sim,w\sim}^+$			W_y^-	W_c	$W_{p,w\sim}^+$	$W_i^\uparrow$	$W_g^>$			
S_c	W_n	$W_{w\sim}$		$W_{c,w}^>$											
$S_{g\sim}$	$W_{g\sim}$	$W_{g\sim}$								W_m					
S_p				W_m^-											
S_u	W_g			W_g				W_g							
S_n	W_e	W_e						W_g		$W_{e\sim}$					
	$C_y^{g\sim}, C_y^b$		$C_y^{g\sim}$		C_y^g					C_z'					paper 11
		$C_y^{g\sim}$		C_y^{g-}		C_y^g	$C_y^g Y_c C_z^b$				C_z^b		C_z^m		paper 13
								C_b	$C_b Y_c C_z^b$			$C_z^b Y_c C_z^{m\sim}$	$C_z^{m\sim} Y_c C_z^m$		paper 12
S_v, S_r			V_i^-												
S_r^h					$V_t^\sim$	V_t					$V_t^>$	V_i			
S_r^s												V_i			
S_r									V_i					V_i	V_t
S_p								V_i, V_p^b	V_i			V_i		$V_i^\sim$	
S_c														V_i^y	
S_g								V_1						V_i^y	

characterized in paper 13. But whereas paper 13 reports small lymphocytes only with endoplasmic reticulum which is not widened ($W_{w\sim}$), paper 11 indicates some small lymphocytes having small but widened amounts (W_i^-, W_w). We note also that channels of endoplasmic reticulum are first reported (in paper 11) in the large lymphocyte; these are not widened ($W_{w\sim}$) and not parallel or lamellar ($W_{y\sim}$). Cisternae are first reported in the endoplasmic reticulum in the hemocytoblast (C_b) in paper 12.

Further, it may be seen that certain transitions between cell stages are correlated with particular specifications of change in the endoplasmic reticulum. Thus paper 13 reports the transition of the large lymphocyte to the plasmablast ($C_y^g Y_c^t C_z^b$) as marked by various and small degrees of widening ($W_i^{\Delta,-}$) in the channels of endoplasmic reticulum (S_r^h), together with a more parallel orientation of the channels ($W_y^>$), whereas paper 12 shows that the transition of the cell termed there the "hemocytoblast" to the stage termed "plasmablast" is marked by change (W_c) in the endoplasmic reticulum. Finding a comparability of this kind in which a commonly recognized cell-stage (the plasmablast) is stated to arise from differently named cell stages (in 2 different papers), via a process of change which is similarly characterized, raises a question of the relation between the cell stage named "large lymphocyte" and that named "hemocytoblast". Inspection of the ultrastructural descriptions of these two stages in the different papers suggests the possibility that they are more appropriately noted as one cell stage.

The lower half of the table similarly indexes the cell stage, and its ultrastructural components with the V group of operators, in particular with antibody content (V_i) or storage (V_t). Of particular interest, perhaps, is the specific mention, in paper 12, of the perinuclear space (S_p) of the hemocytoblast (C_b) as the place of orgin of antibody production (V_p^b).

The increasingly fine level of ultrastructural description, as e.g., represented in Table 1, also may be seen as giving a more precise content to certain of the W operators on C such as W_c (*change*, *differentiation*, W_a (*reaction*, *active*), and even W_m (*mature*) and the negative form $W_{m\sim}$ (*immature*). Here it is interesting to observe that these highly phenomenological or imprecise terms which are 'born' at the level of light microscopy in order to describe or otherwise characterize states of processes not further intelligible at that level of observation, can be viewed as placeholders or incipient classifiers of the more refined description of cellular ultrastructure later available through electron microscopy. It seems quite possible to suppose that replacements of this kind, i.e., of one form of discourse by

another which is grammatically more articulate (as indicated, for example, by the appearance of new subclasses), are one way of gauging when and at what points a science or subscience has changed, or is changing, and may even indicate where further changes are likely to occur.

5. Sublanguage Homonymities

The usage of *immune*, *stimulate*, *sensitize* and their homonymities presents a situation common in the development of terminology in various sciences. A survey of the articles shows that these words and their morphological derivatives fall in various of their occurrences into different word (sub) classes. The occurrence of *immune* and related words both in **J** ('inject') and **V**, of *stimulus* in **J**, **U** (and **:**), and of *sensitize* in both **J** and **U** suggests that the **J** occurrences, usually referring to antigen injection, be seen as proleptic, forward-looking expectations as to the sequence of events attendant upon an injection. Such expectations may be assured by the use of controls. These words were available for use at a stage when detailed knowledge of the mechanism of production was not and later are used with more specific meanings even at the cost of homonymity.

(A) In article 1, *immunity* occurs in the word-class position of A in *the possible relationship of collections of lymphoid cells to the production of immunity* (803.2.1). In *immunity reaction* (802.2.2), *immunity* is represented by $\mathbf{AV_p}$ ('antibody production'). Use of *immunity* to refer to antibody is also found in a late review article (14,579.2.1).

Immunization depending on the environing word classes refers in some of its occurrences to antibody production and in others to the injection. In 1,803.1.4 *the lymphatic system participates in the processes of immunization*, *the lymphatic system* is in **T**, and *participates in* is the **r** operator discussed in *4.2* and further below. The text sentence is accommodated within the established sentence-types by the formula: $\mathbf{AV_p^rT}$, in which *the processes of immunization* receives the index $\mathbf{AV_p}$ (see also 802.3.1 and 803.4.3 of the same article). In contrast, *immunization* in *on immunization with several antigens simultaneously* is **J** ('injection') (from 3,128.4.2).

Immunized, in the bulk of its occurrences, generally as adjectival on *animals*, etc., refers to the injection (**J**) and receives modifiers of a similar informational character to those on *inject*, e.g. *non-* (2,297.3.6), *highly*

(3,121.1.4), *primarily* (10,316.2.7) – the modifiers are symbolized as ~, **3**, and **1**, respectively.

(B) The next family of words to be considered includes *stimulate*, *stimulation*, and *stimulus*. In many of their occurrences, these words clearly refer to the injection. In 9,67.3.3 *this stimulus* is a referential to *a second injection*; in 9,69.2.1 (not in the tables), *following antigenic stimulation in the rabbit* is an instance of **GJB**. Within the same article, there occurs *suspensions made from once-stimulated lymph nodes* (62.2.3) and in article 14, *antigenically-stimulated node* (from 579.2.5). In these cases, with a $\mathbf{T_n}$ argument, *stimulated* is assigned to the word-class represented by **U**. The word *stimulated* also occurs with a **C** argument in a sentence (not included in the tables): *undifferentiated cells ... were perhaps not stimulated* (from 9,68.3.2).

In the nominalized form, *antigenic stimulation* (see 8,49.1.1; 9,62.2.1; 9,66.1.2, and passim), it is not clear whether *stimulation* should be assigned to **J** or to **U**. In the tables, it is generally represented by **J** as *stimulation* occurs with $:_t$ or with *response* both of which have environing **GJB** in other occurrences e.g., *the plasma cell family is a specific response to antigenic stimulation* (from 9,67.4.1).

In 14,574.2.2 *stimulus* is used in the word-class position represented by colon: *the administration of antigens ... is also a powerful stimulus to the formation of immature plasma cells from reticulum cells* (see also 9,66.4.3).

(C) The pattern of occurrence of the word *sensitize* and its kin in these articles is quite interesting. In *after intravenous injections of horse serum into rabbits sensitized to this serum*, *sensitized* (*to*) occupies the position of the word-class $\bar{\mathbf{J}}$ (in the context **G—B**) and receives the index $\mathbf{J^1}$ (from 4,1.2.3). In 4,1.3.1 (not in the tables), we have *The animals were sensitized by means of subcutaneous injections of horse serum.* This may be analyzed by the formulas $\mathbf{GJ^1B}$ *by means of* **GJB**). It is unlikely that this is intended as a repetitious statement, in which case other occurrences of the word may provide indication of a more appropriate representation. In other occurrences (discussed more fully below), *sensitized* occurs with members of the **C** word class, e.g. *the changes undergone by sensitized lymphocytes* (from 14,585.3.1). This suggests that *senstized* in the previous case may be represented by $\mathbf{U^1}$ as in 'the animals whose cells were sensitized by means of subcutaneous injections of horse serum', represented by **GJB:** $\mathbf{GU^1C^B}$.

As illustrated by the first example, *sensitize* in some of its occurrences refers to the primary injection ($\mathbf{J^1}$). In 10,307.2.1, we have *with a second injection ..., the sensitizing injection having been given 3 weeks earlier. Sensitizing* here (and in similar examples, e.g. 10,306.4.3 – not in the tables) may be aligned with other occurrences by representing *the sensitizing injection* with the formula **J** *wh* $\mathbf{J^1}$**: GU** ('injection which causes/prompts sensitization'); the modifier on **J** is recoverable by the sequence of tenses. Such regularization of usage, if in conformity with intent, shows in what ways tacit information is recoverable on grammatical grounds.

Sensitized occurs with *lymphocytes* ($\mathbf{C_y}$) as its argument in ... *if primary immunization contributed specifically sensitized small lymphocytes to the total lymphocyte pool* (from 10,316.4.3 – not included in the tables). Two questions arise here: 1) the representation of *sensitized* and 2) that of *specifically*. Given the preceding discussion, the answer to the first question is $\mathbf{GUC_y^{g\sim}}$. It should be noted, however, that the context permits a $\mathbf{C_y^{g\sim}W}$ formula – that is, it may be unclear whether the change in the cell as a result of antigen reaching it is also referred to by *sensitized*. In this case, *sensitized* may cover the sequence $\mathbf{GUC_y^{g\sim}{:}C_y^{g\sim}W}$.

If *specifically* is taken with **G** and **C** arguments, then it occupies the blank in the context **G__C**, in which case it receives the index **U** – to speak of lymphocytes' being sensitized is to imply that they are specific to the antigen.

6. Extending Sublanguage Grammar

In the following two cases there is a choice between housing certain text sentences within the established sentence structure or extending the grammar to new sentence types. This corresponds to points at which new problems may be emerging in the field or related sciences impinge upon the discussion.

(A) Consider the following sentence from article 5: *The enlargement of the node is due to lymphocytic hyperplasia which is at first diffuse and then becomes organized into the characteristic follicular structure* (204.2.2). *The enlargement of the node* presents no difficulties and receives the index $\mathbf{T_nW_g}$. The sequence *lymphocytic hyperplasia* may be factored into the free-standing form: 'increase in excessive numbers (or: above normal numbers) of lym-

phocytes'; it receives the index $\mathbf{C_yW_i^{\uparrow}}$. If, however, *lymphocytic hyperplasia* is taken as an argument of a higher order (**W**-like) operator-*diffuse*, we have a new sentence-type in which *diffuse* is a higher operator on the $\mathbf{W_i^{\uparrow}}$ operator-*plasia*. Similarly, *becomes organized into* would be an operator with *-plasia* as its first argument and the *characteristic follicular structure* as its second.

There are two options available if we wish to accommodate the sentence within already established sentence types; these correspond to considering *lymphocytic hyperplasia* as a process-nominalization ('the process of increasing...') or as a product-nominalization ('the product of increasing...'). In the former case, *diffuse* could be taken as a manner adverbial (local operator) on *plasia*: 'increases in excessive numbers diffusedly'. Alternatively, *diffuse* can be analyzed as a predicate referring to the resultant distribution of lymphocytes (an operator with *lymphocytes* as its argument). The latter analysis is suggested by *becomes organized into*; only in special circumstances could one speak of a process of increasing being organized into something. In this case, both *diffuse* and *becomes organized into* are **W** operators, intransitive and transitive respectively, with (*many*) *lymphocytes* as their first argument ($\mathbf{C_y}$). Extending the range of sentence-types may point to the sentence's special standing in respect to a related science (histology).

(B) In the following case the sentence is describable in terms of the available formulas though it is identifiable grammatically as presenting a new relation among the distinguished word-classes. In *an antigen molecule can impose a complementary surface pattern on an antibody molecule* (from 9,68.1.3), *an antigen molecule* falls into **G**, *an antibody molecule* into **A**. The sentence is thus describable as an instance of the formula **G:A**, with *can impose a complementary surface pattern on* occupying the colon position. The other operator which occupies this position in these articles is *specific* (*to*). The assignment of *specific to* to the colon position is made on the basis of (in analogy with) the frequently occurring sentence-type **GJ:AV** (as in 'after injection of antigen, antibody was formed'). While *specific to* is clearly related to other members of the colon word class, it should perhaps be represented in terms of some other word-class, say **Q**; this, as *specific* in all of its occurrences connects two arguments (it is an O_{nn}), whereas other members of **:** relate two sentences.

Contra *specific* which has some member of **A** as its subject, e.g. *antibody is specific to antigen*, in the sentence above, **G** appears as subject. *Specific to* is an inverse member of the **:** word class. The operator *can impose a complementary surface pattern on* might be represented as a colon (without inverse), if in that position there was a colon case of *specific to*, as in the non-attested *antigen is being specific to antibody*. In that case, the operator could be represented with G as its subject. The absence of such instances suggests that we are dealing with a new sentence-type, in which case some other formula is to be provided. The new sentence-type here is known to point to a problem related to the one considered in these articles which was subsequently resolved – namely, the mechanism by which antibodies 'recognize' their specific antigen molecule. The sentence under discussion refers to the (subsequently abandoned) "instructionist" hypothesis according to which the antigen "instructs" the antibody as to the configuration the antibody molecule should take in order to bind the antigen molecule.

7. Information Structure and the '**r**' Operator

As an illustration of how the formulas may be worked with in order to probe developments within the articles, it is of interest to consider the **r** operator. The local operator **r** discussed above in section *2*, has special standing in respect to the structure of information in the articles. In many of its occurrences **r** is distinguishable as a sort of meta-scientific classifier. Like the negative, another O_{no} operator (*I deny that S*), a sentence under a particular **r** operator is not asserted – to say, for instance, that a cell-type is associated with antibody production does not mean that the cell is in fact the site of production. Paticular members of **r**, e.g. *has a role*, *is related to*, occur elsewhere in English as O_o classifiers, e.g. *"Hamlet" is a famous role of Olivier*. Even in those instances where this is not the case, e.g. the semantically slightly more specific *is reponsible for* in *the lymphocyte is responsible for antibody production*, it is nonetheless clear, on semantic grounds, that **r** (in the example given) classifies an as yet unspecified relation between the lymphocyte and the synthesis of antibody. We may present these cases in schematic form as: '$\mathbf{C_1}$ **r** $\mathbf{C_2}$ production of antibody; $\mathbf{C_1}$ may be identical with $\mathbf{C_2}$'. In the case where $\mathbf{C_1} \neq \mathbf{C_2}$, there is some relation **Y** which links the two **C**. This sublanguage relation **Y** may, of course, be internally quite complex. [8] Determining the exact nature of this

relation for various of the candidate cells was pivotal in resolving the problem of the cellular source of antibodies.

In the earlier articles in particular, the **r** operator figures prominently in introduction and discussion sections where differing views are presented and commented upon. The **r** operator occurs with **T** as its first argument in article 1 and infrequently thereafter. Beginning with article 3, a particular **C** argument, e.g. $\mathbf{C_y}$, appears regularly, and in article 11, we encounter the formula $\mathbf{AV^r_pS}$. The appearance of these different first arguments corresponds to the development of increasingly more sensitive methods of observation by means of which particular ultrastructural components were eventually linked with the synthetic process (*4.4*).

Given the above, we would look to changes in the character of words occupying **r** position, as well as to neighboring formulas, as an indication of the ways in which this indeterminate relation can be specified. That is, just as transitions within the field are identified above by the occurrence of **r** with new first subjects, e.g. the members of **S**, so may sentences analyzable in terms of **r** or some (perhaps new) sublanguage formula point to areas in which the science is extending itself.

This is illustrated by the two examples below:

> i) *the induction of antibody formation by immunocompetent cells* (from 11,162.2.5)
>
> ii) *these small lymphocytes, now "conditioned" (also sometimes termed "committed" or "primed") to respond to their secondary stimulus* (in 14,583.3.4)

Both *competent* (in *immunocompetent*) and "*conditioned*" (likewise "*committed*" and "*primed*") can be analyzed as occupying the position of **r**. The sequence *immunocompetent cells* can be factored as *cells competent to produce immunity*. [9] Example (i) might be represented by the sequence of formulas: $\mathbf{AV^b_p}$, $\mathbf{AV^r_pC}$ – 'cells competent to produce immunity induce formation of antibody'. However, we can semantically distinguish *competent* as more specific than other members of **r**; correspondingly, *immunocompetent cells* refers in the wider context to cells which have a particular property whether or not they have been changed or have been acted upon and not to the (generic) name of a cell-type. Also, contra other **r** occurrences, *competent* is a dispositional predicate of the cells; [10] *immunocompetent* appears in left-modifier position (adjectivally) on *cells*, indicating its status as a likely

modifier of cells, [11] but we hardly encounter *responsible cells* (with **r** occurring adjectivally).

Is there a distributional basis supporting these semantic judgments? It would appear that there is. A survey of the formulas reveal that, while other occurrences of **r** cooccur with particular cell-types as subject (indeed, *the cell type* appears as subject of **r** in 9,62.2.1 and several other sentences), *competent* occurs with unsubscripted **C**. [12] As *competent* has a distributionally distinguished environment we can set up a local operator α. Here **r** has been specified, at least in part, as α.

We noted, in *3* above, that *respond* is a classifier of **AVC** and **CW** sentences; in example (ii), "*conditioned*" may be treated as a member of **r** with *respond* symbolized $\mathbf{AV_p}$, or "*conditioned*" may be indexed as a local operator on a **CW** sentence. In the tables of the Appendix, the latter is chosen since the sentence later specifies the response to be *presumably the production of plasma cells* – a joint representation is also possible. As indicated by its passival form, "*conditioned*", e.g. being in a state of something conditioning the cell, like *competent*, refers to a property of particular cells (*these small lymphocytes*). Alternatively, we can analyze *these small lymphocytes are now "conditioned" to respond* (with "*conditioned*" an O_{no}) as a reduction of *these small lymphocytes are now "conditioned" that they should respond.* The argument-indicator *that... should* has *for... to* as a variant; upon zeroing *they* as identical with the higher subject *these small lymphocytes, for* is also zeroed. Note that this analysis preserves, via the futurative reference of *should* (GEMP 6.4) the dispositional character associated with the phrase "*conditioned*" to respond. In an expanded form, then, "*conditioned*" would occur as an operator on *these small lymphocytes* (*that* appearing in the tables in the conjunctional position preceding three bars). This can be represented within the available sentence-types as **CW** (with a new subclass designation for **W**), 'cell is in a conditioned state'.

Another possibility is to treat "*conditioned*" on a par with *competent*, i.e., as **r**-like but not **r**, assigning it the index β and leaving open the nature of its relation to α. Within the body of material analyzed here, examination of the formulas merely suggests a relationship between α and β and does not provide any further specification. In fact, it is known on independent grounds that $\alpha \neq \beta$; that whereas "conditioned" cells are immunocompetent, immunocompetent cells need not be conditioned. [13] The relation of immunocompetent cells to "conditioned" cells and of both to the production of antibody can be roughly depicted in terms of existing sublanguage structures as follows:

$\mathbf{GJ^1{:}GU^1C_y^w{:}C_yY\ C^w}$

$\mathbf{WH|||\ AV_p^{\alpha}C_y\ WH|||\ CW^{\beta}}$

('following first injection of antigen, antigen is taken up by lymphocytic cells which are immunocompetent; i.e., capable of responding to a specific antigen; upon uptake of antigen, these cells become "conditioned" cells')

$\mathbf{GJ^2{:}\ GU^2C_y^w{:}\ C_yY_c^tC_z^w}$

$\mathbf{WH|||\ CW^{\beta}\ WH|||\ AV_p^{+}C_z}$

('upon their second stimulus, these lymphocytes, which are "conditioned", respond chiefly by the production of plasma cells, which produce antibody in large amounts')

With the examples of *competent* and "*conditioned*", we can see a way in which **r**, and – through **r** – the relations for which it is a placeholder, are specifiable within sublanguage formulas. As with **r**, the dispositional character of α and β would lead us to expect informational changes in terms of the words occupying **r** position and in terms of the sentences which are conjoined to sentences containing **r** or '**r** – like' operators. For example, such changes may be evident in the findings, outside the immediate concern of these articles, of functionally distinct lymphocyte types, **T** and **B** cells.[14]

As suggested by the last remark, this inquiry can be advanced a step further. Note that the β (or α) operator, as **r**, does not specify the relation **Y** of our schema above: cells competent (or "conditioned") to produce antibody needn't be those cells which produce antibody. A **Y** relation is however hypothesized in the following passage from article 10:

> *These speculations rest on the assumption that small lymphocytes participate in primary responses by generating the cells which eventually synthesize antibody. If this assumption is false then the only alternative is that small lymphocytes transfer some antigen – conditioned material to other cell types. There are only the vaguest precedents for such a mechanism* (317.3.1–3)

In the first sentence, the **r** operator, *particpates in*, is connected via the instrumental *by* to a (sub)-sentence analyzed as $\mathbf{C_y^g{\sim}Y_cC}$ 'small lymphocytes generate the cells'. These cells are those which synthesize antibody ($\mathbf{AV_pC}$), which yields the (informationally represented) temporal sequence $\mathbf{AV_p^rC_y^g{\sim}} \rightarrow \mathbf{C_y^g{\sim}Y_c^tC{\rightarrow}AV_pC}$. In the next sequence, however, a new **Y**-like

relation is indicated: *small lymphocytes* ($\mathbf{C}_{\mathbf{y}}^{\mathbf{g}}{}^{\sim}$) *transfer some antigen-conditioned material to* ($\mathbf{\bar{b}Y}_{\mathbf{x}}$ *other cell types* (**C**). In the tables, this sentence has been accomodated within existing structures by an **AVCC** representation: 'antigen-conditioned material is transferred from small lymphocytes to other cell types'. In cases like this expanding the corpus might well provide grounds for a more definite analysis.

NOTES

[1] For instance, the restrictions on combinations of phonemes enable us to distinguish morphemic segments. More generally, all linguistic elements are characterized in terms of their mutual cooccurrence in discourses – referred to as "the Saussurean principle" in Henry Hoenigswald, *Studies in Formal Historical Linguistics*, Dordrecht, Reidel, 1973.

[2] In operator grammar, there is, for instance, a likelihood constraint operating within the partially-ordered dependence of operators and arguments in a sentence.

[3] An instance in operator grammar would be the multiple classification of a word in respect to its operator-argument status, "class cleavage" (Leonard Bloomfield, *Language* New York, Henry Holt, 1933, p. 204.) e.g., of *walk* as both transitive and intransitive; the apparent O_{nn} status in *The nurse walked the patient* is derived from a sentence containing a causative operator in which *walk* has O_n status.

[4] The function $p_E x$: X→ X/E, where X is the set of text sentences analyzed, and X/E, the quotient set of X by E, is the set of elementary sentences out of which X is generated, i.e., X/E = the set of all equivalence classes of the elements (word subsequences) of X = {K| K * X and K = yEx}.

[5] Note also that the leftward arrow instructs only that the segments be read right-to-left; the words within each segment are read normally, left-to-right.

[6] Our employment of the leftward pointing arrow in the tables of the Appendix follows from the choice of a normal linear form, the requirement that transformational departures from the form of the text be minimized, and a policy of reading the segments of a normal form representation contiguously (either left-to-right or right-to-left). In particular, it does not indicate a normal form relinearization of a word sequence in the text. In this respect its function differs from that of the arrows ('→' '(←') in the tables of the French articles. These are assigned the different task of indicating a linearization of the segments of a row of the projection which yields a reading that may or may not be a relinearization of a word sequence in the text.

[7] Words of the **A** class also occur as arguments of the **Y** operator which is restricted to operating on two arguments of the same word class.

[8] That there is some relation between the two subjects (the higher $\mathbf{C}_1$ and lower $\mathbf{C}_2$) including the possibility of identity, is what is meant by stating that **r** does not introduce a non-independent subject into the sentence (cf. Chapter 5.2).

[9] *Produce* is reconstructed in a parallel fashion to the example (9,68.3.6) discussed in section *4.4.2* of chapter 5. For *immunity* as occupying the position of **A**, see *5*.

[10] This dispositional feature indicates why *competent*, like other members of **r** does not assert the cells' production of antibody.

[11] See GEMP 5.32-3.

[12] There are some cases in which this is questionable. 9,66.4.1 has *the cells responsible for synthesis of antibody* but specifies them as *members of a family* (**C**$^{\checkmark}$). In 10,316.2.5, we have *the secondary response is mediated by cells*, where these cells are contrasted with cells mediating the response to primary injection, which are small lymphocytes (i.e., can be withdrawn from a thoracic duct fistula). In 12,113.5.5 *the cells involved in the synthesis of antibody* are again *immunocompetent cells* (113.5.2). 14,573.3.2 speaks of *the actual cells concerned in the process* (of antibody production), *the actual cells* here being variable, rather than definite. If these cases cannot be accommodated to the claim of a distributional distinction, the argument can be judged on the weaker, semantic, grounds provided.

[13] As distinguished, e.g., in N. R. Rose, F. Milgram, C.J. van Oss (eds.) *Principles of Immunology*, New York, Macmillan, 1973, p.64.

[14] For a discussion, see H.N. Eisen, *Immunology*, in Davis, Dulbecco, Eisen, Ginsberg, and Wood, *Microbiology*, second edition, New York, Harper and Row, 1974, pp. 456 ff., or more recently, in B. Benacerraf and E. R. Unanue, *Textbook of Immunology*, Baltimore, Williams and Wilkins, 1979, chapter 5.

CHAPTER 5

THE APPARATUS OF SUBLANGUAGE TRANSFORMATIONS

INTRODUCTION

The use of transformational methods to obtain sublanguage formulas, while new to linguistics, presents less of a novelty than might first be thought. This is seen in respect to both point of origin and method. Historically, transformations were arrived at by examining the dependence between the successive sentences of a discourse. The dependence consists in the recurrence in particular positions of particular words (or word-sequences) within the word classes of the successive sentence structures. Transformations, in their initial formulation, are a relation between sentences preserving selection (normal range of cooccurrents). In subsequent characterizations, including the operator grammar discussed in Chapter 2, and further below, transformations state a paraphrastic relation between sentences. The restriction to semantical notions concerning the equality (paraphrase) or difference among sentences is what has been called "weak" or "differential" semantics and does not entail any hypostatization of "meanings" (Henry Hiż, "The Role of Paraphrase in Grammar," *Monograph Series in Languages and Linguistics*, No. 17, 1964).

As to method: the current investigation presents another stage of research into the regularities of word combination – here over a set of research articles (discourses) in a specific field of science (sub-language). Within the domain of this sublanguage, where vocabulary and possibilities of word combination are limited, the application of various transformations yields a compact description of the sublanguage in terms of recurrent (families of) sentence types. Together with subclass- and adjunct-designations, these sentence types constitute the sublanguage formulas which have a definite standing in relation to the information carried in these articles (for further discussion, see Chapters 3 and 4).

The sublanguage transformations enter into the analysis as follows. In establishing repeating sequences of word classes (each sequence forming a sentence type), these transformations may be applied to one or another of the text sentences so that the words in that sentence have the same

grammatical relations to each other as they do in other sentences. Restrictions in the sublanguage, which allow for the setting up of sharply defined word (sub-) classes (that is, excluding certain word classes in particular grammatical positions) permit us to define other transformational reconstructions in respect to the partially similar sentence types. A few simple instances of realigning sentences by transformations are given in a–c (where the elementary sentence type is given in parentheses):

a) *Proliferation of plasma cells increased in the renal fat* is transformed into *Plasma cell proliferation increased in the renal fat* (**CWT**).

b) *The effectiveness of free ribosomes in the synthesis of protein was demonstrated* is transformed into *Of free ribosomes the effectiveness in the synthesis of protein was demonstrated* (**AVS**).

c) *Injection of horse serum was intravenous* is transformed into *Horse serum was injected intravenously* (**GJB**).

The sublanguage transformations presented in this chapter satisfy the conditions for a regularization of texts. All are a priori specifiable and hence apply to any given text sentence fulfilling the structural requirements of the transformation. Moreover, the transformations (as may be seen in the examples above and as discussed in detail below) are parapharastic (see discussion in Chapter 4 Introduction). While the analysis is thus a controlled one, it should be noted that a first approximation to our results is obtainable by purely semantic judgments of paraphrase. A set of sentences so related will intersect with those paraphrases establishable by transformational means.

1. A Preliminary Survey of Sublanguage Transformations

Operator grammar, briefly described in Chapter 2, analyzes and derives sentences in terms of two operations on word occurrences. These are the entry of words into a sentence and reduction of words carrying low information. Words are distinguished as operators and arguments of various kinds. There are indicators of argument status (e.g. *that*, *that*... *should*, *-ing*) and of operator status (*-s*).

The partial ordering of word entries (most entries are morphologically simple, affixless, words) does not uniquely determine the linearly ordered word sequence which is the sentence: at each stage, the entering operator – whose argument requirement is satisfied by words which are the previous entries – is positioned in a linear relation to its arguments. In English, an operator is normally placed ("said") after the word which is its first argument and before any others, e.g. for *John, fish*, which satisfy the requirement of *eat*, we form *John eats fish*. But other linear arrangements of the words are also possible. This happens, for example, when, as 'topic' of the sentence, the final argument (with its modifiers, if any) is placed in front position before the first argument: *Fish John eats*, *Three day old fish John never eats*. Since the point of departure is the original text sentence, the operations of *2* below are technically relinearizations, although text sentences and their counterparts in the tables may, in the absence of other transformations, be regarded as variant mappings of the basic partial ordering. Unlike the reductions addressed below, the relinearizations do not alter the phonemic shape of the words in a sentence and may present less of a burden in mechanical processing of the texts. Moreover, the relinearizations change only what element is regarded as the 'topic' of the sentence, but otherwise preserve its substantive content. Nonetheless, use of the relinearizations results in some cases in what may be felt as a stilted or archaic style. For example, the sentence (article 4, 10.1.3) *In culture fluids, where small pieces of spleen tissue had been kept, the presence of varying amounts of antibodies could be demonstrated* has been aligned into an **AVT** sentence type, as *of antibodies the presence of varying amounts could be demonstrated in culture fluids, where small pieces of spleen tissue had been kept.*

The other operation is the reduction of a word entering into a sentence, or of a word which is – in most cases – the immediately prior entry. These reductions, largely optional, are defined on operator-argument pairs, taking place as the operator enters. They take place on the condition that the entering word or its prior entry has high likelihood of occurrence in respect to the other or else broad selection (a word's normal range of cooccurrents is called its "selection"). Reductions necessarily leave a trace, which ensures a formal control on the system of reductions, while the likelihood condition enables the reduced sentences to be established as paraphrases of their unreduced counterparts. Below, we survey the types of reductions employed in the analysis.

In reduction of a word to zero, the trace consists of the absence of that word (or sequence) when its presence is required by the operator-relations

of neighboring words: the word which has been reduced to zero phonemic shape is thus recoverable. Section *3* discusses zeroing on the basis of repetition and *4* the range of zeroings on the basis of low information.

All cases of repetitional zeroing involve the reduction to zero phonemic shape of the second occurrence of a word (or word-sequence) when that word occurs in particular positions in respect to its antecedent. Under *and* and *or* the second of two occurrences of a word (along with its modifiers, if any, provided they are the same for both occurrences) may be zeroed if these occurrences occupy parallel positions in their sentences. This parallel position is not only in respect to linear order of words in the sentence but also in respect to their partial entry order in the composing of the sentence (Z.S. Harris, *A Grammar of English on Mathematical Principles*, 2.5, 3.4.1, hereinafter cited as GEMP). In *This experiment served to demonstrate the early appearance of agglutinins in the regional lymph nodes and serum* (from article 1, 789.4.1), the trace of the zeroing is the absence of the required argument (a sentence) for *and*. Here the sentence is expanded to ... *and the early appearance of agglutinins in serum.*

A text sentence can be transformed by reconstructing occurrences of words in zero phonemic form ("unsaid") on grounds that these word occurrences had a high likelihood of occurring in a particular stated situation (environment) and so had made little or no informational contribution to their sentence. These low-information zeroings are wide-spread in language, and are always reconstructible from a trace of their phonemically zero presence in a sentence. As they involve reduction of a word (or words) under the condition of high likelihood of occurrence rather than under stated identity with a previous occurrence, these zeroings can be recognized apart from repetitional zeroing.

Two types of low-information zeroing can be distinguished, generally corresponding to whether the conditions of "appropriateness" (high likelihood) are statable in terms of the grammar of the language as a whole (GEMP) or only in terms of the additional restrictions on word combinations characterizing the special sublanguage in the given science. In the former case, there are zeroings of words which either are unique within their grammatical environment ('constants' such as *than*, *as*) or which have broad selection within the language as a whole (*amount*, *number* in *The cells increased in the nodes*). In the latter, the sharper selections in the sublanguage permit specification of word classes and subclasses not identifiable with the grammar of English. They concomitantly yield grounds for reconstruction of words which have a high likelihood of occurring in a particular

sublanguage environment. A commonly encountered case is the reconstruction of *to the injection* or the like in the environment of specified "response" sentences (chapter 2.6) e.g., *Antibody appeared in the regional lymph nodes*, where the lymph nodes are regional in respect to the site of injection.

To obtain recurring informational units, a text-sentence is often decomposed into a 'primary' sentence with one or more appended secondary sentence – this operation is discussed in *5* on the relative clause. If the text-sentence contains as a result of relative clause formation (and related reductions), a secondary sentence which conforms to the established repeating sentence types, the relative clause is indicated as a conjoined secondary sentence. To take a simple example, in the text-fragment *antibody-containing vesicles are abundant in immature plasma cells* (article 12, 112.5.6), the secondary sentence is *vesicles contain antibody* (**AVS** sentence type) and is conjoined by *WH* to a 'primary' sentence *vesicles are abundant in immature plasma cells* (of the **SWC** sentence type).[1]

Finally, we include among the sublanguage transformations (below) the large-scale restructurings of a text-sentence brought about in various denominalizations, the passive, and the causative (*6*). Some can be formulated as a product of several reductions (e.g., the passive *6.2*). Others, marked *, involve a known transformational relation between sets of sentential forms, but whose conditions of application require further study. Section *7* discusses the treatment of comparative constructions and *5.8* that of the quantifiers and the negative.

A summary of the major operations used in obtaining the tables is presented in Appendix 3. The relinearizing operations and reductions are collectively referred to as "sublanguage transformations". Most of these are derived from the grammar in GEMP. Some of the linearizations and passive-related reductions, while in conformity with that grammar, require further specification of their domain. Lastly, there are the operations established specifically in this sublanguage – these include particular appropriate zeroings and the other special sublanguage transformations mentioned in Chapter 1.3.3.

These latter two are noted in the summary by an asterisk. Each of the operations is provided with an abbreviation to facilitate reference to the notes in Appendix 3. These notes present an extensive listing of the sublanguage transformations applied to the original text-sentence along with a discussion of specific cases.

In the sections below (and again in the notes), the recast sentences of the tables are often referred to as "projected sentences", reconstruction of zeroings is called "expansion." Certain of the sublanguage transformations are formulated in terms of the more familiar categories – noun (*N*), verb (*V*), tense (*t*) placed in some situations on the carrier *be*, adjective (*A*), adverb (*A-ly*), conjunction (*K*) – the relation of these categories to operators and arguments is discussed in GEMP (Chapter 4). Aside from examples which clearly have been chosen for general expository reasons, all examples are from sentences of the texts. These are occasionally excerpted from longer text-sentences so as to focus more closely on particular grammatical features; all of the examples are provided with a citation indicating the article number, page, paragraph, and sentence, e.g. 1, 789.3.2 refers to article 1, page 789, paragraph 3, sentence 2 (the paragraphs counted include any from a previous page). Within the discussion of particular examples, the '→' is used informally to indicate the course of reduction. In contrast, the '→' in the summary of sublanguage transformations (Appendix 3) relates sentences of particular sentential forms; a right-directed arrow relates sentential forms in the text (on the left) to those in the projectd form (on the right). A bi-directional arrow indicates that sublanguage transformations in either direction are performed.

Not covered in the present investigation are the various reductions to pronoun, producing, e.g., *they*, *the latter*, *the former*. Replacement of referentials by their antecedents is noted by 'Repl'. In Chapter 7 a procedure, adequate for the French material, is described by which the anaphor for referentials is decided. Section *9* discusses some possible directions for further regularization of the texts.

2. Relinearization

Alternative linearizations of a sentence S_1 may yield an acceptable paraphrase S_2 or, at least, a sentence which is recognizably informationally equivalent to S_1. The sole constraint on relinearizing the sequence of words constituting a sentence is that the resulting linear order of words preserve the partial ordering of the oriented semilattice representing the dependence relations of the words of the sentence (GEMP 3.1). Within this restriction imposed by the grammatical theory, various linearizations of a sentence can be viewed as alternative, with preferences for one as opposed to

another being seen as matters of style (including 'topic' and 'focus') or customary usage.

In obtaining the "normal form" linearity (chapter 4.1) of the segments of the projection, a general policy has been to favor preservation of the actual phonemic shape of the words occurring in the text sentence, changing only their linear order. The relinearizing transformations discussed below are adopted to this end. Each of the word sequences transformed by relinearization could have been transformed by other means, producing the same normal formal form alignment but with the difference that the output of the latter may be in a more familiar or standardly encountered style. This is shown, for instance, by the possibility of transforming *the presence of antibodies in blood serum* to *antibodies have a presence in blood serum* (or further to *antibodies' presence in blood serum*) as opposed to the relinearized form *of antibodies the presence in blood serum*. The interest in using the relinearizing transformations to as wide an extent as possible resides in the demonstration that, by applying to many word sequences of the text only certain relinearizations – which, by preserving the dependence relations of words, violate nothing in grammar and are largely available in English as a whole – we are able to obtain further instances of the elementary sentence types while at the same time minimizing use of reductions whose domain and conditions of application have to be stated and, in certain cases, are quite complex.

In view of the discourse analytic goal of deriving an alignment of a text (or sets of texts) in which the recurrent grammatical relations of the various word classes are clearly exhibited, it may be that certain of the relinearizations are particular to the aims of the discourse analysis or have not been widely investigated enough to be included in the grammar of English as a whole. An example is the relinearization (type M) which moves a sentence adverb, e.g., *however*, occurring within a science language sentence to a front position (i.e., to the left of |||) in the projection of that sentence. Similarly for the relinearization which effects the positioning of a local modifier upon its host (type III) and that (type IVa, employed in the example above) which permutes the linear order of a nominalized verb and its first argument. Other of the relinearization transformations, e.g., subordinate clause permutation to front or end position (type II) and prepositional phrase fronting (type I) are merely adopted from the grammar of English (GEMP, 3.11). The following is a list of the relinearization operations applied; all notation is interpreted in the summary of transformations given in Appendix 3. An asterisk marks those either specific to the

sublanguage or which require specification of domain. Constituents incidental to the statement of the transformations are omitted.

Lin I: i) $N\ V\ PN \leftrightarrow PN\ N\ V$
ii) $Vn\ PN_1\ PN_2 \rightarrow PN_2\ PN_1\ Vn$

This relinearization consists in moving a prepositional (*PN*) phrase (together with its modifiers, if any) from front to end position, or inversely. In either case, the displacement concerns only the front and end positions in the elementary sentence, with no insertions or extractions between constituents.

EXAMPLES: of *i)* (from 13,464.2.2) *Within the group of mature plasma cells, the ER occupied the greater part of the cytoplasm... → The ER occupied the greater part of the cytoplasm within the group of mature plasma cells ...*

of ii) (from 9,67.3.5) ... the uptake of two doses of antigen by the same primitive cell of the proper variety... →... by the same primitive cell of the proper variety, the uptake of two doses of antigen...

Lin II: $S_1\ K\ S_2 \leftrightarrow K\ S_2,\ S_1$

A subordinate clause ($= S_2$), together with conjunction ($= K$), is permuted to before the primary sentence ($= S_1$), where K is often *after, following* and S_2 is an instance of a GJB elementary sentence. In this case, K is indicated in the formulaic representation as :, connecting two units (elementary sentences) within the same row.

(7,1.5.2) *After subcutaneous injection of the antigen it was mainly the regional lymph nodes that were responsible for this production. → It was mainly the regional lymph nodes that were responsible for this production after subcutaneous injection of the antigen.*

This linearization is also applied to other subordinate conjunctions which are not represented in the index formulas, but conjoin two rows in the projection of a text sentence.

(12,112,6,1) *As the plasma cell matures, the ergastoplasmic cisternae become increasingly distended. → The ergastoplasmic cisternae become increasingly distended as the plasma cell matures.*

Lin III: This relinearization moves a local modifier (chapter 4.4.2) to a position adjacent to its host. In many cases this movement is to the right of its host; infrequently, an adverbial form moves to its left, losing the *-ly* suffix. In the formulas, local modifiers may be represented by superscripts.

(from 11,162.2.6) ... *a method for detecting single cells which have produced antibody in vitro* → ... *a method for detecting single cells which have produced in vitro antibody*;
(from 4,4.1.1) *While the development in the reaction centers apparently ceased with the formation of these cells...* → *While the development apparently ceased in the reaction centers with formation of these cells...*

Lin
IVa: $Vn\ PN_1\ PN_2 \rightarrow PN_1\ Vn\ PN_2$

The (usually) first argument of a nominalized verb, together with the prepositional indicator of the nominalization, is positioned before the nominalized verb to the front of the elementary sentence.

(from 4,11.1.7) *The transition of the immature plasma cells into mature cells...* → *Of the immature cells the transition into mature cells...* ;
(from 10,303.2.1) ... *the chronic drainage of cells from a thoracic duct fistula* → *of cells the chronic drainage from a thoracic duct fistula...*

Lin
IVb: i) $An\ PN_1\ P\ Vn\ PN_2 \rightarrow PN_1\ An\ P\ Vn\ PN_2$
ii) $N_2\ PN_1\ to\ V\ N_3 \rightarrow PN_1\ N_2\ to\ V\ N_3$

This operation may be considered a variant of type IVa but is distinguished in that An/N_2 is an O_o classifier (e.g., *function*, *role*) or a nominalized form (e.g., *effectiveness*, *significance*) whose subject is the same as the subject of **V** (= $\mathbf{V_p}$ 'produce). These words are indexed by the **r** (or **k**) superscript.

EXAMPLES OF i): (from 11,167.1.1) *The effectiveness of these free ribosomes in the synthesis of secreted protein...* → *Of these free ribosomes, the effectiveness in the synthesis of secreted protein...*
of ii): (from 4,10.2.3) ... *the capacity of the red pulp to form antibodies...* →... *of the red pulp the capacity to form antibodies...*

Lin
IVc: $N_Q\ PN_1\ V \rightarrow PN_1\ N_Q\ V$

Here, apparent quantifier and number modifiers are positioned after the noun within the verb (main operator) segment of the row. Although this operation is characterized as an alternative linearization, involving as it does no further changes in the shape of the sentence, it requires additional justification since its effect is to take what is apparently a modifier of a noun and position it as a modifier of the main operator of an elementary sentence. This is outlined in section *8* of this chapter.

> (from 4,12.4.3) ... *only insignificant amounts of antibody were detected in the follicle culture fluids.* → ... *of antibody, only insignificant amounts were detected in the follicle culture fluids*;
> (from 7,2.2.7) ... *95 per cent of these cells were lymphocytes...* →... *of these cells 95 per cent were lymphocytes...*

Lin M: Relinearization in this case effects the extraction of meta-science and conjunctional material from a science language sentence. In the projection of the text-sentence, this material is placed within a row marked 'M' (meta-science language) or to the left of three bars (|||) as introducing or conjoining rows of the projection.

> (from 10,303.1.4) *The view that the immunological deficiency is due solely to a lack of small lymphocytes would be greatly strengthened if...* → *The view would be greatly strenghtened that the immunological deficiency is due solely to a lack of small lymphocytes if...* ;
> (12,112.3.3) *The rare ergastoplasmic cisternae in this cell sometimes also contain antibody* → *Sometimes also the rare ergastoplasmic cisternae in this cell contain antibody.*

3. Reconstruction of Repetitional Zeroing

All cases of repetitional zeroing involve the reduction to zero phonemic shape of the second occurrence of a word (or word sequence) when that word occurs in particular positions in respect to its antecedent. Both words are required to have the same coherent selection – e.g., *Max took an umbrella and Max took a drive* is not reduced to the unacceptable *Max took an umbrella and a drive.* The sameness of the two words or of their referent is provided by a meta-textual statement. In subject-zeroing, identity of referent is required (*3.2* below); in parallel- and end-zeroing, sameness of

referent is only likely (*3.1*) The tables of Appendix 1 do not reconstruct all instances of repetitional zeroing – relevant considerations are noted below.

3.1. Parallel-zeroing and end-zeroing

Parallel-zeroing is widespread under *and*, *or*, and other conjunctions, e.g., *but*, the comparative (*7*). In (a) *both lymphocytes and plasma cells produce antibodies* (from 3, 218.9.1; the conjunction here is *both...and*), parallel-zeroing in the source sentence: *both lymphocytes produce antibodies and plasma cells produce antibodies* results in *both lymphocytes produce antibodies, and plasma cells*. To obtain (a), the residue of the zeroing, *and plasma cells*, is requiredly transposed to after the last word which did not serve as an antecedent for the zeroing (here, *lymphocytes*). For a sentence involving a comparative form consider (b): *the total bacterial content had in most cases fallen considerably and at a greater rate in the red than in the white pulp* (4,9.1.1) *And at a greater rate* indicates a zeroing of the second sentence (under *and*) aside from its modifier: *the total bacterial content had in most cases fallen.* Under the comparative *-er... than*, which raises the likelihood of word-repetition, *the total bacterial content had in most cases fallen at a rate* is reconstructed following *than*.

In end-zeroing, the final sequence of words (usually in the second sentence) has been repetitionally zeroed. End-zeroing is recognized under many operators, e.g. *and*, *or*, comparative, and other conjunctions (chiefly O_{oo}, an operator whose first and second arguments are operators). In (c) *The lysed lymphocytes did not contain specific agglutinin, whereas the cultured lymphocytes did* (14,577.1.5), the sequence *contain specific agglutinin* is reconstructed under the contrastive conjunction *whereas*.

The reconstruction (expansion) of all the text-sentences in accord with zeroings just mentioned would entail considerable extension of the tables. To avoid this situation, conjunctions, principally *and* and *or*, have been left in the rows and are indicated in the formulas by a comma. For instance, (d) *the antibody production in vitro of red and white splenic pulp* (from 7,3.5.1) is not expanded in the tables; its formula is abbreviated as $\mathbf{AV_p^vT_d, T_f}$.

3.2. Subject-zeroing

Under various prepositions, and subordinate conjunctions, the subject of the second sentence, if it is the same as an argument of S_1, is zeroable, along with *is*. In (e), *When present, it occurs chiefly in the interior of some or all of*

the large flattened sacs... (from 12,113.2.2), *it* is a pronominal reduction of an antecedent *antibody* (the second sentence in this example has been moved to before the primary sentence, S_1). The sentence is then expanded to *When antibody is present....*

Another, infrequent, case of subject-zeroing arises where the subject of a lower sentence has the same referent as the subject of a higher operator. This zeroing is reconstructed in example (f): *if agglutinins had seeped through the permeable vessels on the inflamed ear for agglutinins to be drained to the lymph nodes.* The text-sentence has ... *on the inflamed ear to be drained* (from 1,792.4.1), where the *for* (of the *for... to* argument indicator) preceding the zeroed lower subject is also zeroed.

4. Reconstruction of Low-Information Zeroing

This section examines the considerations according to which a text-sentence can be regularized by reconstructing occurrences of words present only in zero phonemic form. Word occurrences with high likelihood in a stated situation make little or no informational contribution to their sentence and are readily zeroable. In terms of the present analyses, it is often unnecessary to reconstruct all zeroed forms. In general, this has been done when some feature of the analysis depended upon, or was made clearer by, such reconstruction. In the tables of Appendix 1 reconstructions of zeroing are enclosed within parentheses.

4.1. Broad selection words

Certain words normally occur with an exceptionally large domain of operators over them or arguments under them. These words have only very general meanings and corresponding to their high likelihood, the informational contribution they make to their sentence is low. As such, they often occur in zero form but can be reconstructed, e.g., by noting that their presence is required in order to satisfy the argument requirement of a neighboring word. However, unlike reconstructions of repetitional zeroings, words which have been zeroed on grounds of low information are often not uniquely reconstructible. Rather the trace of the zeroing suggests only that some word or words from a small set of words, all of which have roughly the same favored likelihood in the specified environment (and thus are locally synonymous), may be reconstructed. In the present material an

important set of these broad selection words are the classifiers *amount, quantity, degree, number, period, time.* These, under a characteristic preposition, may occur as modifiers of many of the verbs (main operators) of sublanguage sentences, e.g., *antibody production was in a quantity, plasma cell proliferation was to a degree, antigen uptake by the cell occurred at a time, cell differentiation occurred throughout a period.* When occurring under their (selectionally) favored "appropriate" operators, these modifiers are often zeroed. For words like *quantity, number, amount, degree* this appropriate operator may be the comparative *more* (*than*), a specifying adjective e.g., *high, some, little* or this adjective under the comparative as in *higher, greater* (cf. 7). As the zeroing of these broad selection classifiers is extremely widespread and of little significance in establishing the informational structures of the sublanguage, only rarely have reconstructions been performed in the projected sentences, and then only to preempt possible unclarity as to the choice of a word class or subclass. A case in point is *the changes in nucleic acids in lymph nodes* (from 6,158.2.1) which is reconstructed under conditions discussed below and which is represented formulaically as $\mathbf{DV}_{\mathbf{i}}^{\Delta}\mathbf{T}_{\mathbf{n}}$. In such cases, the reconstruction serves to illustrate that what may appear as a new sentence type or subclass can be accommodated within existing forms.[3] Similarly, in (6,164.4.2) *the rise in lymphocytes did not prevent the PNA from dropping* is reconstructed as *the rise in numbers of lymphocytes present did not prevent the PNA quantity* (or: *concentration*) *from dropping.*

4.2. Strong selection zeroing

A case related to the zeroing of broad selection words under an appropriate operator is that of strong selection, i.e., the zeroing of certain words with exceptionally high likelihood of having particular cooccurrents. For example, in GEMP (6.14) apparent O_{oo} (that is, bisentential) occurrences of the time-order prepositions *before, after, following* and the like are derived from base occurrences as O_{on}.[4] As O_{on} operators, these prepositions can have as first argument an aspectually modified sentence – S_1 *at a time/in a period* – and as second argument a duration noun such as *time, moment, period.*[5] Their apparent conjunctional occurrence stems from strong selection to the duration words which, by this fact, can occur only in zero form. A second sentence may then be appended as a relative clause via *when* or another relative pronoun. Schematically, the reductional path from O_{on} to O_{oo} is S_1 *in a period after the time when* $S_2 \rightarrow S_1$ *after* S_2. By application of a relinearization transformation of *2*, this becomes *after* S_2, S_1. Taking a

concrete example, we have: *high titers of antibody in the regional lymph nodes in a period after the time when injection of antigen occurred* which reduces to *high titers of antibody in the regional lymph nodes after injection of antigen* (in 3,121.7.1) to which several relinearizations are applied to obtain the normal form representation.[6]

For the analysis of most text sentences, many of which are resolved into an informational representation having a **GJB** sentence conjoined by *after* or *following* represented (:) to a "response" sentence, nothing is gained by exploiting all the details of this reductional path. However, the discussion here will serve to motivate several cases where reconstruction of the zeroed time words under *after, following* is integral in constructing information units or in establishing relations between them. This happens, for example, if a duration noun, such as *time,* occurring in a *PN* aspectual modifier of S_1 (e.g., *at a time)* is the antecedent of a relative pronoun connecting a further secondary sentence to S_1. Modifying the terms of the schema in the paragraph above, we have S_1 *at a time after* S_2 *when* S_3. This construction is exemplified by (4,3.5.5) *Thus on the 2nd or 3rd day, when the titer curve had still hardly begun to rise, the large reacting reticulum cells (called transitional cells) were met with* where S_1 = *the large reacting reticulum cells ... were met with,* S_3 = *the titer curve had still hardly begun to rise* and *after*, in addition to nominalized S_2 = *the reinjection*, are recoverable as appropriate zeroings (see *4.4.1*). So construed, (4,3.5.5) becomes *thus the large reacting reticulum cells (called transitional cells) were met with at a time on the 2nd or 3rd day after the reinjection when the titer curve had still hardly begun to rise.* In this example it is clear that the relative pronoun *when* replaces a second occurrence of a time word in a (zero) *PN* aspectual modifier of S_3.[7] The condition for this replacement is that there is sameness of designate with a first occurrence; the second occurrence of *a time* must, like the first, occur under a repeated *after* (i.e., *after a time when* S_2) in zero form. This further reconstruction gives, finally, the form in the projection: *thus the large reacting recticulum cells (called transitional cells) were met with at a time on the 2nd or 3rd day after the reinjection when* (= *at which time*) *on the 2nd or 3rd day after the reinjection the titer curve had still hardly begun to rise.* In this example, as in several others in the text, it is necessary to show the strong selection relation of *after* to a zeroed time word in order to obtain an informational representation adequate to the assertion of a time relation; in this case, that the time (after injection) when the large reticulum cells were met with was when the antibody titer curve had just started to rise. As an aside, we observe that the time-order relation obtaining among the

great majority of the sentences of these texts is established with respect to the time of a specified injection of antigen although an entire antigen injection sentence may not appear in the text. [8] The grammatical conditions under which it is possible to reconstruct the antigen injection **(GJB)** sentence and conjoining time-order preposition, *after* (or: *following*) are discussed in *4.4.1)*.

Another common instance of strong selection zeroing is where the zeroed word has strong selection for a particular preposition expressing spatial relations to occur over it. The reduced form is then the N_1 *is* PN_2 construction where the P (e.g., *in, at, on*) together with N_2, the second argument of P, "carries" the informational contribution of the zeroed verb (e.g., *occurs, present*) which is the first argument of P. Thus, in many text sentences we find that verbs of the $\mathbf{V_i}$ subclass are zeroed under this strongly selected P, as in *the antibodies in the lymph nodes*) (from 5,205.2.6) reduced from *the antibodies present* (or: *contained*) *in the lymph nodes*. These verbs are also often zeroed under certain quantity words like *concentration* or *titer* which usually carry as well a reference, via zeroed *PN*, to a particular location; for example, *This is precisely the time when the concentration of RNA was highest* (from 6,164.5.3) is reduced from *this is precisely the time when the concentration of RNA present in the regional lymph nodes was highest*, where *the regional lymph nodes* is reconstructed from an environing sentence.

The zeroing of an appropriate verb under P is widely applied in descriptions of the hierarchy of levels of physiological and histological detail, with the zeroed verb a member of the $\mathbf{W_i}$ subclass: *the lymphoid cells in lymph* (from 6,157 fn. 1) reduced from *the lymphoid cells present/occurring in lymph*; *the ear tissue on the uninjected side* (in 1,787.2.7) from *the ear tissue located on the uninjected side*. In addition, several sentences have the preposition *from* in the environment $N_1 - N_2$ where N_1 is **C** (or **T**) and N_2 is **T** (or **B**). Here the zeroed appropriate word is not of the $\mathbf{W_i}$ subclass but instead is a member of $\mathbf{W_\ell}$ (e.g. *derived, extracted, removed*, etc.) the subclass of metascientific (i.e., having as subject a member of N, cf. chapter 2, *1*) procedural or operational terms. But, in constructing a source for the reduced form, N_1 *from* N_2, we see that the decomposition of this sentential fragment reconstructs as well a member of $\mathbf{W_i}$ and its appropriate preposition in the source. As an instance we find *salivary glands or muscle tissue from the same immunized mice* which is reduced from *salivary glands or muscle tissue extracted from the same immunized mice* which in turn is from *We* (or: *workers*) *extracted from the same immunized mice salivary glands or muscle tissue present in them* (cf. *lymph nodes derived from rabbits which had*

received antigens other than influenzal virus, from 5,204.2.5). The availability of this transformation which we note here but do not perform in the analyses, enables us to state that the zeroed operator in the $N_1 - N_2$ environment above is a member of $\mathbf{W_i}$.

4.3. Constants

A few words are grammatically characterizable as having unique occurrence in a particular sentential position. As such, they are highly expectable in that position and are readily zeroed. The most frequent zeroing here is that of the *wh-* pronoun together with the *-s* operator indicator (attached to a "carrier verb") at the head of the conjoined secondary sentence (*5* below). In some cases, instances of the elementary sentence types are obtained by reconstructing the relative clause introducing a modifier by giving the *wh-* (*-s*) phonemic form and returning the left-transported residue of the relative clause to its original position. When this operation is performed on two left modifiers, they are returned to the original order of their free standing relative clauses. Thus from *a cell characterized by its large electron-lucent nucleus* (in 12,112.3.1) we reconstruct *a cell characterized by its electron-lucent nucleus which is large*, thence to *a cell characterized by its nucleus which is electron-lucent*; *said nucleus is large* and finally to *a cell characterized by its nucleus which is electron-lucent*, *which is large*, represented as two **CSW** sentences.

Sometimes the left modifier of a noun receives full stress with secondary stress on its host (compound noun structure), e.g., *antibody-forming cells.* In these cases, transportation is of the already compounded form: *cells which are antibody-forming.* This decomposes to *cells which are forming antibody* with *cells forming antibody* an example of an *N Ving N* base form (cf. GEMP 2.043). In cases where there is an additional left modifier, e.g., in *individual antibody-forming cells* (from 13,448.1.1), the outermost left modifier is again decomposed first: *antibody-forming cells which are individual* transformed from *cells which are antibody-forming; said cells are individual.*

Another, very small, group of words which are zeroable as constants consists of *than, as.* These are morphemes that are only part of an entry (of the comparative construction) and are zeroable when what follows in the conjoined sentence under the comparative is zeroed.

4.4. Reconstruction of sublanguage appropriate zeroings

Some words and word sequences are present in text sentences in zero form on grounds that the informational contribution they make is highly redundant in the context of their occurrence. It is of interest, then, that the present methods of analysis are adequate for identifying traces of many of these zeroings and, by this fact, permit their reconstruction. In so doing, we are extending the notion of appropriateness – the high likelihood condition that given material occurs in a specified position – to recognition of specialized discourse or sublanguage environments. While the full measure of this process of zeroing under an extended notion of appropriateness can only be gauged from a sizeable expansion of the corpus beyond the 14 articles analyzed here, an indication of its nature can be gathered from the instances addressed in this section.

A commonly encountered case of sublanguage appropriateness reduces to zero an occurrence of the colon conjunction (chapter 1.3.2) together with the antigen injection (**GJB**) sentence occurring under it. Although nearly all occurrences of "response" sentences (chapter 2.6) are either directly or indirectly (i.e., mediated by other sentences) conjoined to an occurrence of **GJB** (even if in zero form), such reconstructions have been made only where a formal basis exists, which is to say that some change in the shape of an expression in the grammatical environment of the zeroing can be identified as the trace of the reduction. In the discussion below, these reconstructions are addressed in terms of the identifiable traces of zeroing. In *4.4.2* other cases of sublanguage appropriate zeroings are noted. In addition to these there are reductions specific to particular texts (e.g., *cannulation, closure of the fistula* in paper 10) which are discussed in the notes accompanying the tables.

4.4.1. Details of reconstruction of a zeroed : *operator and the* **GJB** *sentence under it*

a) We noted above that the time-ordering relation obtaining among many sentences has as its base point the time at which a specified injection of antigen was made. This is seen in forms like *on the 2nd or 3rd day after the reinjection, before the antibody content had begun to increase, it was possible to observe the occurrence of cells of characteristic appearance in the reaction centers* (from 4,1.3.4) where the ordinal modifier upon the time word *day* indicates an ordering in respect to an initial time which is that of a (second) injection. Given the occurrence of these sentences, prepositional phrases

containing a time word modified by an ordinal word, e.g., *on the 4th day*, which have apparent occurrence on a verb (e.g., *appear*) can be recognized as the trace of zeroing of *after* (or *following*) and the **GJB** sentence under it. For example, *mature plasma cells began to appear in large numbers only on the 4th day* (from 6,164.3.2) can be reconstructed (following the details of the discussion in *4.2*) as *mature plasma cells began to appear in large numbers at a time which was on the 4th day after the time of the injection.* This is reduced, by zeroing the aspectual words, to the form in the projection which is *mature plasma cells began to appear in large numbers on the 4th day after the injection.* Here we can take *the injection* as referential to the single occurrence of an antigen injection sentence in the "Experimental" section of the paper which describes methods and procedures: *Forty-one animals received 0.5 ml of "febrile antigen typhoid O" Lederle) into each footpad* (158.3.2). In the formulas, these ordinal modifiers are represented by a **t** subscript to **:** .

A related case is where the ordinal modifier of a (zeroed) aspectual *PN* has apparent occurrence as a noun modifier, as in *the first cells which demonstrably contain antibody* (from 9,66.4.2). Here again, the ordinal word has reference to a time ordering established by the time of an injection of antigen. In this case we find the injection specified as *the injection of a second antigenic stimulus* in the previous (66.4.1) text sentence which we relinearize as *the second injection of an antigenic stimulus.* Reconstructing (in 66.4.2) this **GJB** sentence, we have *the first cells which demonstrably contain antibody after the second injection of an antigenic stimulus.* We now reconstruct the *PN* aspectual modifier whose *N* time word is the argument of *first*, obtaining *the cells which demonstrably contain antibody (at a time which is) first after the second injection of an antigenic stimulus.* In the formulaic representation *first*, represented by **e** is superscripted to **:**.

A more unusual example is (4,9.3.3) *In the earliest stages of the reaction, in the first phase of antibody formation, large reticulum cells of characteristic appearance were found*, where a series of events are stated to have overlapping chronologies within a time-ordering initially fixed by a specified injection. But the transformational treatment is exactly the same as in the previous, simpler, example: since *earliest* occurs on *stages* and *first* on *phase*, we can perform two reconstructions of **:** and its **GJB** argument. All that remains is to locate the antecedent occurrence of an antigen injection word sequence, which is *the reinjection* in the immediately prior sentence (9.3.2). In reconstructed form, we then have *in the stages of the reaction which occur earliest in the period after the reinjection, in the phase of antibody formation*

which occurs first in the period after the reinjection, large recticulum cells of characteristic appearance were found. By inverting the primary and secondary sentences via a relinearization, we obtain the form seen in the projection.

b) Zeroing of : with preceding **GJB** under the classifiers *response, reaction.* In Chapter 2.5, it was noted that the classifier words *response, reaction*, are found to have occurrence in the environment **GJB:**____, replacing there one of a small number of types of sentences (the so-called "response" sentences). When this **GJB** is in zero form, it can be reconstructed on the grounds that the nominalized form *response, reaction*, like the denominalized verbs *respond, react*, always occur with the preposition *to* which is an indicator of their second sentential argument. In this corpus the second argument is a **GJB** sentence and the argument indicator *to* can be reconstructed to serve as a conjoining link to the zeroed **GJB**, appearing in many analyses in the position of the projection represented by :. While we have not always indicated the zeroed **GJB:** in the environment of each "response" sentence (limiting reconstruction of such zeroings to the conditions discussed in this section), we have always done so in the case of these classifier replacements of the "response" sentences. This has been done to show that in many of their occurrences the classifier words have a specific meaning which can be indicated by factoring them in the formula as the "response" sentence they replace (chapter 4.3).

A widely encountered variation of this zeroing yields the reduced forms *primary response, secondary response* with *primary, secondary* apparent modifiers of *response*. Reconstruction of the zeroed GJB sentence under *response*, however, shows these to be modifiers of the injection word; for example, *small lymphocytes play a part in primary immune responses* (from 10,303.1.1) is reconstructed as *small lymphocytes play a part in immune responses to primary injection* where *primary* appears on the sentence zeroed under *response*. We note that the term *secondary response* is sometimes used to refer to those immunological and histological events – as well as their magnitude – which are evoked by repeated injection of antigen and is not necessarily restricted to characterizing the situation after a second injection as this transformational treatment suggests (cf. paper 4,1.2.1-3).

c) Zeroing of **:** and **GJB** where the trace of the zeroing is the adjacent occurrence of a word of the **G** class and a word of the **A** class, perhaps with intervening argument indicator (**A** *to/for* **G**) or hyphen (**G-A**). We find, for example, *some formation of antibodies to antigens* (from 1,783.2.1), *the serum in turn contained more agglutinins for B. enteritidis* (from 1,796.4.2) and *homologous-antibody titers of extracts of a given node* (from 5,205.1.1). The

environment **A**__**G** is restricted to occurrences of the operator *specific to/for* whose first argument is a word of the **A** class and whose second argument is a word of the **G** class which is referential to an occurrence of **G** word in an environing **GJB** sentence; *antibody specific to antigen* is reduced from *antibody specific to the antigen which was injected.* If the **GJB** sentence is present only in zero form it can be reconstructed under a conjoining : operator representing *after*, as in *they (the large cells) synthesize antibody specific for the antigen which stimulated their development* (from 9,66.4.3) reconstructed as *they (the large cells) synthesize antibody specific for the antigen after injection of the antigen; the antigen stimulated their development* (Chapter 1.3.2). As noted in chapter 4.2, these referential occurrences of **G** words under the operator *specific to* are written in the **A** segement of the projected sentence, the entire segment receiving the index $\mathbf{A}^{\mathbf{G}}$.

A variant of *specific to* is the technical term *lyse* which is sometimes compounded to the antigen word, e.g., *hemolytic* in *hemolytic antibody plaque production* (from 13,448.1.1) where *hemo* is a shortened form of *sheep red blood cells* (SRBC), an antigen (more properly, a bearer of antigen). (Immunologically, hemolysis does not result from the presence of antibody unless the antibody is specific to SRBC.) There is also the term *hemolysin* as in *the agglutinin and hemolysin titers obtained with the extracts of lymphoid cells* (from 2,297.3.2) which has the distribution of an **A** word and which can be decomposed as *the globulin* (or: *protein*) *which lyses sheep red blood cells* (= *hemo*).

4.4.2. Other sublanguage appropriate zeroings

We note here several other examples of zeroings under the condition of sublanguage appropriateness.

a) A form of zeroing of a $\mathbf{W}_i$ word related to strong selection zeroing (*4.2*) is shown where the quantificational modifiers *the number of*, *a number of* have apparent occurrence upon a noun, as in *the numbers of cells engaged in antibody synthesis* (from 9,61.1.2) and *it occurred over an area of the follicle involving a number of cells in an indistinct way* (from 9,68.3.5). Unlike the previous cases of $\mathbf{W}_i$ zeroing, here no strongly selected preposition is present enabling the $\mathbf{W}_i$ verb to reduce to zero. We can, nevertheless, reconstruct the $\mathbf{W}_i$ verb *present* (or: as nominalized *the presence of*) by appeal to the distributional regularities of the sublanguage corpus, where quantifier words have strong selection only for $\mathbf{W}_i$ or $\mathbf{V}_i$ verbs. Since the subject in each case is a member of **C**, the zeroed word is a $\mathbf{W}_i$.

b) Under the O_{no} **r** operator, which in this corpus selects a member of $\mathbf{V_p}$ as the main operator in the sentence which is its second argument, words of the **A** and $\mathbf{V_p}$ classes may be reduced to zero. For example, in *The implication of the experimental facts concerning antibody production is that the cell type responsible does not exist in the absence of stimulation* (9,67.4.1), we reconstruct ... *the cell type responsible for antibody production* since *responsible*, as **r** here, requires a sentence argument whose main operator is a $\mathbf{V_p}$ word with an **A** word as argument.

5. Relative Clause

A particular set of reductions are of special note in the grammatical analysis here (as in English generally) – these are the *wh-* pronounings. All modifiers, e.g. adverbs, *PN* phrases, subordinate clauses, are derived from secondary sentences, via the relative clause. To obtain the relative pronouns, e.g. *which*, *where*, we start with semicolon intonation – an O_{oo} operator connecting a primary (S_1) and a secondary (S_2) sentence. Under this operator, a word in S_2 which is stated to be the 'same as' one (its antecedent) in S_1 may be moved (along with S_2 plus the conjunction) to a position immediately after the antecedent in S_1. The second occurrence of a word can thereupon be reduced to a *wh-* pronoun.[9] The restrictive form in (a) *Pathogenic bacteria carried on the lymph stream are often arrested in the glands...* (from 1,783.1.7) is explained by the insertion of broad-selectional indefinite nouns, as seen in the slightly simplified derivation below:

(i) *some things are often arrested in the glands; (said) things are pathogenic bacteria; (said) pathogenic bacteria are carried on the lymph stream*
→ (ii) *some things are often arrested in the glands; (said) things are pathogenic bacteria (which are) carried on the lymph stream*
→ (iii) *some things, which are pathogenic bacteria carried on the lymph stream, are often arrested in the glands*
→ (iv) *Pathogenic bacteria carried on the lymph stream are often arrested in the glands*

As to derivation[10] – in (i), *said* attached to the second occurrence of *pathogenic bacteria* (and *things*) is regarded as equivalent to an appended metalinguistic statement which asserts the sameness of the two occurrences (or, in some cases, that the words have the same designate). In (ii),

the semicolon plus secondary sentence – *(said) pathogenic bacteria are carried on the lymph stream* – has moved to the "host" primary – *(said) things are pathogenic bacteria)*, with reduction of the word in S_2 asserted to be the same as that in the primary to *which*. The constant *which are* is zeroable as bearing low information (cf. section *4.3* and below). In (iii), the secondary (S_2) is moved inside the host – *some things* – *(said) things are pathogenic bacteria carried on the lymph stream – are often arrested in the glands*, with reduction of (*said*) *things* to *which*. Zeroing the indefinite *some things* along with the constant yields (iv). It may be seen that the operator *are often arrested in the glands* is not asserted of pathogenic bacteria in general, but enters into the construction with, i.e. is restricted to, *pathogenic bacteria carried on the lymph stream.* The unrestrictive (descriptive) relative clause in (b) *These cells, which obviously originated from reticulum cells, were called transitional cells* (from 4,1.3.7) is obtained from *These cells were called transitional cells; (said) cells obviously originated from reticulum cells*, where the secondary sentence is independent of the primary.

The difference between the two types of relative clause, restrictive and unrestrictive, is indicated on the conjunction *wh-* (see *5.2*): in the latter case, the conjunction is preceded by a comma (, *wh-*); in the former, it is not. With the restrictive relative clause, the entire derivation as sketched above is not brought into play. In the tables, the secondary sentence is not attached to the true primary (in the above example: *some things are often arrested in the glands).* The restrictive reading is however obtained by a convention which reads the secondary (in (a), *pathogenic bacteria are carried on the lymph stream*) immediately upon encountering, e.g. *pathogenic bacteria.* The sentence to which it is attached, *pathogenic bacteria are often arrested in the glands*, is called a "primary" sentence, though it is so only in a derivative sense provided by this convention.

5.1. Representation and reading in the tables

The importance of this set of reductions arises from the attempt to obtain the largest repeating sequence of word-classes in each text sentence (cf. Chapter 1.3.2). In this material, the words (or phrases) symbolized by superscript adjuncts in the formulas are obtained from relative clauses (generally restrictive). Representation of these secondary sentences by adjuncts is a means of maximizing the informational content of the formulas. Two conventions of abbreviation assist in this objective. In (c) ... *the lymphoid cells of the efferent lymph of this node contained 5 to 7 times as much*

antibody (from 6,157.1.3), the sequence *the lymphoid cells of the efferent lymph of this node* is not decomposed further into **CWT** sentence-types, but is left within the row with the index $\mathbf{C}_{\ell}\mathbf{T}^{\mathbf{f}}_{\ell}\mathbf{T}_{\mathbf{n}}$. Another case is presented in (A) of *5.2*.

Reconstruction of relative clauses is a means by which the related objective – maximizing recurrence of established sentence-types – is achieved. If the text-sentence contains as a result of relative clause formation (and related reduction) a secondary sentence which conforms to the established repeating sentence-types, the relative clause is indicated as a conjoined seondary sentence.

The antecedents of *which* in this material are either words which i) are member of an argument word-class; **A, C, T**, etc., ii) are represented by the "major category adjuncts" (**B, G**) of *5.2*, or iii) are represented as a unit sentence. An instance of i) is provided by example (a) *Pathogenic bacteria carried on the lymph stream are often arrested in the glands*... . An instance of ii) is (b) *the nodes on the side injected with paratyphoid bacterin becoming slightly large* (from 1,792.1.2 – see *5.3*). In (c): *there is a moderate increase in cellular proliferation which subsides after a few days* (from 14,583.3.2), *which* is on the preceding sentence, symbolized $\mathbf{CW}^{\uparrow}_{\mathbf{p}}$.

Other *wh-* words which figure in the tables include *where* – replacing a *PN* (*in a place*), *whose* for *'s* following the replaced word, and *when* – replacing *at a time* (the **t** modifier on the **:**, see *4.4.1* for details). For instance, *where* is a pronominal reduction of the *PN* phrase *within the ergastoplasm* in (d): *antibody remains within the ergastoplasm where it tends to accumulate into spherical masses* (from 12,113.1.1)

In the formulas, the **w** superscript is attached to the word-class whose member carries the secondary sentence as modifier. Example (a) above is thus represented by the formulas: $\mathbf{G^{w}UT_{n}}$, $\mathbf{GU^{y}T}_{\ell}$. If, as in (c) above, *which* is on a sentence, the **w** is appended to the main operator ($\mathbf{CW^{w}_{p}}$).

In the tables, *wh-* is treated as (a variant form of) the semicolon conjunction and the secondary sentence is written on a neighboring line to the primary (usually, immediately below). The *wh-*, as a conjunction, precedes three vertical bars. If reconstructed, it is written as **WH**; otherwise, the (non-zero) *wh-* word in the text is given. The word(s) in the secondary which has been pronouned is enclosed by parentheses. This aids in reading the tables, although it is a departure from the convention adopted in the tables, where pronouned elements are frequently replaced by their antecedents and zeroed ones are parenthesized.

The convention adopted for reading project units with secondary sentences is as follows. In the reading imposed by the arrows, the secondary sentence is read upon encountering a word in the primary to which a secondary sentence is attached. This is noted by tracking the formula as the reading proceeds and has the advantage that sentences to which several secondaries may be attached do not individually require indexing with a superscript **w**. When the secondary sentence is on the **t** – modifier of the **:** (indicated as a **w** superscript directly on the colon), the left argument of the colon segment is read before the appended secondary sentence. The parenthesized word(s) in the secondary is yet another indication of the relevant *wh*-ed element; while this element may be read along with the remainder of the secondary, it is perhaps stylistically more comfortable if it is not.

5.2. Reductions associated with relative clause

The discussion (and derivation) above noted the relationship of the *wh*-pronouns to semicolon intonation. The *wh*- pronouns are obtained as reductions in the material which can be front-positioned in the secondary (cf. fn. 9).

(A) *Wh*- appears as a member of the word-class represented by **:**. In *the nodes of the side injected with paratyphoid bacterin becoming slightly larger* (from 1,792.1.2), the zeroed *which is* (see D below) is reconstructed, yielding *the nodes of the side which is injected with paratyphoid bacterin*.... This in turn may be decomposed into a primary and a secondary sentence conjoined by *wh*-: *nodes on a side become slightly larger; (said) side was injected with paratyphoid bacterin.* The primary is of the form $\mathbf{T^{B}W}$; the secondary is **GJB** (connected by semicolon – *wh*-). **GJB** is here a secondary sentence under *wh*- as it is under *after* and the like. Hence *wh*-, with the meaning "sameness of two specified words, one from each sentence" is in the same combinatorial class as other members of the "colon conjunction." The coreferential relation is marked by the superscripted capital letter **B**. In the absence of an apparatus to handle referentials, it is preferable to accommodate referential occurrences of words within the same formula, where the words have fixed positions (Chapter 1.3.2). Consider the following sentence from article 1: *On the 10th day agglutinins were found in the extract of ear tissue on the injected side but not until the 12th day did they appear in the nodes of the uninjected side* (789.2.5). The temporal modifiers (*on the 10th day*; *not until the 12th day*) indicate the zeroing of a **GJB:** (see section *4.4.1* above),

recovered from (789.2.1), *following the last injection* (**GJ²B:**). The **GJB:** positions are no longer vacant for occupation by the secondary sentence *which side was (un) injected.* Rather than expand the sentences to form a new row (**GJ(~)B**), *on the injected side* is left within the row and receives the superscript **B** as its index; *of the uninjected side* receives the index **B~**, marking its non-coreferential relation with the **B** in **GJ²B**.

(B) In a few text sentences, the primary and secondary sentences have been inverted to conform to the ordering of segments in the formulaic representation. For example, *the extracts were made from tissues showing almost exlusively plasma cell infiltration* (from 3,122.4.2) has *the extracts*, indicated otherwise as a superscript modifier of *tissues*, etc. preceding *tissues.* The primary and secondary are inverted, yielding *tissues showed almost exclusively plasma cell infiltration; from said tissues the extracts were made*, which is then transformed into *tissues from which the extracts were made showed almost exclusively plasma cell infiltration.* The same operation enables us to consider the intracellular sentence-types **C** *has* **SW** and **S** *of* **CW** as variants (cf. Chapter 1.3.3); from (4,1.3.2) *The cells had a nucleus which was more abundant in chromatin; (said) nucleus the cells had* is derived *the nucleus which the cells had* (= *of the cells*) *was more abundant in chromatin*, of the type **S** *of* **CW**. The semicolon, in meaning, is roughly commutative; the lowered stress on the secondary sentence marks it as an aside. Consequently, in the inverted forms above, there is a shift in emphasis, but no change in the substantive information conveyed.

(C) Alternative linearizations enable P + *which* S_2^- ('S_2^-' symbolizing the secondary minus the pronouned element) to be transformed to *which* S_2^- P, e.g. *Pathogenic bacteria carried on the lymph stream are often arrested in the glands through which this stream passes* → ... *which (glands) this stream passes through* (from 1,783.1.7).

(D) *Which is* → ∅. In the sentence above, *which are* has been zeroed as a constant on grounds of low information (cf. *4.3*) and so *Pathogenic bacteria carried on the lymph stream...* is reconstructed to *Pathogenic bacteria which are carried on the lymph stream.*

(E) In many sentences a secondary sentence modifier which has been moved frontward to before its host argument (upon zeroing *which is*) is returned to its former position. Where the residue upon zeroing *which is* is a single adjective or adjectival compound, this movement is required, e.g. *the inflamed nodes* → *the nodes which were inflamed.* In cases where the residue is *of N* or *PN* (*P*, an appropriate preposition), the frontward movement is optional – thus, the reduced form *plasma cell infiltration* is recons-

tructed to *infiltration of plasma cells* and *serum-antibodies* (5,204.5.2) is reconstructed to *antibodies in/from serum* (from *antibodies which are present in serum*).[11]

6. Larger Transformations

The transformations discussed below all involve a large-scale restructuring of text-sentences; some can be formulated as the product of several reductions (e.g., the passive, *6.2*). Others, marked *, involve a known transformational relation between sets of sentential forms, but whose domain requires further specification. This is the case for denominalization into passival forms in *6.1* and the causative of *6.3*. The stated operations are broadly consonant with the theory presented in GEMP and it may well be possible to reformulate the operations in terms of the available reductions.[12].

6.1. Denominalization

In many sentences, an operator, i.e. a sentence, which has become the argument of a higher operator assumes nominalized form, e.g. *Max reads Balzac* under the O_{on} operator *surprise* (with the second, *N*, argument *Jean*) yields *Max's reading Balzac surprises Jean*. Grammatical indication of this argument status is carried by argument-indicators such as *that... should* (in *that* Σ *should V* Ω and its variant for Σ *to V* Ω, *whether S or not S*, etc. Σ stands for the subject of various verbal and adjectival operators and Ω for the various objects of these operators. Other "deformations" of an argumented sentence may be written as:

(1) *N's Ving* Ω
(2) *N's Vn* (*of* Ω)

The subject *N* in (1–2) is alternatively *by N* or *of N* (this is assumed in the transformations below). *Vn* stands for a verb plus its nominalizing suffix, e.g. *-ion* in *injection, production*. In contrast with (1), form (2) selects adjectives rather than adverbs, e.g., *intravenous injections of horse serum*, and allows for *the* in place of *N's*, e.g. *the production of antibody*. To the above should be added (3): *N's An*, where the *n* in *An* stands for the nominalizing suffixes of adjectives, e.g. *-ity* in *eccentricity*.

While not a full listing of the various nominalizations encountered in the articles, the above covers those forms to which denominalization transformations have been applied. In many sentences containing nominalized forms, the linearization (IVa) discussed in *2* suffices in aligning them with others, e.g. *secretion of antibody by active lymphocytes* (from 11,167.2.1) is linearized to *of antibody, secretion by active lymphocytes.* These sentences may otherwise be transformed by the operations below (with possible minor extensions).

Which deformation occurs depends on the particular higher operator; some operators occur with more than one. In 1,783.1.2, (a) *Peripheral lymph flow is far more rapid than is generally supposed*, the higher operator (disregarding here the comparative, treated in *7*) is *is rapid.* The denominalization may be conveniently stated as an operation on a set of sentence forms. Thus by

Nom I: Σ*'s Vn t A/PN* $\rightarrow$ Σ *V A-ly/PN*

peripheral lymph flow is rapid is transformed (via the intermediate *peripheral lymph's flow is rapid*) into *peripheral lymph flows rapidly.* In restoring the sentence to its free-standing form, *flow*, with a zero nominalizing suffix returns to verbal status, and the adjectival operator becomes an adverbial modifier on *flows.* In (b) *intravenous injections of horse serum into rabbits* (from 4,1.2.3), the adjective *intravenous* is moved to its position before transposition and zeroing of the constant *which were*: *injections of horse serum into rabbits which were intravenous.* The secondary sentence *injections of horse serum into rabbits were intravenous* is reconstructed and then transformed into *horse serum was injected intravenously into rabbits* by:

* Nom II: *Vn of* N_1 *t A* $\rightarrow$ N_1 *t Ved A-ly*

An alternative transformational path might be suggested via the passive. This formulation however presents several difficulties. To note just one – the passive has as one of its physical components the *by-* nominalization seen in, e.g. *the burning of the books by the censors.* It is questionable to reconstruct in (b) an appropriate zeroing of *by N* which would then again be zeroed. In (b) above, the higher operator is a member of the word-class symbolized as :. In yet other sentences the operators are members of the

meta-scientific verb-class distinguished as *M* in section *1* of Chapter 2. The nominalized adjective *eccentricity* in (c) *eccentricity of the nucleus* (from 4,3.4.3) of the form *An of N* is denominalized as *nucleus is eccentric*, of the form *N t A*. In the tables, it appears as *cells with a nucleus which is eccentric*; the *which is* due to the status of *nucleus is eccentric* as a secondary on *nucleus*, which is itself an argument of *with*. The higher operator in (d) *the direct importance of lymphoid tissue in antibody production* (from 7,1.5.1) is the **M** operator *gave evidence of*. By the operations discussed above, we obtain *the importance of lymphoid tissue in antibody production is direct*, denominalized by (IIIa) as *lymphoid tissue is directly important in antibody production*, which requires a change in argument-indicator to *that* (*gave evidence that*):

* Nom IIIa: *An of* Σ *in N Vn t* $A_i \rightarrow$ Σ *t* A_i*-ly A in N Vn*

By means of (IIIb) below, (e), *the difference in titers to the homologous and heterologous virus are clearly marked* (from 5,204.5.2), is transformed to *Titers in the homologous and heterologous virus are clearly markedly different.* The plural abstract noun *differences* is taken here as the nominalized form of the adjective *different* (*An*) which itself is derived from the verb *differ* (thus, *differences* is indicated below by *Van*).

Nom IIIb: *the Van in/between* Σ *and* Σ' *t* $A_i \rightarrow$ Σ *and* Σ' *t* A_i*-ly A*

Due to the reciprocal status of *different*, the sentence above is transformed (after repetitional reconstructions noted in section *3*) to *Titer to the homologous virus is clearly markedly different from titer to the heterologous virus. Antibody* is reconstructed as required by *titer* yielding *titer of antibody* (→ *antibody has a titer*). Further discussion may be found in the notes of Appendix 3.

In connection with nominalization, we should mention again the transformation which sends *of N* in *the Vn of N* into a form with possessive *'s*: *N's Vn*, as in (f) *the injection of antigen into the footpads of rabbits* (from 6,157.1.2) → *antigen's injection into the footpads of rabbits*. In the tables, a number of nominalized forms in the articles are not transformed, e.g. *injection*, *immunization*, *development*, though the appropriate arguments of these forms are indicated in the formulas, e.g. *injection* as **GJ** in some occurrences, and, in some instances, in the transformed sentence.

6.2. Passive

As formalized in GEMP (8.4), the passive transformation is not the product of an independent restructuring of the active form, but rather the resultant of several reductions. The components of the passive are found elsewhere in English: the *-en/-ed* is seen in the perfective *have -en* with a stative aspectual character (*Max has broken the contract*); *by* before a permuted original subject is evidenced in various nominalizations (*the burning of the books by the censors*). The apparent 'permutation' of subject and object derives from the object in a sentence (*antigen* in the nominalized sentence *the injecting of antigen*) occurring as subject of a higher operator on that sentence. The higher operator may be taken as *be -en/ed*, with *-en/-ed* a variant of *in the state of* (cf. *-ed* meaning 'state' in *moneyed*). By zeroing the repeated *antigen*, *antigen was in the state of the injecting of it* (= *of its being injected*) is reduced to *antigen was injected.* In this analysis, the domain of the passive is thus the logical product of those of its components. With these restrictions attached, most of the passivizations (and de-passivizations) can be rendered in terms of the familiar formulation:

Passive I: $N_1\ V\ N_2 \leftrightarrow N_2\ t\ Ven/ed\ by\ N_1$

The *by* N_1 is zeroed as redundant in the transformation from (a) *They injected the antigen into the foot of a rabbit...* (from 3,121.7.2) to *the antigen was injected into the foot of a rabbit* (the antecedent of *they* is in a preceding sentence). In contrast, an indefinite subject is reconstructed in depassivizing (b) ... *plasma cell proliferation can be demonstrated also on immunization with a single antigen* (from 3,128.4.1) to *one can demonstrate also plasma cell proliferation...*

A passive-like transformation –

*Passive II: $N_1\ V\ N_2 \rightarrow N_2\ t\ Ven\ P\ N_1$

is applied in the alteration of (c) ... *a remarkable biological event engaging many cells in the area* (from 9,67.3.3) to *many cells being engaged in a remarkable biological event.*

6.3. Causative

In all but a single case, discussed below, application of the causative transformation (as, too, the passive) involves not the inverse of particular

reductions but further restructuring of the text-sentence. It may be stated as:

* Causative: $\Sigma\ V\ N \rightarrow \Sigma$ *causes N's Vn*

The transitive verb thus assumes nominalized form under the operator *cause*. In (a): *every scratch or puncture wound serves to rupture some of the minute lymphatic capillaries* (from 1,783.1.1), *every scratch or puncture wound* falls into the word-class J and *some of the minute lymphatic capillaries* into $\mathbf{T}_{\ell'}$. Rather than establish a new word-class **X** with **J** and $\mathbf{T}_{\ell'}$, as arguments, the causative is applied, yielding *every scratch or puncture wound serves to cause rupture of some of the minute lymphatic capillaries*, of the form $\mathbf{J{:}\ T}_{\ell'}\ \mathbf{W}_{c}$. The preverb *serves to* then has *cause* as its operand. In (b), *experimental procedures which deplete lymphoid tissue of small lymphocytes* (from 10,303.1.1), the meta-scientific subject of *deplete* is factored out via the causative: ... *which cause lymphoid tissue's depletion of small lymphocytes.*

By way of contrast, *starts off* in (c) *a further stimulus starts them* (= *these small lymphocytes*) *off on their secondary response* (from 14,583.3.4) is a reduction of *start off* compounded under *cause*. The inverse of this reduction results in: *a further stimulus causes these small lymphocytes to start (going) off on their secondary response*, where *start... off* is an O_o operator on a zeroed appropriate verb, e.g. *going*.

7. Comparative

In Chapter 1.3.2 it was noted that the treatment of the comparative in these articles departs from the derivation proposed in GEMP. There (GEMP 9.1) the source of the comparative consists of three sentences connected by semicolon: S_1; N_1 *is more than* (*less than, as much as*) N_2; S_2 with N_1, N_2 arguments in S_1, S_2 respectively. In order to maximize the informational content of the formulas, an ad hoc transformation is set up which relates (a) *Agglutinin was found in the lymph node extract in an amount which is far more than the amount in which agglutinin was found in serum* to the components: *Agglutinin was found in an amount which is far more in the lymph node extract* and *Agglutinin was found in an amount in serum.* These in turn are reducible, by the zeroings noted below, to the text-sentence (1,798.3.4). In effect, the comparative is treated as a binary connective, *-er ... than*, on two sentences, where the word modifier *more* (*-er*) is moved into the first sentence, e.g. *agglutinin was found in an amount in the lymph node extract,*

marking what is compared, and *than* connects the two sentences. In the formulas, the comparative marker *-er* is indicated as a modifier, written as $>$, on the first component. In the transformed sentence, *than* is indicated as a conjunction before the second component, i.e. preceding the triple bar. The problems presented by the comparative are closely tied to the further question of the relations among the units established in the present project. Further work in this area will likely suggest modifications of the treatment here.[13]

The bulk of the comparative cases encountered in the articles have the word-modifier *more* (and its variant *-er* as in *higher, greater*) or the related *less than, as much as*, operating on an often appropriately zeroed *amount, degree* (*in an amount, to a degree*). *Amount* and *degree* are broad-selection classifiers, i.e. classifiers, here of measurements, which have normal likelihood of occurrence with many cooccurrents (*4.2*). In (1,798.3.4) *far more agglutinin was found in the lymph node extract than in serum* (with replacement of the pronouns), *far more* is moved in the projected form onto the verb by a (relinearizing) transformation discussed in the section below with *in an amount* here the appropriate *PN* modifier of *found* (see (a) above).[14] Further evidence of the presence of these modifiers is the explicit indication in similarly structured sentences of words (frequently nominalized) pertaining to a unit of measurement, e.g. *titer, concentration, amount.* In (b) *The amount of antibody found in tissue cultures of red pulp was considerably large than in lymph follicle cultures* (4,10.2.2), *amount* is a nominalized modifier operating on *found in*; *larger* in turn modifies *amount.* Sentence (b) receives the (simplified) index $\mathbf{AV_i^{>}T_d} \mid\mid\mid \mathbf{AV_iT_f}$. Such formulas are to be understood as having a tacit modifier indicating *amount, degree* on the verb.[15]

In other sentences, where the *-er* modifies less commonly occurring adjuncts (local operators), the formulas are more explicit. Thus, (c) *The cell synthesizes antibody at a higher rate* (from 11,167.1.4) is represented by the formula $\mathbf{AV_p^{o>}C}$, where **o** is *rate* on the verb *synthesizes* ($\mathbf{V_p}$) and *-er* ($>$) is on *rate.*

In the tables of Appendix 1, not all of the comparative sentences are reconstructed into their components. Those text-sentences which do not contain an explicit occurrence of the comparative indicator *than* are left unexpanded, unless the points of comparison are otherwise noted, i.e. by preceding components of the text-sentence or referentials (such as *the former, the latter*). These (unexpanded forms) include all instances of the superlative and many of the comparative-related forms listed below. [16]

In those occurrences of comparatives which have been expanded, there are, aside from the "appropriate" reconstruction noted above, various repetitionally-based reconstructions. In example (d) *Agglutinins were found in both nodes and sera. They were much stronger in the former* (1,788.1-2), the antecedents of the pro-forms are replaced in the second sentence; the second component of the comparative – *than agglutinins were strong in sera* – is then reconstructed. As a constant of the comparative construction, *than* is reconstructed as a morpheme zeroed when what follows it is zeroed. The remaining sentence is reconstructed as having been repetitionally zeroed. As comparatives raise the likelihood of word-repetition, there are also possibilities of end-zeroing (as in 1,796.4.2) and pronounings, e.g. *that* pronouns *the absolute quantity of newly produced agglutinin* in *the absolute quantity of newly produced agglutinin in red pulp extracts was also much greater than that in white pulp* (from 7,8.3.2)

Other comparative-related forms are noted below.[17]

(A) Quantified-comparatives. These forms are expanded in the tables, though there is no indication of the quantifier. Quantifiers and complex terms such as *ratio, percentage* will be addressed in later work, e.g., *The titers in the extracts of lymphoid cells were approximately eight-fold higher than those in the corresponding sera on the basis of nitrogen contents* (2,297.3.3). Similar sentences have *as... as* in place of *-er .. than.*

(B) Superlatives. Superlatives are indicated by the local operator '>>'. In the grammar of GEMP, the superlative form *-est* is obtained from *most (out) of all*, a variant of *more than all the others*, e.g. *This is precisely the time when the concentration of DNA was highest and mature plasma cells were found to be present in highest numbers* (6,164.5.3).

(C) Comparative forms occur on names of cells (without *than*). In *The finding of these diverse cell types, lymphocytes smaller and larger* (from 11,167.5.1), the classifier *cell types* indicates a reference made to kinds of cells rather than a comparison. Accordingly, the comparative adjunct is not represented.

(D) There are a few sentences in the text in which the first component sentence indicates a grading in the amount and *for, to, that*, conjoins a second indicating a boundary of that amount, e.g. *a cell could be producing and secreting enough antibody to produce a rosette or plaque* (from 13,471.1.2).

(E) Finally, there is a residual group of words semantically related to the comparative. In the tables of the Appendix, *exceed* (1,798.3.5) is represented as >; *maximum* (6,157.1.2), *peak* (ibid.,164.5.4), and *substantial majority* have the >> superscript.

8. Quantifiers and the Negative

Detailed examination of quantifiers and the negative has been reserved for a later study. Analysis of the negative is tied to broader questions concerning the organization of the meta-scientific material (**M**), in particular, the status of meta-discourse operators which assert a sentence as being probable, conceivable, unlikely, etc. Issues concerning the quantifiers and quantity words, e.g. whether these are closed in respect to this subfield or some prior science, cannot be decided on the limited corpus here. Sections *3.1* and *5* of chapter 3 address these issues further.

As a first step towards an analysis, we have applied transformations which effect the movement of quantifiers (and quantity words) and the negative particle *no* from their position as apparent noun modifiers onto the operator on that argument (noun). In GEMP, the negative and the quantifiers are derived as operators on a sentence rather than, for instance, the quantifier being taken together with its noun as a lexical primitive ('quantified noun-phrase'). To adopt the quantifier plus noun as primitive would have the undesired consequence of considerably expanding the vocabulary without isolating the distinct semantic contribution of the quantifier. The adjectival position of certain quantifiers is not derivable (as is the case with other left-modifiers) from a relative clause with subsequent zeroing of the constant (*wh-is*) and movement to the host, e.g. *each antibody* ↞ *antibody which is each.*

Plural quantifiers (*few, many, several*) are only apparently modifiers of their nouns. For instance, *a few* in (a) *a few lymphocytes were large* (from 13,453.1.2) is not predicated of lymphocytes per se but only of lymphocytes in respect to their being larger. In GEMP (5.56), these quantifiers are obtained as second arguments of the verb *mount to* (*lymphocytes being larger mounted to a few*, see section 5.5 of GEMP for further discussion).

In many sentences with quantifiers or expressions of quantity, movement onto the operator is effected by a linearization (IVc) fronting the *PN* phrases following the quantifier (or quantity-word), e.g. *the variations in the amounts of the two nucleic acids observed in our our experiments...* (from 6,158.8.1) → *of the two nucleic acids, the variations in the amounts observed in our experiments*; *many of ribosomes of the lymphocytes were found lining the scattered channels...* (from 11,166.4.2) → *of the ribosomes of the lymphocytes, many were found lining the scattered channels.*

In (b) *Microscopic examination revealed no plasma cells in the muscles and only very few in the thymus...* (from 3,125.5.1), the quantifier occurs as a

referential due to referential zeroing: *only very few in the thymus...* is obtained by the zeroing of *(of) plasma cells* in *only very few plasma cells in the thymus.*

As mentioned above, the negative is an operator on a sentence (equivalently, on its main, or highest, operator). It may be grouped together with other operators, often in the meta-scientific material (**M**), which indicate 'degree of assertedness'. In many instances of the negative, the degree of assertedness may be directly attached to the formula, by moving the negative (indexed as $\sim$) in the text-sentence onto the operator. To derive (c) *No agglutinins were demonstrable in the extracts of the nodes...* (from 1,792.3.4) from *agglutinins were demonstrable in the extracts of the nodes*; *said agglutinins were none* would violate the requirement that the formulas be informationally additive (chapter 1.3.2). As a modifier of nouns *no* is obtained form *not any* on the main operator of the sentence. Under the operator *not* (itself from *We deny that S*), *any* has as a variant 'so much as one': *Not so much as one (bit/occurrence of) agglutinins was demonstrable...* This sentence can be reduced to *None* (= *not so much as one bit/occurrence) of agglutinins were demonstrable* and then linearized as *of agglutinins, none were demonstrable...* .

9. Further Regularization

In this section we consider ways in which the tables may be regularized further, i.e. ways of extending the apparatus of sublanguage transformations above.

Vocabulary: The vocabulary of the articles can be reduced by factoring words into, e.g. a sentence consisting of another word-subclass plus adjunct. This is most readily accomplished in the case of morphologically complex words for which we can find paraphrases consisting of simple (affixless words). Thus, *lymphangitis* (1,783.1.5) is taken as a reduction of *inflammation of lymph vessels.* The prefix *hyper-* as in *hyperimmune* (7,2.6.2 and *passim*) can be derived as a reduction of an adverbial modifier such as *more than normal.* The word *lymphocytogenesis* (7,14.2.1) is decomposable into *genesis* (= *production*) of *lymphocytes.* In terms of its component morphemes *hyperglobulonemia* may be rendered as *globulins present in large amount in blood* – as in effect indicated by its formula $\mathbf{A_g V_i^+ T_b}$. Decomposition of other morphologically complex terms may also yield "complete"

formulas, e.g. *agglutination* (1,792.3.2) as reduced from *the product of agglutinin floculating with antigen.*

In the case of simple words, factoring requires further controls: *free of* may be decomposed as *does not contain* ($W_i^{\sim}$); *proliferate* as *is produced in large numbers* (W_p^{+}). The possibility of reducing the vocabulary, which would faciliate processing, is suggested by the restricted combinatorial properties of words in this subscience. As noted above, use of the formulaic representations eliminates instances of both synonymy and homonymy in the sublanguage vocabulary.

Sentence-types: By extending the use of transformations, largely those reconstructing appropriate arguments and operators, various sentential formulas may be filled out. Whereas "appropriateness" in the grammar of the whole language is normally thought of as the high likelihood of particular words occurring in a given grammatical environment, within a corpus consisting of research reports of a subscience, the notion of appropriateness can be specialized to the established sentence types and we can speak of strong selection of words of a given class (or subclass) for words of other classes (or subclasses).

Given the restricted range of possible arguments and operators for a particular word, determination of the zeroed material is further specified by the neighboring formulas – especially those within the same text-sentence. All such reconstructions are thus instances of low information in respect to environing formulas.

One may reconstruct **GJB:** in *On the 10th day agglutinins were found in the extract of ear tissue on the injected side...* (from 1.789.2.5) and in *The response consists of cell multiplication...* (from 8,49.1.3). The latter case contains a referential *the* to an immediately preceding sentence *a response to the stimulus*; moreover, *response* has a required argument-indicator *to* which occupies the position of the "colon word class". In the former, we note first the explicit mention of *injected*; the ordinal in *on the 10th day* indicates an ordering in respect to some point, provided by a preceding *following the last injection* (1,789.2.1). In the later articles of this series, involving electron microscope techniques, it may be observed that the time-modifier on the ':' drops out and mention of the injection is infrequent (as being presumed and no longer needed as a reference point for time). Whether there are grammatical grounds for reconstruction of **GJB:** here requires further study. [18]

'Appropriate' arguments and operators have been reconstructed in the following sentences:

7,2.6.3. *Together with the synthesis of antibody by the lymph node a marked lymphopoiesis and increased output of lymphocytes was found.*

9,68.3.6 *The lymphocyte family of cells obviously cannot be exluded from participation in the formation of antibody, although under the conditions of our experiments its contribution was minor if present at all.*

In the former sentence, *increased output of lymphocytes* is represented by $\mathbf{CW}_{\mathbf{i}}^{\uparrow}$, which lacks an argument (note that *output* is *from* some **T**); the missing argument is provided by the preceding *the lymph node* (note the correlation indicated between synthesis and output). *Its* in the latter sentence is referential to *the lymphocyte family of cells*; the appropriate operator under *contribution* (**r**) is determined from the preceding *formation of antibody* ($\mathbf{AV}_{\mathbf{p}}$) and the weakly contrastive conjunction *although*.

The "shortened" variants of an elementary sentence type are sometimes not expanded – clear grammatical grounds may be lacking regarding which particular word of an appropriately specified class should be taken as occupying the vacant position. For instance, an $\mathbf{AV}_{\mathbf{i}}$ formula may be expanded in some case to $\mathbf{AV}_{\mathbf{i}}\mathbf{C}$. The formula $\mathbf{AV}_{\mathbf{i}}\mathbf{C}$ can represent distinct operator-argument relations among words in the text, e.g. *antibody is present in cells* (N_1 *VPN*$_2$) and *cells containing antibody* (N_2VN_1). In effect, the three symbol sequence $\mathbf{AV}_{\mathbf{i}}\mathbf{C}$ is indifferent to the internal operator-argument relations of the words which it represents. It might be possible to define a superordinate level of operator-argument relations directly on various word classes which would confer a precise character to the notion of sublanguage appropriateness. An inital step in this direction has been taken in the proposed rewrite system for the French corpus (Chapter 7).

Meta-scientific Material. With the provision of grammatical criteria for demarcating meta-scientific segments (partially supplied in section *1* of chapter 2), it is possible to seperate out such material in the projected units by extraction transformation (and others). Thus the **M** operator *supposed* in *If the plasma cell is supposed to be a highly active cell type* (from 3,128.3.4) is extracted in the transform *If it is supposed that the plasma cell is a highly active cell type*. The passive forms, e.g. *was obtained* (in 4,9.3.2), *was demonstrable* (in 8,54.4.1), *detectable* (in 9,61.1.2), *could be obtained* (in 10,316.2.7) may be depassivized, with *one obtained*, etc. then in the **M**-segment. In the examples above, *was demonstrable*, etc. may be considered a stylistic variant of *was demonstrated* – hence, depassivization does not alter (by extraction) the degree of assertedness.

Sentence Sequences. The next phase of research, for which a larger body of material is needed, will consider the conjunctions in detail. Here, it sufficies to note the following. Various "introducers" occupy conjunction position in the tables (preceding the triple bar). These may be considered as reductions involving two sentences. For instance, *therefore* in S_1, *and therefore* S_2 (the period may be considered a variant of *and*) may be reduced from S_1, *and for* S_1, S_2. Similarly, for *nevertheless*: S, *and nevertheless* $S_2 \leftarrow S_1$, *and despite* S_1, S_2 (GEMP 9.6). The absence of S_1 in many text-sentences can be considered the product of repetitional zeroing. In the concessive conjunctions, e.g., *but, except, only*, there is a high likelihood of matched component sentences; one of which has *everything* (*else*) corresponding to an N_1 in the other and one of the components containing *not*. In *these cells coccur* (sic) *nearly constantly in all lymphatic tissue-except perhaps thymus* (from 3,128.3.3), the second component is reconstructed to *these cells do not occur nearly constantly in thymus.*

Special sublanguage transformations may be constructed relating material in two (or more) text-sentences, though further controls are needed to determine, e.g. the appropriate conjunction.

NOTES

[1] The restrictive reading is obtained by a convention which reads the secondary sentence immediately upon encountering the word *vesicles*. The sentence *vesicles are abundant in immature plasma cells* is thus 'primary' only in respect to this convention and is not so in respect to a full derivation. For further discussion, see section *5*.

[2] Aside from instances of intransitive **W** operators (e.g, article 1,783.1.5), this convention applies only to the arguments or adjuncts of the main operator within a row; if the conjunction connects two different main operators, the sentence is expanded.

[3] Justification for this reconstruction: the environment **D—T** requires **V** although *change* in other environments is a subclass of **W** or **Y**. From *nucleic acids in lymph nodes* we reconstruct an appropriate verb *present* (or: *contained*) which is $\mathbf{V}_i$ and for which *in*, in this environment has strong selection. Just as a broad selection word like *amount* or *content* is a likely modifier of the appropriate verb *present*, *changes* is a likely modifier of *amount* under which the broad selection word is zeroed.

[4] GEMP 6.14 and T. Ryckman and M. Gottfried, "Some Informational Properties of Prepositions", *Linguisticae Investigationes*, V, 1981, 169-214.

[5] *Time, moment, period*, with their characteristic prepositions, occur as aspectual modifiers of sentences, indicating the durational or 'extendedness in time' semantic quality of the event of situation characterized by the main sentence verb. For example, while we might have *cell differentiation occurred throughout a period* referring to one or many cells, it is not likely – in texts of the period treated here – that we would find *cell differentiation occurred at a moment*

(or: *in an instant*) even with respect to observations of one cell. Similarly, *cell disintegration occurred throughout a period* is most readily interpertable as many cell disintegrations over a period rather than as the extended process of the disintegration of a single cell. Still, the relation of these aspectual modifiers to their verb is only selectional, i.e., a matter of more or less, and within the domain of a sublanguage of a science, it is foreseeable that new techniques and methods can upset previously established selectional regularities. For further discussion of aspectual modifiers, see the references cited in footnote above.

[6] In the projection of a text-sentence the aspectual modifiers of its composite elementary sentences are written within the (conjunctional) colon segment. This is a convention whose point is to indicate the grammatical status of the conjoining time-order prepositions as operators upon aspectual modifiers of sentences, rather than, as with other conjunctions, upon the sentences themselves (upon their main operator).

[7] For typographical clarity, the *wh-* is written as a superscript to the $:_t$, i.e., as $:_t^w$ rather than as a superscript to the symbol representing the aspectual word it is actually operating on, the t subscript.

[8] This is the case even if the connection to an initial time specifiable as that of the stimulation by (injection of) an antigen is not directly evidenced – as when temporal modifiers, e.g., *early, first*, occur in **V** or **W** operator categories, rather than on the temporal conjunction $:_t$. To take an example, *the earliest of the differentiating cells* (from paper 12,112.4.2) is reconstructed as 'the cells earliest differentiating from the hemocytoblast of the cells differentiating from the hemocytoblast' where the representation is $\mathbf{CY}_c^{w\text{-}f}\mathbf{C}_b$. This can be further expanded as 'the cells differentiating from the hemocytoblast at a time in the period after the injection; said time is earlier than all other times in the period after the injection when cells differentiate from the hemocytoblast'. In this way nearly all temporal modifiers may ultimately be reconstructed as operating of the aspectual modifiers of sentences which we include within the colon conjunction.

[9] "Word" includes here, as in GEMP 3.2, an operator together with its arguments. The *wh-* pronouning is performed on a word at the head of its (S_2) sentence: this positioning often involves an intermediate linearization of the sort discussed in *1* above and more fully in GEMP 3.1.

[10] The derivation given ignores the plural – thus, we use *some things* instead of the more accurate *something* – as well as the definite article. For details on *the*, see GEMP 5.36.

[11] Nouns which become left modifiers drop the plural; certain science nouns are adjectivized in the left-modifier position, e.g., *plasma cellular reaction* (← *reaction of plasma cells*), *cytoplasmic protein* (← *protein present in cytoplasm*).

[12] A departure from GEMP should be noted: the strong nominalizing suffixes discussed below are not derived via an intermediate O_o noun (ibid 2.043).

[13] The possibility of an alternative source is suggested by the analysis, consonant with operator theory, presented in D. Estival, H. Hiż, S. Kimball, and F. Seitz, "Information in Comparatives," Department of Linguistics, University of Pennsylvania, 1981.

[14] If *found* is extractable as a meta-scientific verb (via the passive), we have *X found agglutinin in an amount which is far more in the lymph node extract...* , where *in an amount* operates on an appropriately zeroed operator *present, contained.*

[15] For an instance of the appropriate reconstruction of *to a degree*, see 1,792.1.2.

[16] The comparative form, *some days later* and the like, which appears frequently in the position of the : conjunction is also not indicated here for reasons of space. In the formulas, the scope

of the comparative extends over the colon conjunction, **GJB:AV>T, GJB:AVT** (as opposed to **GJB:AV>T, AVT**). The choice between different scope representations requires a larger body of data than that surveyed in the present work.

[17] These forms are discussed further in GEMP 9.12 and in section 2.7 of "Report and Paraphrase," in *Papers in Syntax*, op. cit. Chapter 1.

[18] In the earlier articles (especially articles 1-6), **GJB:** is often reconstructed in the formulas (and occasionally within the rows), if the text-sentence contains some **GJB:** or if it contains a referential to a preceding sentence in which **GJB:** is present. The basis for such reconstructions is provided in the notes to the sentence.

CHAPTER 6

EXTENDING THE ANALYSIS: THE INFORMATIONAL ENVIRONMENT OF THE SCIENCE SENTENCES

1. INTRODUCTION

Identification of the word classes and sentence formulas characterizing the immunology sublanguage involved the demarcation of linguistic material specific to immunology from the other types of material in the articles studied. First of all, metascience material was separated from the immunology science sentence and given classification as **M** (above, p. 26). Second, sentences – generally, but not exclusively, from the "Materials and Methods" sections of articles – containing only one of the immunology word classes were not further analyzed, as they could not be used to show sentential relations among word classes specific to this sublanguage. The present chapter reverses this procedure: taking the word classes and sentence formulas of the science sublanguage as a starting point, we investigate the structure of the sentential material which forms the context of that sublanguage, and the connections between the latter and the former.

One motive for this is the desire to extend the analysis beyond the specifically immunological word classes and their relations. While **M** is formally a word class within the science language – a class of operators (verbs, conjunctions) on science sentences – in practice the analysis of the articles presented in the appendix to this volume uses **M** in an extended way as a classifier of all the non-science material in the sentences studied. (Thus in paper 9, along with the relatively simple *This paper reports...* and *correlates ... with...* [9, 61.1.1] – an **M** verb with its first argument and an **M** conjunction – **M** also covers such complex constructions as *These observations confirm, therefore, those of numerous investigators summarized below, and extend them one step further by the demonstration that in fact...* [9, 61.1.3].) This reflects no more than that detailed investigation of the metascience material was deferred while the work on the immunology classes and formulas went forward. The same combinatorial methods used in the analysis of the non-**M** material, however, make possible some progress in the direction of the definition of new word subclasses and word-class sequences characterizing the metascientific segments.

Similarly, a survey of Material and Methods sentences suggests that this material too has a definite structure (perhaps that of a sublanguage). An interesting byproduct of this survey is the discovery of a set of expressions characterized by words for magnitudes and relations between them.

These results suggest a second motive for this extension of the analysis of information structures beyond the immunology material proper: the possibility of casting light on the ways in which a scientific field of study, as represented by published papers, is constituted by the assembly of a number of distinct types of material – experimental techniques, observations, measurements and calculations, and various sorts of reasoning on the basis of data – into a unified whole. This is of particular interest for the light it may shed on problems about the structural character of scientific explanation.

While logical empiricism assumed the adequacy of an analysis of scientific knowledge in terms of theories, understood as interpreted logical systems, this approach has been largely abandoned in recent decades. In place of the logical empiricist attempt to formulate a "syntax of science" in terms of truth-functional logic, many philosophers have come to think, in Dudley Shapere's words, "that what is needed is a closer examination of actual scientific development and practice – of the jobs performed by terms and statements in their actual employment in science, and of the respects in which those jobs change and remain the same as science develops." [1]

This approach led to the development of the concept of "domain" (or "field") – a body of information bearing on a particular problem and utilizing characteristic methods of study – as a substitute for earlier analysis of science as made up of theories defined in terms of logically interrelated observational and theoretical statements.[2] But unlike the treatment of scientific theories as axiomatic systems, the concept of domain lacks precise definition in terms of the units of information and the relations between them which create the basis for such structures.

But precision is desirable above all in dealing with questions about the nature of science employing such concepts as "meaning" and "theory change". How are we to distinguish or identify as "the same" or as "different" various uses of key scientific terms? And how are we to identify the objects of study in the philosophy of science; to use Shapere's terminology, how are we to define the boundaries of a domain, establish the relations between domains, or discuss the relations between methods, concepts, and observations within a domain? Here the methods illustrated in this book seem to have much to offer. The research reported in this chapter is

intended to sketch, at least, some of the linguistic means by which sentences are grouped to state relations between facts, within a given domain of investigation or between related domains, and in the statement of scientific reports as wholes constructed of observation reports, background information, hypotheses, and conclusions.

2. Word Classes and Sentence Types

The metascience operators **M** were identified as operators whose second argument is a sentence and whose first argument is not the subject of that sentence (e.g. *shown* in *The present experiments have shown that the primary antibody response is severely depressed in such rats*). The second arguments of such operators are immunology sentences; the first arguments form a set **N′** (including, e.g., *workers, students, investigators,* names of scientists). Some of these **N′** have been taken to be first arguments of a class of operators **M′** (see p. 27 above), whose second argument is a noun of the science language. **M′** includes many operators typical of materials and methods sentences, such as *excise* in *We excised small pieces of red pulp.* **M** and **M′** were naturally classed together as metascience material given their sharing of **N′** as first arguments. For our purposes, however, it will be more useful to distinguish among various groups of these words and formulas, with the aim of constructing a more differentiated classification of the material in the immunology articles.

We distinguish four main types of sentential material, which will be discussed in turn:

1. Elementary fact sentences
1.1. Immunology sentences
1.2. Materials and methods sentences
2. Quantity sentences and operators
3. Science fact relations (operators on members of 1. and 2.)
4. Metascience operators and arguments

2.1. Elementary fact sentences

"Elementary" is here to be taken as relative to the description as a whole; they are those sentences on which the operators in the other categories

operate. Thus their status is peculiar to the immunology subscience and its sublanguage and are not to be identified with metaphysically atomic units.

2.1.1. Immunology sentences

These are the sentences instantiating the formulas of the immunology sublanguage, excluding metascience material and the colon connective, henceforth "L_i": sentence-types with operators and arguments from the L_i wordclasses (see p. 60 and, for greater detail, pp. 42–56 above. The sentence type involving the colon connective will be discussed in *2.3* below). These sentences are found in connection with sentences and connectives which are not part of L_i.

2.1.2. Materials and methods sentences

These are sentences consisting of arguments under first-order operators, which can come under the same higher-order operators, including the metascience operators, as the immunology fact sentences. For this reason they can also be considered "elementary" fact sentences. They typically have human first arguments, in pronominal or zero form; their second and third arguments may be immunology science words, although they need not be (as in *Plastic Petri dishes 5cm. in diameter were used*).

To the syntactic similarities with elementary science fact sentences correspond semantic ones. Like science fact sentences, the elementary methods and procedures sentences state facts (rather than relations between facts or assertions about factual statements). They are like metascience segments in that they are about experimenters' activities, rather than directly about the subject-matter of the field as narrowly defined. However, seen in relation to the other science-forms of the corpus, these sentences reporting the activities of scientific workers in manipulating materials in experimental situations appear as stating facts the report of which is integral to the report of the observational results of those activities. In other words, they describe the facts of science as an activity or process, while the immunology sentences describe the informational output of that activity. As we shall see, the two types of elementary sentences are classified differently, the former by *methods*, the latter by *results*. However, both are distinguished – one might say as facts – from hypotheses and conclusions drawn from the experimenters' results.

Further justification for treating these two groups of sentences as alike in their status as elementary fact sentences is the circumstance that the boundary between the methods sentences and those of *2.1.1* is not simple to draw. To take the most prominent example, L_i includes sentences like *The animal was injected with antigen*, instantiating the sentence-type **GJB**. This is in fact the most regularly appearing sentence type in the corpus considered, especially in conjunction with the type **AVT** under the colon connective. This is not surprising, since the effect of the **GJB:AVT** construction is to link the intrusion of antigen with the appearance of antibody, a linkage constituting the phenomenon with which the field of immunology is concerned.

On the other hand, *injected*, while it falls under the class **J** could also be seen, from the point of view of the subset of English found in the corpus of articles, as a member of the set **M′** of operators with first arguments from **N′** and second arguments from L_i (if we understand e.g. *Antigen is injected into animal* as reduced from something like *Experimenter injects antigen into animal*). Thus we find this sequence of procedure descriptions: *The antigens were prepared as follows: Typhoid bacilli ... were taken from an 18 hour nutrient broth culture, washed three times ..., heated, ... and then diluted ... 0.2 cc. of antigen was injected subcutaneously into the plantar surface of the hind feet of 2000 gm. Chinchilla rabbits ...* (Harris et al. [1945] 73.3.14). Here, *injected* appears as one of a sequence of procedure verbs. *Injected*, however, unlike the others, is not classified as a member of **M′** because of its special role in the **GJB:AVT** formula, a "macro" environment not shared by other members of **M′**. *Injected* appears also in another L_i class, marked **I**, chracterized by the context **C – B(B)** (see p. 33 above). In addition some articles outside the set described in this volume contain a word sequence typified by *the injection of adrenal cortical extract* [Eisen et al. 302.1.3]; here we have yet another sentence type containing *inject*, in this case with argument words (locally) synonymous with *hormone*. Given the distributional facts, we might eventually identify a new L_i word category **H**, treating *inject* here either as a subcase of **I** (which would thus require redefinition) in the structure **HIB** or as falling under **M′**.

Inject may thus play (at least) three distinct roles in the immunology corpus. From the point of view of English as a whole, all of these appearances can be thought of as reductions of an O_{nnn}, with human subject. As such they would be classified, in relation to L_i, under **M′**, since **M′** is not a class within L_i. (This situation is not unique to *inject*; it holds also for all the W_ℓ words for laboratory procedures, with **C** or **T** objects, which also

fall under **M′** when considered as having **N′** subjects. The descriptions of *inject* as **J** or **I** treat *inject* as an O_{nn} word within L_i: this corresponds semantically to treating the activity of the experimenter as taken for granted and inessential to the description.

The different uses of *inject* may be distinguished from each other by their argument classes and by their formula-defined synonym classes, and in the case of **J** by its role in **GJB:AVT**. Thus *inject* seems to be both several words in L_i and a word in the operator class **M′** distinct from L_i, although transformationally relatable to it. The homonymity of *inject*, as falling under several L_i classes, together with its homonymity as falling also within **M′**, may be understood as an indicator of the "interfield" character of the procedures and analyses providing the framework for injection. For example, the injection of hormone applies in immunological studies a technique developed in another area of biochemistry; but of course injection is a procedure used in many such areas (as in non-biochemical areas as well).

This sort of situation suggests the idea of a "methods and materials" sublanguage, definable by a closed set of word classes and sentence formulas (**M′** would then be the intersection of this sublanguage with the immunology corpus). To investigate this possibility would require examination of papers in a wide range of biomedical disciplines, laboratory equipment manuals, etc. Some of the operators which would be contained in such a sublanguage are found in English generally (*cut out*, *excise*, *collect*, *examine*), but in science texts have the sublanguage characteristic of appearing in highly restricted environments. Others (*centrifuge*, *lyse*, *titrate*), may be unique to various laboratory contexts. As such a "laboratory language" would be used for the description of techniques applicable to a number of related fields, we can imagine its sentence forms as involving classifiers, with arguments specific to the various sciences as classificands; thus *We inject a substance into an organism* would be the "laboratory-language" sentence related (within English as a whole) to *Antigen was injected into rabbits* by classification statements *Antigens are a kind of substance. Rabbits are a kind of organism.*

2.2. Quantity sentences

It is not possible at this time to give a detailed description of this group of sentences, but only to characterize it, and some sets of sentences composing it, in a rough way. What all these sentences share is the presence

of what we call "magnitude arguments", such as *volume*, *ratio*, *titer*, or of "magnitude operators", in particular *to a degree*. The magnitude arguments can be (provisionally) defined as words that can be first arguments under the operator *mounts to* (or *amounts to*) in the scalar construction discussed in GEMP 245ff. The operator *to a degree* turns certain verbs, especially in nominalized form, into magnitude arguments. Thus *dilute* often appears as an argument, as in *the dilution is to a degree* (Harris et al. [1945] 74.3.1). (As a result of this structure, we find (Harris et al. [1945] 74.4.2) *dilution was made* in place of the original *we diluted* form.) We therefore take *We calculated the dilution* (source of the *calculated dilution* of Harris et al. [1945] 74.3.60) as reduced from *We calculated the dilution-degree* ← *We calculated the degree of dilution* ← *We calculated the degree; dilution is to a degree.*[3]

This is obviously a definition, not on the basis of co-occurence relations within the immunology texts, but on that of structures observable within English as a whole. Much of this material occurs, in the immunology corpus, in the Materials and Methods sections, which were excluded from the analysis. However, my study of some of this material shows that the magnitude words, identifiable within English as a whole, are found in the present corpus in certain characteristic patterns. For example, only magnitude arguments will appear under the O_{nn} operators *is equal to*, *is greater than*, *is 25 times*, *is in ratio to*, *differ from* (see *4.3* below). There are also O_{nn} operators with N' first arguments such as *determined*, *calculated*, *derived* over certain magnitude second arguments (e.g. *volume*, *dilution*) and *measure* over others (e.g. *height*). Such patterns are sufficient to permit the detection of quantity words in zero form. For instance, in (7, 12.1.2) *the respective production of agglutinin is strikingly proportional to the percentages of large cells in the two fractions*, the phrase *is proportional to* may be taken as marking the presence of a missing magnitude word such as *extent* (with the sentence in its unreduced form being something like, *the extent of production, in respect to the two fractions, is proportional to the percentages of large cells in the two fractions*).

The fact that the magnitude arguments can come under the operators *greater than*, *equals*, and the like shows that they are classifiers for numbers (by way of the *mount to* operator); in the science sublanguage, at any rate, these expressions are equivalent to the $>$, $=$ of arithmetic. This is explicit in forms like *the titer was 1:64* (derivable from *the titer mounted to 1:64*). We have here, in other words, a complex system of sentence types including quantity measurement expressions and arithmetical statements, with number arguments and relational operators on them. While arithmetic may be

considered a sublanguage of natural language, it seems unlikely that there is a quantity sublanguage, although there are certainly regularities in English as a whole, such as *substances have volume* which is linked to *lymphocytes have volume* by the classifier-classificand relation stated in *lymphocytes are substances.* An important set of quantity sentences have $\mathbf{N}'$ first arguments (*we measured the dilution, we calculated the volume of cells*); these are a subclass of the Materials and Methods sentences discussed in *1.2*, and may be thought of as occurring in the hypothesized laboratory sublanguage.

In the description of L_i the quantity words appear as local modifiers on the central word-classes. For example, in 5, 204.5.2, *The difference in titers to the homologous and heterologous virus are clearly marked ...* is given the analysis $\mathbf{A^G V_i T_n^B}$ [differs from] $\mathbf{A^G \sim V_i T_n^B \sim}$ (I leave out the **GJB:** supplied to each of these conjoined segments as immaterial to the present point); that is, *has a titer* is treated as a variant of $\mathbf{V_i}$ and the comparative as a conjunction between two sentences, so that the quantity sentence *titer$_1$ is different from titer$_2$* disappears from sight. The informational point of the sentence, however, remains intact, in so far as the difference $\mathbf{A^G/A^G \sim}$ is correlated (around $\mathbf{V_i}$) with the difference $\mathbf{T_n^B/T_n^B \sim}$. In other cases the quantitative material does not disappear, as in 5, 205.1.3, containing *antibodies in higher titer in the local lymphatic system than in the serum*, which gets the representation $\mathbf{AV_i^{>} T^1}$ [*than*] $\mathbf{AV_i T_b}$. Here the difference in magnitude is represented by the $>$ superscript on the first of the $\mathbf{V_i}$s; the specific magnitude compared (*titer*) is missing, however. The upshot of this treatment of the magnitude vocabulary is to absorb it into the description of the relationships between the items making up the immunological domain. Information is not lost, when the articles are taken as wholes, as the information survives in its original form in the Materials and Methods sections, and in the Tables in which data is normally summarized. A consequence of this representation is therefore that information about measurement units, and about relations between quantitites is not treated as part of the language specific to immunology. Such consequences might be less desirable in the case of other sciences, e.g. ones in which quantitative relations play a more central role in the statement of the content of the sciences, as opposed to figuring in the methods used to arrive at substantive conclusions, as in the present case.

2.3. *Science fact relations*

So far we have discussed only elementary facts, that is, facts stated by the elementary sentences into which all immunological sentences can be factored. These sentences are combined with one another under a number of operators, which may be given semantic interpretation as expressing information about relations between the elementary facts. The two chief forms here are: modifiers (reductions of relative clauses) and relative clauses (reductions, via the *wh-* form, of semicolon with identity of reference); and a set of O_{oo} operators on pairs of sentences.

Relations of the first sort are relatively straightforward: two facts about an argument are said at the same time, as in *Antibodies first appeared in the afferent lymph 2 to 4 days after the injection of antigen*, which contains *Antibodies first appeared in the lymph* and *The lymph was afferent.* (The derivation makes clear the mechanism of correlation between the two elementary facts, namely the statement of the identity of reference between words in the two sentences: *Antibodies first appeared in the lymph, which was afferent* ← *Antibodies first appeared in the lymph; The lymph was afferent; Lymphs are same.*[4]) Correlation may be similarly expressed by use of the relative pronoun; thus 11, 165.7.1, *The observations reported here indicate that cells which are clearly shown to have produced antibody include plasma cells and lymphocytes.* In both sorts of case, two facts are correlated by their being facts about the same object.

The other main type of correlation may be described as a structure which relates two facts which need contain no common elements, formed by an operator on two elementary sentences. There is a long list of such operators, including *cause, is due to, is responsible for, is related to, is characterized by, corresponding with, produces, accounts for, coincides with, is dependent on, is associated with, when.*

A satisfactory subclassification of this set of operators is not possible at this time; not only is the sentence sample too small, but the distinctions between them undoubtably involve complex relations, so far unexplored, between sequences of sentences. One important subtype can be distinguished, however: operators specifying a time relation, commonly present in the form of the pro-word *when.* These temporal operators can be derived from a more fundamental structure, an O_{nn} operator stating a relation between two points in time.[5] Thus the familiar **AVT** *after* **GJB** can be derived from **GJB** *at* $time_1$; **AVT** *at* $time_2$; $time_1 > time_2$. This construction may be seen as a type of quantity comparison, like $rate_1 > rate_2$.

From this point of view, the temporal operators are a case of a general category of operators relating points in a space (a quantity space, a time space, etc.)

Time information may be present in affix form; thus in Harris et al. [1945] 73.1.3, *This antibody formation was preceded and accompanied by a rise in the ouput of lymphocytes in the efferent lymph* ... Here the *pre* and *ac* may be taken as reductions of *at a time* > *the time* and *at a time* = *the time*, respectively. Other members of this group are *subsequently* (4, 11.2.1), *preceded* (4.11.2.3), *when* (6.164.3.3), *on the 5th and 6th days [after]* (6,164.5.2, and perhaps *concurrent with* (9, 67.3.4). It is to be noted that *when* appears as an operator relating two facts in uses other than the literally temporal, for example in 13, 463.4.2, *They were called lymphocytic when free ribosomes were the main constituent of the cytoplasm* .... This is not another, nontemporal use of *when* but an extended use of the underlying *time.*

The remaining correlation operators relate facts without specifying a space, as in 4, 11.1.3, *The appearance of more mature cells was associated with an increase in the antibody content of the culture fluid.* While the distinction between time relations and more abstract correlations is syntactically clear in individual sentences, because of the presence, even in zero form, of the time relation, the difference between correlation and causation cannot be stated – at least on the basis of the current sample – in terms of features of single sentences, but is a matter of the function of sentences joined by the operator in relation to other sentences, and by semantic relations between words. A simple example is 5, 204.2.2, *The enlargement of the node is due to lymphocytic hyperplasia which is at first diffuse and then becomes organized into the characteristic follicular structure.* In formulaic terms this is $\mathbf{T_nW_g}$ *is due to* $\mathbf{C_yW_i}$, together with $\mathbf{C_y^+W_i}$ *and then* $\mathbf{C_y^+W_c^+T_f}$. The explanatory force of *is due to* is explained by the meaning relation between $\mathbf{W_g}$ and $\mathbf{W_i}$, together with the likely existence of some sentence asserting a relation between $\mathbf{T_f}$ and $\mathbf{T_n}$. (In more traditional terms, while a correlation need state no more than the joint occurence of some pair of facts, a causal statement involves the statement of some "mechanism" connecting the two.) On the other hand, the existence of a distinction is explicitly stated in one text: Craddock 170.1.1, *In the present series the same decline in the total lymphocyte content of lymph per unit of time after cannulation was noted but was not felt to be a result of adrenalcortical hormone administration* (where *cannulation* = *hormone administration*).

It may be that in the case of these operators we are dealing with elements of English, although the restrictions on their use in science material may

be tighter than in the language as a whole (in science contexts we do not find sentences such as *He associates with a large group of people* or *She doesn't relate well to them*). They are certainly common to several scientific fields, and it is for this reason that we refer to them as "science fact relations."

There is a subset of this material which appears within L_i: this contains those operators which fall in the colon class :. As explained above (p. 33–34), : is defined by its occurrence between **GJB** and one of **TW, CW, AVC, AVT**. Given the central importance of this structure, : is taken as an "intra-formula word class" rather than as a conjunction (above, p. 16.) The colon class includes examples of all the types of operators discussed in this section: *wh-* conjunctions and pronouns; *after, following, prior to*; *produce, results after, give rise to, is stimulus to.* Here again, as with the **M′** words incorporated into L_i discussed under *2.12* above, we have material which might be classified both as outside and as within L_i. Alternatively, as with the other case, what we have here is a change in the status of words when they appear in a certain sublanguage context. In many sentences of immunology articles, the correlating operators function as external elements, i.e. they do not repeat as co-occurrents of other L_i words. But **GJB – AVT** (etc.) is an environment in which many relational words appear, so that they can be collected into a class. As such they enter into formulas for a type of extended sentence, which plays a role in the texts as a unit (the "macro sentence" of p. 60). They are thus given a special sublanguage status over and above their place in the grammar of the language as a whole (or of some scientific subset of that language).

The case of the colon therefore appears to be the opposite of the normal case of the relation between sublanguage and English, where the sentence form in the latter (e.g. NVN) is an envelope of various sublanguage formulas (e.g. $N_iV_jN_k$)).[6] In the present case *S:S* (where *S* is any elementary sentence) includes what are from the viewpoint of English distinct subclasses of the bisentential operator. It is possible that, as analysis of inter-sentence constraints proceeds, the colon class may be replaced by conjunctional subclasses, so that the macro formulas would be replaced by a set of more restricted formulas. On the other hand, it might be the case that both such subclasses of operators and sequences like **GJB:AVT** as wholes play significant roles in L_i; this would mean that the structure of the sublanguage becomes more complex above the level of elementary sentences.

2.4. Metascience operators and arguments

The material discussed so far consists of (a) elementary science sentences, (b) elementary materials and methods sentences, (c) quantity sentences, and (d) sentences formed by members of (a)-(c) under certain O_{oo} operators repesenting relations between them. We now consider a class of material based on a group of O_{no} operators, with sentences of types (a)-(d) as second arguments and **N′** first arguments. This material is used to state relations between scientists and their work, on the one hand, and between the materials, methods, and results of that work, on the other. Calling these metascience operators, I call all the sentences which can be their arguments science sentences (thus including under this heading some forms called metascientific in earlier parts of this book). While the material available for analysis at this time is, again, too small for more than sketchy results, it has been possible to group the metascience material into a few word classes and formulas which form a closely interconnected set.

The metascience O_{oo} operators **M** include *show, deal with, report, notice, call attention to, describe, establish, give an account of, demonstrate, give evidence of, find, conclude, report, indicate, observe, contend, believe, reveal, suggest, throw light upon.* Their second arguments are fact sentences, generally under science or quantity relation operators; their first arguments are generally members of the set **N′**, including *experiment, investigation, study, paper, table, these authors, the present writer, students*, names of authors, such as *Ehrlich, Fagraeus.* Typical examples are 1, 803.4.2, *Matko described marked changes in the lymph glands within 3 days following vaccination with typhoid "vaccine"* and 5, 204.2.1, *The data presented show that following the injection of inactivated influenzal virus into the foot-pad of rabbits there is a general burst of activity of the local lymphatic system ....*

N′ includes both names and titles of scientific workers and nouns denoting their work. This usage appears also in citations, as in *a development suggested by Nossal et al. (25)* (in Gudat et al. [1970], p. 472) and in bibliographies. Such names and nouns, that is, seem to be locally synonymous and distinct from the human subject of the **M′** operators (it is noteworthy that the **M′** verbs almost always occur in passive, subjectless form). On the other hand, there are exceptions. For example, 1,801.4.1 contains *Pfeiffer and Marx titrated the bacteriolysin content of various organs* ... and 1.801.4.2 continues, *They reported the antibody titre in the spleen, bone marrow, lymph, glands, lungs, and blood.* Here the same noun, *Pfeiffer and*

Marx (appearing once as *they*) seems to be both subject of the **M′** verb *titrate* and the **M** verb *report*.

A simple solution is to derive such forms as *Pfeiffer and Marx* from *papers by Pfeiffer and Marx* (with *paper of* and the like zeroed under conditions of high likelihood). This allows us to take the word class **N′** as consisting of classifiers for sets of sentences, namely the sentences in (the named) articles. This identification is strengthened by the fact that a subset of **M** (including *indicate, show, suggest, confirm, points to, demonstrate*) occur with fact sentences (singly or under science or quantity relation operators) as first and second arguments, as in 4,9.1.1, *20-25 minutes after the injection of bacteria, the total bacterial content had in most cases fallen considerably and at a greater rate in the red than in the white pulp, indicating that the bacteria perished more quickly in the red pulp.*

The **M** operators, therefore, state relations between facts or between the groups of facts reported in whole articles (**N′**) and facts stated by sentences or groups of sentences within articles. These science sentences, second arguments of **M**, are classified by words in the groups which **I** call **R** and **P**. **R** contains *results, data, observations, evidence, findings*. Since the sentences classified by **R** (and **P**) words are sentences of articles, they form subsets of the sentences classified by **N′** words. This is said explicitly in phrases of the form **N′** *has* **R**, as in *Results of this study show that...* (Harris et al. [1945] 73) as well as in reduced form in the section heading *Results*, presumably from something like *This article has results (as follows)*. **R** words are distinguished from **N′** words by their appearing as arguments under a second group of metascience operators **E**, which take nominalizations of some **M** words as second arguments (see below).

R words also appear in sentences like *The results are summarized in Table 2*; other contexts for *results* are *are shown in table, can be seen in table, is demonstrated in figure, is illustrated in figure*. The function of *results* as a classifier can be seen in the form *It appears from Table X that...* in which a sentence argument takes the place of *results*. In the case of sentences of the form **R** *are shown in Table X*, the function of the classifier is to relate sets of sentences to non-language material containing the same (in whole or in part) information in the form of numerals, reproduced photographs, or other illustrative figures.

Similar to **R** is **P**, the set containing *methods, materials and methods, procedure, technique, test*. These are words which classify sets of the materials and methods sentences of *2.1.2, such as Rabbits were injected with antigen, The lymph node was excised, Cells were washed in solution, He calculated the*

volume of the cells, and classifiers of sets of such sentences, such as the sentence nominalization *electron microscopy*. As with **R**, I hypothesize a source of the section heading *Methods* in *The experiment employed (the following) methods* or the like.

Both **R** and **P** words are used not only to state relations between subjects of **N′** words, but also (together with other heading words like *discussion* and *summary*) to impose a structure on the group of sentences constituting an article. The grouping together of sentences into sections classified by *Introduction, Methods, Results, Discussion* is a product of scientists' adherence to a standard form for the writing of papers, a form with clear functional justification. However, our sentence types are not simply produced as artifacts of this formal standard, as is shown by the fact that the match between sentence types and article subsections is not an exact one. For instance, **N′ M** *that* ... sentences appear in both introductory and concluding sections; result sentences can appear at various points, as can method sentences. Rather, these sentence types seem to correspond to types of information, and it is this in fact which provides the basis for the standard organizational structure.

While the classifiers **P** and **R** articulate an article into informational areas, these areas are linked together by the sharing of word classes among the formulas. Beyond this, we find co-occurrence likelihood relations holding between members of the word classes for which these classifiers are referential. There are correlations between words used to describe methods, results, and theoretical hypotheses or conclusions. Thus an article like Dougherty et al. [1944], with method sentences such as *titers were done* has result sentences listing and comparing titers, while articles such as Harris et al. [1966], with methods sentences classified under *electron microscopy* contains result sentences describing kinds of cells found in preparations and their sizes.

Finally, there is an important group of metascience operaters that we call evaluative or epistemological operators **E**. These take science sentences or classifiers of them as first arguments and nominalizations of certain members of **M** (most commonly *conclusion, hypothesis, suggestion, finding*) as second arguments. **E** includes *strengthens, is consistent with, supports, confirms, substantiate, emerge from*, as in *The demonstration that they individually contain antibody confirms these observations* (8, 57.5.3). The nominalized **M** ($\mathbf{M}_{\mathbf{nom}}$) words are referential for (and may be taken as transformations of) sentneces such as **N′** *hypothesized that* ... and **N′** *contends that* .... It is possible that this referential link will aid in distinguishing subclasses within

the **E** class which are relevant to the epistemological status of the information presented. The difference between sentences like *McMaster and Hudack gave unequivocal evidence of the direct importance of lymphoid tissue in antibody formation* and sentences like *Harris and co-workers contended that the spleen played the major role* may correspond to a restriction on those words of the **M** class which appear in nominalized form under **E** in **R E** $\mathbf{M}_{\mathbf{nom}}$ and $\mathbf{N}'$ **E** $\mathbf{M}_{\mathbf{nom}}$.

Related to the $\mathbf{M}_{\mathbf{nom}}$ is a set of sentence modifiers, such as *probably, in fact, demonstrably, possibly, may be, is true, likely, is a fact*,[7] in structures like *So far we can only state that the possibility that ... is just as good as the possibility that ..., We therefore consider it improbable that ....* Such modifiers on a sentence *S* may be derived, following GEMP (pp. 305ff.) from a pair of sentences, for example *Probably S* ← *S, which is probable* ← *S*; *S is probable.*

This group of operators is metascientific, as operating on elementary science sentences. Like the other metascience words, they cannot be considered part of L_i, but are either part of English or (in scientific texts) of some restricted subpart of English. Semantically, they are about the elementary sentences, expressing degrees of assertion of them, with *is a fact* (equivalent to Frege's ⊢ operator?) at one end of the scale and a fuzzy boundary (*is highly probable* and the like – we have not encountered *is possible*) at the other. Assertion in this sense should be distinguished from the metalinguistic *I say*,[8] which only states that a sentence is said, not that it is asserted as true. Distinguishing degrees of assertion will require detailed investigation of co-occurrence patterns of these operators in sequences of sentences.

3. Conclusions

While it is obvious that any conclusions to be drawn here as to the linguistic representation of scientific domains will be fragmentary and tentative, some points emerge. (1) To begin with, the world as represented in immunology texts is a world of facts and not of things: first order arguments occur only under operators. We can distinguish a set of facts peculiar to immunological discussion as stateable in the sublanguage L_i; disregarding for the moment the "macro" structures involving the colon operator, these are the elementary science sentences of *2.11*. These are combined with each other, and with elementary sentences describing materials and methods

(with quantity measurements and manipulations perhaps a subset of these) into more complex structures.

The fact complexes turn out to be only in part formed by the truth-functional operations *not, or, and* (in some uses). In addition to various contrastive conjunctions (e.g. *however, nevertheless*), whose meaning is not fully rendered by translation into logical *and*, and argument-tracing ones (*so, thus*, etc.) distinct from logical *if ... then ...*, there is the large set of operators stating science fact relations, which are crucial to scientific argumentation. There are also the last-discussed group of metascientific operators, with a range of informational effects not formalized by the "possible/necessary" dichotomy of modal logics (and indeed far closer to statements of probabilities). The metascientific operators are generally not truth-functional but present to logical analysis the well-known difficulties of oblique contexts or "propositional attitudes". All this reflects the fact that natural language is a much richer system of representation than logical calculi, at the most general semantic level because sentences are mapped not onto the two values true/false but onto a range of acceptabilities.[9] Of course, logical structures are to be identified in natural language discourse, as in all cognitive activity. The question as to their relation to the other sorts of structures involved in scientific work must await a more thorough analysis of the types of discourse structure to be found in science.

(2) There is a clear distinction between scientific and metascientific material, which is formulable in purely syntactic terms: the metascientific material is to be found in operators over science sentences (and conjunctions of these). Since science sentences can be distinguished from their discourse environment as expresions in a particular sublanguage, there is even a strict meta-/object-language distinction to be made here such as is not present in language as a whole, which contains its own metalanguage. (This points up the metascientific character of the classifiers **R**, **P**, etc.: in statements of the type *The observation that ... confirms the hypothesis that ...* the judgement that **R** *confirms* $\mathbf{M}_{\mathbf{nom}}$ is made in English (or a fuzzy subset of English) about two elementary sentences in L_i classified, respectively, by **R** and $\mathbf{M}_{\mathbf{nom}}$.) At the same time, it is clear that metascience material, while distinct from L_i, is not outside science, or even the subscience of immunology, but plays a fundamental role in articulating and organizing the information specific to or relevant to that subscience, by providing classifiers and argument structures.[10]

(3) This leads to the question of the determination of boundaries of scientific domains or fields and of their relations to neighboring domains,

background information, "interfield theories", and the like. If we are to use a term like "domain" in Shapere's sense (see p. 152 above), it is already clear that it would be erroneous to identify the domain of immunology with the universe of facts describable in terms of L_i. Indeed, a description of immunological research reports which excluded the matters covered in Materials and Methods sections, on the one hand, and information about the metascience (evidential, epistemological, modal) status of science statements, on the other, would fail to represent the full body of material which a student wishing to master the field of immunology would be expected to learn.[11]

On the other hand, the work reported in this book demonstrates the existence of a sublanguage, L_i, whose sentences, as forming a set closed under the (transformational) operations of natural language as a whole, can therefore be thought of as carrying a particular body of information. We might identify this body of information as the "core" science language of immunology, by reference to which definite roles can be assigned to material entering immunology texts from other sublanguages or from the language as a whole. For example, "laboratory language" sentences are integrated into the language of immunology by two means: (1) the use of laboratory sentences involving members of L_i word classes (e.g. *We injected antigen into the popliteal lymph node*), in which case we may speak either of an intersection between the laboratory language and L_i or, as suggested above, of a classifier-classificand relation linking the two; (2) the classification of nominalized methods sentences, in which most of the methodological material not specific to immunology is found, under **P** (and also under **R**), classified in turn under **N′**, and so with the immunology texts as wholes.

Similarly, information about relations between facts, where those relations are not peculiar to immunology as a subscience, are brought into immunology accounts (1) as higher-order structures within L_i (the "macro" formulas). which may be described as an intersection of L_i with sets of (science) language structures; and (2) as structures in which metascientific operators have L_i sentences as arguments, or in which L_i sentences are given evidential or epistemological status by being classified as data, questions, results, or hypotheses.

In this way facts constituting a domain are related to each other both by the information structures peculiar to the domain (and defining its core, as represented by L_i) and by more general structures representing information about experimental and theoretical manipulations. The "syntax of science", so understood, suggests also an approach to another central

concern of the philosophy of science, the analysis of meaning change in the development of scientific domains. While it is more than likely that there are important differences in this regard between different sciences, we can show in the case of immunology how, for example, the reclassification of plasma cells and lymphocytes was accomplished in such a way as to leave undisturbed the reference of the two terms (since the cells were identified by features) and the contexts of their use (except those touching on the relations between them). Thus an apparent conflict is resolved in a manner which both preserves existing sentence types and adds new information (in the formula **CYC**), while reorganizing the relations between items of information.[12] We catch in this a glimpse of the way in which science develops, not by the accumulation of facts, but by their redefinition and interrelation into structured bodies of information.

NOTES

[1] Shapere [1984], p. 29.
[2] See Shapere [1984], chapters 13 and 14.
[3] *To a degree* is here treated by analogy with the treatment of *to a bit* in **GEMP**, p. 220, with *degree* zeroable as highly likely in contexts like that provided by *calculate* and *dilution*.
[4] See GEMP, pp. 120 ff.
[5] See GEMP, pp. 191-3.
[6] See Z.S. Harris, "Discourse and Sublanguage", pp. 231-236 in Kittredge and Lehrberger [1982], pp. 236, 235.
[7] For a similar list, see above, p. 43.
[8] See GEMP, pp. 98 f.
[9] See Harris [1965], p. 203.
[10] This was clearly anticipated by Carnap [1937], pp. 328 ff.
[11] See Golub [1981], p. xi, in which "an up-to-date overview of the biology of the immune response" is held to require illustration with "as many points as possible of experimental design, as well as" with descriptions of "the rationale and, when possible, the historical sequence of the experiments."
[12] See above, Chapter 4, section *4*.

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CHAPTER 7

INFORMATION UNITS IN A FRENCH CORPUS

1. INFORMATION GRAMMAR AS A PATTERN-MATCHER ON SENTENCES AND LINEARIZATION RULES TO PRODUCE SENTENCES FROM INFORMATION UNITS

We shall be concerned here with a procedure for recognition of informational units in parts of articles in French by A. Bussard (1972), P. Grabar (1953), and A. Gustavo and A. Ficq (1954) about the origin of antibody production. We also present rules of linearization which permit us to produce sentences from information units. The fact that it was possible to use the informational categories originally designed for the English corpus, without any addition or modification, is in itself an a posteriori confirmation of the results presented in Chapter 2.

In this chapter, we start from the existence of an informational structure common to the articles belonging to the same well-delimited subdomain and we show that using the "grammar" of informational units, after it has been made explicit in terms of an applicative structure (this notion will be explained below), rather than using the grammar of sentence formations, provides an efficient method for the informational recognition of texts. This method includes the recovering of implicit textual information, such as the reconstruction of antecedents of pronouns and ellipsis. Moreover, given the way informational categories were constructed, this method will apply to articles in various languages, provided they belong to the same scientific subdomain, without preliminary sentential transformations and without restructuring rules from sentences structure to units structure.

Usually the order in which words appear in a sentence does not correspond to the order of informational categories which represent them in a unit. The order of application of categories in informational units is independent both of word order in actual sentences and of operator entry order in the linguistic structure subjacent to actual sentences (as defined in GEMP). If we add linearization rules to the grammar of informational units, it is possible to produce sentences from units. We give here the linearization rules for producing French sentences. These rules depend both upon the application status of categories and upon lexical properties of the

corresponding French word expressions. Word order can differ in French and English sentences. These differences can be accounted for by using a pair of arrows indicated specifically in French or English expressions in the respective dictionaries of categories. It can be expected that the behavior of the arrows, according to the applicative status of categories, will not vary in the linearization rules for the different languages.

2. An applicative grammar of informational units

2.1. How the construction of categories from word class combinations, in sentences in scientific texts, expresses both the specificity of word use in that domain and a notion of correctness in informational units

As shown in Chapter 1, the notion of meaningful sentences in our corpus is sharper than it is in every-day language. Words, even if they can have more than one use, are often used in a technical sense which is either explicitly defined or else reveals itself through combinatorial restrictions with other words. For example, somebody who knows nothing about immunology could ask the question: (a) *Do antigens produce antibodies*? But an immunologist will never formulate such a question, and if asked it, will correct the use of words in his answer, saying for example: (b) *An injection of antigens produces antibodies formation* or (c) *Some cells produce antibodies after antigen injection.* Sentences (b) and (c) are meaningful in that domain, as they refer to experiments which can be reproduced or falsified depending on which cells are involved and on a preliminary definition of the couple antigen/antibody. In contrast, the question (a), which is an acceptable question in ordinary English, does not belong to our subdomain.

As explained in Chapter 1, the construction of informational categories (e.g. **V**, **A**, **C**, **J**, etc.) results from the classification of word class distribution in sentences which are actually found. Assuming that the sentences appearing in our corpus are always meaningful, the rules of informational combinations represent exactly constraints on word combinations, such as the acceptability of (b) and (c) versus the unacceptability of (a).

In everyday language, acceptability of a sentence is not a binary notion, as is explained in GEMP. Here, acceptability is a binary notion because the selectional properties of informational categories (e.g. the category **V** can select the pair **A**, **C** but not **G**, **C**) correspond either to established facts or to the immunologists' description of reproducible experiments at a given

time. The acceptable word class combinations in the subdomain are exactly represented by the selectional properties of categories. We call the selectional properties of categories the grammar of informational units.

The relevant linguistic aspects in the coding of texts with informational units are essentially the way word class combinations are constrained and, as a consequence, how these contraints change in parallel with knowledge acquisition. We are not concerned with all the syntactical means by which a language can produce meaning effects. These remarks could seem obvious but they are of practical interest, as we shall use the grammar of informational units, and not the grammar of French sentences, to recognize units from sentences, or more precisely, from the *relevant word sequences* which can be extracted from sentences.

2.2. The contextual meaning of words in sentences is accounted for by deterministic categories in units

We account for the contextual nature of interpretation in French sentences in a deterministic way, introducing as many informational categories corresponding to a given word as there are different technical uses of it (in the sense defined above). For example, the word *lieu* (meaning *place*) has to be interpreted as *une cellule* (*cell*) when used in expressions such as *lieu de la synthèse des anticorps*, *lieu de stockage des anticorps* (Bussard's paper). But it means a tissue in: *le lieu où se fait l'injection d'antigènes*. The word *comporter* has a very different meaning in: *cette technique comporte des inconvénients* (here a metalinguistic M sentence) and in: *cette cellule comporte des polyribosomes groupés en rosettes*, where *comporte* will be represented by $\mathbf{W_i}$.

We must distinguish *augmentation* in: *l'augmentation numérique d'une cellule* ($\mathbf{W_p^+}$) and in *l'augmentation en volume d'une cellule* ($\mathbf{W_g^\uparrow}$), *l'augmentation de la capacité à synthétiser* ($\mathbf{V_p^{k\uparrow}}$).

We must also distinguish the difference in the meaning of *intermédiaire* in: *une expérimentation intermédiaire* and in *une cellule réticulaire intermédiaire* which means an immature cell ($\mathbf{C_r^{m\sim}}$).

And we must also distinguish *se développer* in: *les lymphocytes se développent dans le tissu lymphatique* ($\mathbf{W_p}$) as opposed to: *les lymphocytes se développent en plasmocytes* ($\mathbf{Y_c^t}$) or *les cellules réticulaires développées réagissent...* ($\mathbf{C^m}$). As the reader will see from the tables, this situation is quite common.

On the other hand, words having *a priori* different meanings can be very close, or even identical, in informational content in our universe of

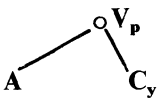
discourse. For example, usually *lignée* does not mean *cellule*, but *cellules lymphocytaires* and *lignée lymphocytaire* have a related meaning when one speaks of the various stages in the evolution of a lymphocyte. *Fixation* and *digestion* can be closely related in this corpus when one is talking about antigens and tissues.

Disambiguation of linguistic expressions is achieved through introduction of categories having specific selectional properties. The categories are defined in such a way that the representation of a word, which is not listed in our dictionary (i.e. the list of categories and corresponding actual words) as belonging to an elementary category, depends on what are the elementary categories recognized in the same sentence.

Actual words represented by the same categories in our dictionary can be taken as having a similar informational content when they co-occur with words represented by the proper argument-categories of that category. This defines a contextual criteria of synonymy which could not have been defined using intuitive semantic criteria.

2.3. The applicative status of categories and the applicative structure of units

The intuitive signification of the applicative status of informational categories or of words is the dependence relation of meaning among word-expressions in a sentence, or among categories in a unit. For example, the meaning of elementary (or zero-order) categories like $\mathbf{T}_n$ for *lymph node* or $\mathbf{C}_z$ for *plasmocyte* does not depend on other words, but the meaning of *produire* or *se developper* depends on other words in the sentence. We can represent this dependency relation on the meaning of words by applicative dependencies in sentences, for example, *produire* as an operator on two arguments. We can also say that we represent *produire* by a non-elementary informational category which will be determined following its argument categories (e.g. on **A, C** it is $\mathbf{V}_p$). The applicative structure of the unit $\mathbf{A}\ \mathbf{V}_p\ \mathbf{C}_y$ can be represented by the scheme:



This unit could represent a sentence like: *Les anticorps* (**A**) *sont produits par* ($\mathbf{V}_p$) *les lymphocytes* ($\mathbf{C}_y$). In that case, the sentence has a structure which parallels the structure of the corresponding unit. But we shall see below that usually this is not the case.

The application of a non-elementary category is defined for an explicit selection of categories. These selections of argument-categories are stated in the English dictionary of categories (e.g. **V** operators selecting **A** as first argument and **S** or **C** or **T** as second argument). Superscripts can be considered as 2-order categories selecting a l-order category as argument. Their respective selection of categories is stated explicitly in the French dictionary of categories. The operator :, which selects two units, can be considered as a 3-order category. (The explicit constraints on unit formation are stated and explained in chapters 1 and 2).

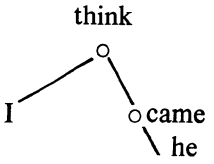
2.4. Applicative structure of a unit and linearizations

In arithmetic, the division function of two numbers has a value which depends on the value of its arguments. The rank of arguments is strictly determined in respect to the operation of division and similarly for the application of informational categories. For example, the order of argument in the notation 0/3 or $\mathbf{C}\ \mathbf{V}_{\mathbf{p}}\ \mathbf{C}$ is a matter of convention but once an order is chosen we cannot permute the arguments (the meaning of 3/0 or $\mathbf{C}\ \mathbf{V}_{\mathbf{p}}\ \mathbf{A}$ is undefined). In sentences which express 0/3 some changes of word order can be obtained without altering the meaning of 0/3: for example, *the division of zero by three* or *zero divided by three*. The same is true for sentences which express $\mathbf{A}\ \mathbf{V}_{\mathbf{p}}\ \mathbf{C}_{\mathbf{z}}$ (examples (1) to (8) in section *3.1* below). We shall say that all these expressions are linearizations of the same applicative informational structure represented by the scheme (i) above.

The linearization of an applicative structure, either informational or sentential, can be considered as a way to read the items occuring in that structure, that is a superficial order as compared to the applicative order itself. For example, intuitively, the permutation in examples (1), (2) and the permutation in examples (3), (4), do not correspond to the same operation:

(1) *I think he came.*
(2) *He came, I think.*
(3) *John ate a snake.*
(4) *A snake ate John.*

From a more formal point of view, we say that (1) and (2) are two different readings of the same applicative structure, roughly represented by:



But (3) and (4) have different applicative structures, roughly:

Very often the applicative structure of a sentence can be linearized in several ways, depending on lexical features proper to a language. Even if the meaning of the resulting sentences can be slightly affected by the linearizations, their interpretation is the same (e.g. the way words are combined in order to get a meaning).

It should be stressed here that linearizations of units structure should not be confused with the linearization of sentence structure. The examples (1) to (8) in section *3.1* below are not linearizations of the same sentence structure but linearizations of the same unit structure. The important point is that linearizations of an applicative structure, either sentential or informational, do not change the operator-argument relations in the sentence structure or in the informational unit. Linearization rules are used to produce sentences from units. We show in section *3* that it is not necessary to use them for recognizing an information unit from a sentence.

The order of application in informational units is independent both of word order in actual sentences and of operator entry order in the linguistic structure of sentences. The pattern matchings we define on lists of categories will not restructure or transform the applicative order of words in the linguistic structure of a sentence. It will associate directly an informational structure to sequences of relevant linguistic expressions in sentences.

3. USING THE GRAMMAR OF INFORMATIONAL UNITS AS A PATTERN-MATCHER FOR A DIRECT RECOGNITION OF INFORMATIONAL UNITS

3.1. Avoiding preliminary transformations on the structure of sentences, and operations from sentence structure to unit structure

The applicative structure of the units and the applicative structure of the sentences are independent. This difference is related to the fact that only the "relevant" information of the sentences is represented in the units. In particular, the argument-words of an actual word are not necessarily the argument-categories of the corresponding category. For example, *a injecté un antigène dans l'oreille des lapins* (section *3.2* below). The person who is injecting the antigen is not relevant here and when the name of the author of the experiments is explicit, it is stated anyway in an **M** sentence such as: *X a montré que...* or *X a observé que ....*

We distinguish the applicative order of categories in a unit and the order in which the words corresponding to different categories occur in a sentence. The order of word occurences in an actual sentence is a linearization of a unit. The following sentences, which have a similar informational content, would be represented by the same unit $\mathbf{A}\ \mathbf{V}_{\mathbf{p}}\ \mathbf{C}_{\mathbf{z}}$:

(1) *Les plasmocytes sont producteurs d'anticorps.*
(2) *Les plasmocytes produisent des anticorps.*
(3) *Des anticorps sont produits par les plasmocytes.*
(4) *Des anticorps sont produits dans les plasmocytes.*
(5) *La production plasmocytaire d'anticorps a été établie.*
(6) *La production d'anticorps par les plasmocytes a été établie.*
(7) *La production d'anticorps qu'on observe dans les plasmocytes, a été établie.*
(8) *L'origine plasmocytaire de la production d'anticorps a été établie.*

The linguistic structures of these examples are very different. For example, contrary to *plasmocyte*, *plasmocytaire* has the status of a non-elementary argument as an actual word, and sentence (5) will be represented by a rather complex structure. The cost of defining all the necessary transformations would be very great. These transformations are permutations, zeroings and insertions of actual words. For example, we could relate sentences (2) and (3) or (4) by using a transformation which permutes the

arguments *plasmocytes* and *anticorps* and adds a passive morphology plus a preposition *par* or *dans*. In this example, *dans* and *par* can be considered as variants, but this is not always the case. More generally, the possibility of having these eight paraphrases depends on lexical and semantic properties. It cannot be generalised to all sentences represented by units. This means that such transformations would be rather ad hoc devices. In fact, we are not obliged to use the complete linguistic representation of sentences in order to define the way they are to be associated with units. We can use our informational representation itself, that is, the fact that only relevant words or word-expressions are transformed into categories. All the sentences which are represented by the same unit can then be considered as having a similar informational content in this sublanguage, which does not imply that their sentential structures have to be related.

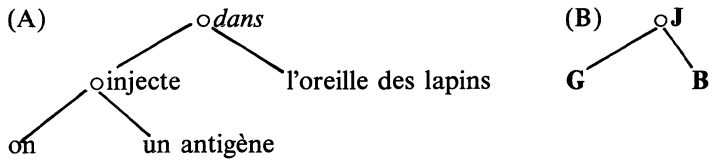
Further, one can extend this list of actual sentences represented by $\mathbf{A\ V_p\ C_z}$, $\mathbf{V_p}$ can also represent words which are not morphologically related to *produire*, e.g. *synthétiser* or *former*. We could not use the same notion of transformation to relate actual sentences which do not contain morphologically related words in the $\mathbf{V_p}$ position.

The argument order of an informational category is independent of the argument order of actual operator words it can represent because, due to their respective lexical properties, these operator words don't always have the same arguments in the same position. For example, the following sentences are represented by the same unit $\mathbf{A\ V_i^+C_z}$:

Les anticorps existent en nombre élevé dans les plasmocytes.
Les plasmocytes contiennent des anticorps en nombre élevé.
Les plasmocytes sont riches en anticorps.
On observe une prolifération d'anticorps dans les plasmocytes.

3.2. *Getting a list of categories from a surface sentence and matching a unit on it*

If one wants to relate the structure of: *On injecte un antigène dans l'oreille des lapins* and **GJB** (as in chapter 2) we have to define a complex restructuring operation, that is, an operation which would transform the (roughly expressed) applicative structure (A) into the applicative structure (B):



Instead, we can choose a lexical representation where **J** is not associated with ... *injecte*... but to *on injecte* ... *dans*... (or equivalently ... *a été injecté de* ...) with the appropriate linearization feature. Then, we do not have to define transformations at the level of applicative structures. It suffices to define permutations of categories in a list, if we want to go from a sentence to a unit, or permutations of lexical items, if we want to go from a unit to a sentence. In order to get the unit, we use the dictionary and recognize from left to right the list of units: **J**, **G**, **B** – then using the selectional properties of **J** as stated by the informational grammar (i.e. the applciative structure (B) above), we transform the list at once into the unit **GJB**. As they are used in our rows, the linearizaiton rules proposed in section *4.1* enable us to get a grammatical sentence out of a sequence of words corresponding to the categories of a unit. From **G**, **J**, **B** we get at first something which is barely a sentence: *un antigène* | *on injecte dans* | *l'oreille des lapins*. Second, we decide on a convention, either using addresses or pointers, such as: *un antigène* →| ← *on injecte dans* | *l'oreille des lapins*. which is read: *on injecte dans l'oreille des lapins un antigène*. This is a well-formed sentence and it differs from the initial one only by a stylistic permutation which does not alter its meaning. This difference is not important here, but if we wish to produce a sentence identical with the initial one, it suffices to modify the dictionary with *on injecte* for **J** and *dans l'oreille des lapins* for **B**. Then, corresponding to **G**, **J**, **B**, we will have: *un antigène* | ←*on injecte* | *dans l'oreille des lapins* which is read: *on injecte un antigène dans l'oreille des lapins*.

Sentences (9) to (14) all have the same informational content in our subdomain. They are all represented by **GJB**:

(9) *On a injecté un antigène dans l'oreille des lapins.*
(10) *On a procédé a une injection d'antigène dans l'oreille des lapins.*
(11) *L'injection d'antigène s'est faite dans l'oreille des lapins.*
(12) *L'injection des oreilles de lapin s'est faite avec cet antigène.*
(13) *L'antigène a été injecté dans l'oreille des lapins.*
(14) *L'oreille des lapins a été injectée d'antigène.*

It isn't necessary to define transformations on the structure of these sentences. It suffices to recognize directly from them lists of categories, i.e. from (10): **J, G, B**; from (11): **J, G, B**; from (12): **J, B, G**; from (13): **G, J, B** and from (14): **B, J, G**. All these lists can be restructured at once into the well-formed unit **GJB**. The same method can be applied to examples (1) to (8) above. For instance, if we take (2), we recognize *plasmocytes* as $\mathbf{C_z}$, then we read *produisent* and we don't know at this stage how to represent it. We continue and recognize *anticorps* as **A**. We now have the complete list: $\mathbf{C_z}$, **A**, $\mathbf{V_p}$, on which can be matched the unit: $\mathbf{AV_pC_z}$.

The method we are proposing here is made possible by the way informational categories were constructed. It could not be applied with categories grounded on *a priori* synonymy criteria. The fact that selectional properties of non-elementary categories are fully deterministic is fundamental here. In fact, the selectional properties of categories are so restrictive that we can even recognize units from sentences without using the linearization rules. To see this, consider that we don't have two 1-order categories selecting the same categories as arguments. For example, the **V** categories select the couple (**A, C**) but no category selects (**C, A**). The **U** categories can select **C** as a second argument but they require **G** as first argument, which is incompatible with **V**. Moreover, except for $\mathbf{W_i}$ which can select two **T**, and the **Y** operators which can select either two **A** or two **C** or two **S**, categories do not select two arguments of the same class. When two **C** are selected by **Y** operators, usually they are not interchangeable in their underlying informational structure. For example, *C_1 is the same as* (**Y**) *C_2* has the same meaning as C_2 is the same as C_1. But *C_1 descends from* ($\mathbf{Y^f_c}$) *C_2* does not have the same meaning as *C_2 descends from C_1*. A minor modification in our dictionaries designed to remedy problems that this can cause, when we suppress linearization rules for the recognition of a unit, would consist of a subclassification of cells or antibodies or ultrastructures under **Y** and of tissues under $\mathbf{W_i}$, i.e. $\mathbf{C_1\ Y\ C_2}$, $\mathbf{T_1\ W_i\ T_2}$ and $\mathbf{C_1 = C_y, C_z}$, $\mathbf{C_2 = C, C^1, C_r^m}$~. However, linearization rules are necessary if one wants to produce sentences from units.

The interest in performing pattern-matchings on lists of categories, rather than transforming the linguistic structure of a sentence into an informational unit, is twofold. First, it applies to sentences independently of their formulation in French or in English without any additional rules. Second, it provides an automatic recovering of implicit textual information such as pronounings and ellipsis. We develop how this is done in the next section.

3.3. Recovering implicit information

Ellipsis or prounounings can be directly reconstructed in units in a much simplified way using the grammar of the units instead of using the grammar of the corresponding sentences. For example, if we wanted to use a sentential analysis to reconstruct the antecedent of a pronoun, we would have to represent lexical features inside the representation of the sentence structure. Another problem is that it would be quite inappropriate to reconstruct all the pronouings in the texts, as only some of them are relevant for our coding (i.e. only a few pronouns have to be recognized as informational categories). We will use the selectional properties of the categories, directly expressed by the grammar of informational units.

In addition to our list of actual words in our dictionary, we have to represent referential words such as (in French): *en*, *les*, *là*, *ailleurs*, *il*, *elle*, *qui*, *que*, etc. We can deduce their representation automatically and the procedure is very similar for appropriate zeroings. In addition to the representation of relative pronouns, we deduce the location of their antecedent and attach a **w** superscript to it. An exhaustive list of referential words must be included in the dictionary with additional features for some of them (for example, *ailleurs* adds a negation).

To give an example we will represent the following sentence:

> *White par exemple admet que les lymphocytes pourraient ne représenter qu'un lieu de dépôt des anticorps, qui pourraient être synthétisés ailleurs.*

We shall proceed as follows: *White par exemple* is represented by **M**; *les lymphocytes – un lieu de dépôt des anticorps* is represented by **A** $\mathbf{V_t}$ $\mathbf{C_y}$. In order to represent: *qui – être synthétisés ailleurs*, we introduce twice the list of categories occuring in the preceding unit, e.g. (**A**, $\mathbf{V_p}$, $\mathbf{C_y}$), for deducing the referent of each referential word. The sequence: *être synthétisé* is inserted only once in our dictionary, it must be represented by a $\mathbf{V_p}$. *Ailleurs* is also in the main list of our dictionary. It could be in **T**, in **B** and in **C**, if we had a larger corpus, but here, it is only in **C**. Anyway, **C** is the only category which matches our list, so **A** and $\mathbf{V_p}$ are eliminated and *ailleurs* is represented by $\mathbf{C_y}_{\sim}$. We then come back to the representation of *qui*. We know now from the grammar that it has to be a reduced form of the first argument of $\mathbf{V_p}$. We can eliminate $\mathbf{C_y}$ and $\mathbf{V_p}$ from our second list. **A** matches the conditions, so *qui sont synthétisés ailleurs* will be represented by: **A** $\mathbf{V_p}$ **C** and a **w** superscript will be attached to **A** in the preceding unit.

We could also define another procedure to represent *ailleurs* and *qui*, using the fact that *être synthétisés* is represented by $\mathbf{V_p}$ with a "flat" linearization: the applicative order of the respective arguments of *être synthétisés* and $\mathbf{V_p}$ is the same. From the list ($\mathbf{A}$, $\mathbf{V_p}$, $\mathbf{C_y}$) we directly conclude that *que* must be represented by $\mathbf{A}$ and *ailleurs* by $\mathbf{C_{y\sim}}$.

We could use the linearization properties in an example like *il interviendrait dans leur transport* (Gavosto and Ficq 7.2), where the two arguments of $\mathbf{V_u^r}$ representing *interviendrait dans leur transport* are to be recognized after the reconstruction of ordinary pronouns. This example is interesting because it is one of the most difficult cases: the preceding word sequence is itself reduced and is represented by $\mathbf{A\ V}$. The expression *interviendrait dans ... transport* must be represented by $\mathbf{V_u^r}$, which selects its arguments in opposite order. From this, the selectional restrictions of $\mathbf{V_u^r}$ and the incomplete list ($\mathbf{A}$, $\mathbf{V_u}$), we deduce that *leur* must be represented by $\mathbf{A}$. $\mathbf{V_p}$ is not an appropriate argument of $\mathbf{V_u}$. As the list was not complete we add to it the categories occuring in the unit before, in sentence 7.2: ($\mathbf{A}$, $\mathbf{V_p}$, $\mathbf{C_y}$). We can eliminate $\mathbf{A}$ and $\mathbf{V_p}$ and keep $\mathbf{C_y}$ which is an appropriate argument of $\mathbf{V_u}$. We can also use directly our pattern-matching: at first we recognize $\mathbf{V_u^r}$ and from a matching with the preceding unit, we extract directly $\mathbf{A}$ and $\mathbf{C_y}$, which are both possible and adequate arguments of $\mathbf{V_u^r}$.

Some indeterminacies could occur using the method proposed here to recover anaphoric relations, but it can be conjectured that when our deduction method fails to produce a unique solution, the actual sentence itself is ambiguous, i.e. it has more than one interpretation in the scientific sublanguage where it is asserted. This hypothesis has been verified for the French corpus.

French uses several "identifiers" in order to avoid the repetition of a word, a phrase or even a whole sentence. For each of these, the way they provide a reference can be made explicit, but I will not go into details here. Instead, I shall give a few examples:

(1) *là* (in Gavosto and Ficq. p. 443 II.I) refers to *l'accroissement de la basophilie cytoplasmique* in:
On observe également un accroissement de la basophilie cytoplasmique, il s'agit sans doute là d'une persistance sinon d'un accroissement des processus de synthèse protéquie.

(2) *telle* (Gavosto and Ficq p. 443 6.1): *L'apparition d'une telle basophilie*, which does not mean here *une forte basophilie* but refers to previously mentioned cells which were such, that

is: *l'apparition de la basophilie des cellules reticulo-endothéliales.*

(3) An interesting "metalinguistic" identifier is *il en est ainsi* (in Grabar p. 640 2.8). Other identifiers are: *comme, (eux)-aussi, le premier type, ce dernier, le premier, réciproquement, à ce stade de.*

(4) A last example will be the recognition of (a) *les plasmocytes produisent et stockent des anticorps.* Instead of reconstructing the sentence *les plasmocytes produisent des anticorps et les plasmocytes stockent des anticorps*, we shall extract directly from (a) the list: $\mathbf{C_z}$, $\mathbf{V_p}$, $\mathbf{V_i}$, **A** and from successive pattern-matchings recognize the units $\mathbf{AV_pC_z}$, $\mathbf{AV_iC_z}$.

In addition to what has been said in section *2*, the contextual interpretation of words may also involve words which allow appropriate zeroings in a rather systematic way. This situation occurs with words like *activité* which has very different meanings when it combines with *cellule* and with *antigène.* Thus, *l'activité des antigènes* can be paraphrased by: *l'activité de contamination, d'infection qu'ont les antigènes* and *l'activité d'une cellule* by *l'activité de synthèse, de production* or l'activité de stockage, etc., depending on the nature of the cell. In fact when *activité* is directly combined with a word represented by an elementary category in our grammar, it has virtually the meaning of any of the actual words represented by a l-order category selecting the elementary category in question. In other words, it works as a classifier of the l-order categories and is highly undefined unless it is used in a context where it refers to a unit. For example in: *la production d'anticorps dans les cellules lymphocytaires à ce stade de maturité a été établie. L'activité de ces cellules est par ailleurs...* here, *l'activité de ces cellules* means *l'activité de production d'anticorps de ces cellules. Activité* is not a pronoun but has a referential function like a kind of "pro-unit". In order to deduce its precise meaning we can apply the method used for ordinary pronouns or relative clauses. We can deduce, if it exists, the appropriate l-order category to which it refers in the preceding unit.

To sum up section *3.3*, we can associate a list of informational categories to linguistic expressions listed in our dictionary, in the order in which they appear from left to right in a given sentence. We then use the selectional properties of informational categories as stated in our informational grammar, and match the structure of a unit on this list. This pattern-matching is a structuring defined on a list and not on an applicative structure of a sentence onto the applicative structure of a unit. It is not always possible

to match at once a unit against the list of categories which were extracted from the sentence, because of sentence reductions (i.e. the list can be incomplete); we have to recover the missing categories. These sentential reductions result from pronounings or ellipsis (i.e. appropriate zeroings). The missing categories can be deduced using again pattern-matchings on categories occuring in previous units (or in the same incomplete list if it has more than three categories) until we find categories which match the selectional properties of the explicit categories in this incomplete list.

4. Linearization rules: producing sentences out of units

4.1. *Linearization rules and the applicative status of informational categories*

Linearization is a superficial reordering on the applicative order of arguments and operators in the units. It is superficial in the sense that informational units are linearized according to the requirements of word order in French sentences. The linearized sentences produced by the grammar may differ from the actual ones in the texts by stylistic permutations which have no effect on their informational content. If our method was implemented in a computer, another minor difference with the initial sentences of the texts would be that explicit words would appear instead of pronouns when they are not relative pronouns.

These stylistic permutations allow simplification in the formulation of the rules of linearization. In most cases we mention the stylistic permutations in a note appended to a unit in our tables. Another difference is that even if they are not explicit in the original sentences, word phrases corresponding to information categories in units are explicitly stated in the corresponding linearized sentence of our tables (they are within parenthesis in the tables). Explicit words appear instead of pronouns, when they are not relative pronouns. For obvious reasons, words or word phrases which appear in the articles but which are not relevant for the information, that is, which are not listed in the dictionary of information categories, do not appear in the sentences that are produced using the linearization rules, in the French tables. We use two pointers according to the linearization rules given in this section. It should be noticed that their use is not the same in the French tables and in the English ones. The first reason is that word order may differ in French and in English. The second reason is that we

avoid transformations at the level of sentential structure such as the passive transformation.

We show that using the applicative status of categories, two pointers and lexical features in our dicitonary, we can linearize the units directly into sentences without using an intermediary stage where units would be transformed into applicative structures of sentences.

Corresponding to the applicative structure of the unit $\mathbf{AV_pC}$ we use the notation $\mathbf{A|V_p|C}$ where $\mathbf{V_p}$ is a 1-order operator. Correspondingly, the symbol "|" in our tables can be understood as representing 1-order relationship between the words represented by a 1-order category and its arguments. In the same way "||" represents a 2-order relationship between the words represented by a 1-order category and "|||" a 3-order relationship. These notations prove to be useful to define the linearization properties of actual words.

Some words are still considered as 3-order words and not as 2-order, even it they are not operating on an explicit 2-order word, (e.g. a word represented by the operator :) because even if a unit is not preceded by an explicit **GJB,** it is still the representation of an immune response. **GJB** is represented when there is a corresponding explicit sentence in the text. This happens, for example, when the author describing the experiments believes that the way the injection is realized affects in some more or less specific way the ensuing immune response.

REMARK: Corresponding to the fact that the French articles analyzed here are more specifically oriented toward reasoning from previous experiments than toward presenting new ones, there are very few references to the antigen injection (which is followed by antibody production). This is true in particular in the fragment of Bussard. This is related to the fact that it appeared *a posteriori* that the place and mode of injection was relevant only marginally to determining which cells are responsible for the production of antibodies.

The "grammar" of French linearization used here is defined by means of two pointers $\leftarrow$ and $\rightarrow$, which specifically move across |, ||, and ||| boundaries. The rules and the hierarchy in which they apply are the following:

(1) Words are read from left to right unless otherwise stated.

(2) Words with leftward pointer $\leftarrow$ are read in leftmost position, but after a word preceded by a ||| boundary or by a || boundary if they occur after such boundaries.

(3) Words bearing a → are read in a rightmost position but before a word having a || boundary if they occur before such a boundary. For example **GJ:** $\mathbf{AV_pC_z}$ can represent:

et ||| *antigènes*→| *une injection*||← *après* || *des anticorps*→| *produisent* |← *les plasmocytes*

which is linearized as follows:

et, après une injection d'antigènes, les plasmocytes produisent des anticorps

The boundary | and || can be crossed by a leftward or rightward pointer.
In particular a **:** word, inserted before a || boundary can bear a left pointer without loosing its boundary property for the linearization of the rest of the sentence (See above and also note 9 in Gavosto and Ficq 5.1 or note (9′) in Gavosto and Ficq 9.1. Notice that a **:** word never has a rightward pointer). Another example is: **GJ:** $\mathbf{AV_pC_z}$

et ||| *antigènes* |← *une injection d'*|| *provoque* || *d'anticorps*|← *la formation* | *dans les plasmocytes*

which is linearized:

et une injection d'antigènes provoque la formation dans les plasmocytes d'anticorps

A word with a ||| boundary, e.g. a conjunction, is always read in leftmost position and does not have a pointer. This is why we need a specific priority rule for WH – words.

(4) When a category has a **w** superscript, the relative clause to which it refers (that is, the next sentence preceded by a WH ||| and containing a word represented by the same category as the one bearing the **w** superscript in the preceding unit) is read immediately after the first occurrence of the word represented by the **w**-scripted category. This rule (4) has priority over rules (2) and (3) which in turn have priority over (1). For example, in Gavosto and Ficq p. 426 8.1, the sequence of units $\mathbf{C_z\ Y^f\ C_b^w}$, **G J:** $\mathbf{C_b\ Y^t\ C_z^w}$ correspond to rows which are linearized as follows:

les plasmocytes pourraient dériver de lymphoblastes qui évolueraient en plasmocytes, (plasmocytes) producteurs d'anticorps, une fois stimulés par l'antigène, plutôt que les lymphoblastes évolueraient en lymphocytes

In short:

WH ||| $\mathbf{u_1}\rightarrow$ || **k** || *qui* |$^{\leftarrow}\mathbf{u_2}$ | $\mathbf{u_3}$ is linearized: *qui* $\mathbf{u_2 u_3}$ **k** $\mathbf{u_1}$ $\mathbf{u_1}$ ||$^{\leftarrow}$ **k** || $\mathbf{u_2}^{\rightarrow}$ k ||| $\mathbf{u_3}$ |$^{\leftarrow}$ $\mathbf{u_4}$ is linearized: **k** $\mathbf{u_1}$ $\mathbf{u_4}$ $\mathbf{u_3}$ $\mathbf{u_2}$

(5) a relative pronoun has priority on the left unless the WH ||| of this row is embedded under a higher conjunction. (See for example Gavosto and Ficq 6.2 p. 435.) WH- is then a metalinguistic identifier between two referentials and there is no relative clause formation. WH- can be considered a zero morpheme in this case.

4.2. *Organization of the dictionary of informational categories*

If we want to recognize informational units (that is, to go from a text to its coding) and not to produce sentences (that is, to go from informational units to sentences), we do not need to worry about word-order in sentences. It is not necessary to use the linearization rules if we use the method described in section *3*. Contrary to what could seem at first glance, it is much more efficient to list the morphologically related words in our dictionary such as *produire, production, producteur* rather than defining preliminary transformations on sentences and preliminary sentential representations. Marginal adjustment rules for plural, gender and tense agreement will be needed and could be used if we wanted to use our representation for producing sentences.

We can optimize our method for getting units if instead of listing the morphologically related words we use a representation of morphologic roots in the dictionary of categories. For example, instead of having: *produire, être produit, production de... dans, production de... par..., producteur*, we would have only *produ-*.

If we want to produce a sentence out of a unit we have to specify how the words represented by the categories are to be re-ordered, that is linearized. These re-orderings depend on the applicative status of categories but also on lexical properties, which can be accounted for by indicating pointers on the lexical items of the dictionary.

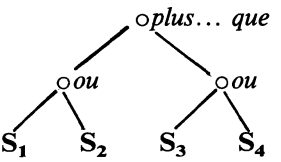
Word-order differs from one language to another. For example, in French and in English, words in simple sentences occur in the order: subject, verb, object. But this is not the case for all languages. Moreover, there are differences even between English and French. An English nominalization can occur after its object, as in: *antibody production occurs after an injection is made.* An English nominalization can also appear after its subject, for example in: *John's description of this subject surprised us.* In the corresponding French examples, the nominalization occurs obligatorily before its arguments. The way we define the applicative structure of a unit, in order to optimize the use of linearization rules, is then relative to a language. For example, in English where a number of passive and nominalized forms are found, it is best to define **V** on (**A**, **C**) rather than **V** on (**C**, **A**). In French, we will have to apply more linearization rules but this is of little cost compared to the advantage of having a common representation of the informational content of the texts.

If the purpose of producing sentences out of units takes place inside the design of a question-answering system or consists in producing summaries, we are not faced with the question of producing *all* the grammatical sentences corresponding to a unit. It would suffice for such purposes to define one standard formulation expressing the informational content of each unit.

5. Questions which are not fully treated here

Some words in the text can be considered to be conjunctions between two units. Some of these conjunctions are represented by the succession of the units (i.e. their concatenation), for example, *et* or **:** or some of the cases of *ou*. Some of the other conjunctions are represented by superscripts like **w** and **>**.

Another case of the independence between the structure of units and the linguistic structure of the corresponding sentences is met with when words and their informational representation exhibit different scope properties. We have in Grabar p. 642: ... *Les extraits de tissus lymphoides ou de lymphocytes sont plus riches en anticorps que le sérum ou la lymphe*... The linguistic structure of this sentence can be roughly expressed as:



The informational content of this sentence is represented by:

A $V_i^{>}$ T^x
A $V_i^{>}$ C_y
A V_i T_b
A V_i T_l

In order to complete the interpretation of our sequence of units, we will have to make explicit the way we interpret the concatenation of units containing a > superscript in the different configurations where it can be found. Also, when they are not represented by superscripts in the units, conjunctions are inserted in the leftmost position of a row, with a ||| boundary. In the linearization of this row, they are to be read first. Their "scope" extends to the entire row and the preceding one. In a next step of our investigation, they would be represented as an operation on the concatenation of the units. The relative clauses in actual sentences are represented by a **w** superscript on the category representing the antecedent, in a unit, together with a WH-||| in the row corresponding to the next unit.

The list of the conjunctions which precede the secondary row but have no symbol inside the primary unit, in our corpus, is as follows: *en particulier*; *et*; *de plus*; *tandis que*; *ou*; *ou bien*; *mais*; *il y a*; *dans le cas de*; *d'une part*; *étant donné*; *plutôt que*; *les relations existant entre ... et...*; *à coté de*; *ni... ni*; *c'est pourquoi*; *tant... que*. We also have conjunctions operating on other (lower) conjunctions such as: *et, de plus*; *il y a parallèlisme entre... et...*; *de plus; dans certains cas*; *d'autre part, spécialement dans le cas*; *de plus, de par*; *mais plutôt*; *et, étant donné*; *et, en général*; *et non*; *et, d'autre part*; *et en cas de*; *par exemple, dans le cas de*; or any one of these conjunctions followed by a WH-. From the point of view of the applicative structures of the actual sentences, we should introduce a |||| symbol in order to represent properly the highest conjunction of these sequences, for instance: *et,* |||| *de plus*. But we can also consider them as having a unitary informational content and regroup them into a few categories. This is why we shall use the notation as *et, de plus* |||. Besides, these sequences are linearized as single units.

The period which ends a sentence should be considered a conjunction though it is represented without a ||| boundary. In any case, the numbering of the units in the left margin allows it to be recovered. In contrast, ; is considered here to be an explicit conjunction.

Pending further research, the sequences which are represented by **M** symbols, such as *on voit que.., X a démontré que.., on n'a pas réussi a mettre en évidence que ..,* can be considered as having a scope extending to the rest of the units belonging to the same paragraph unless there is another M, in which case its scope stops at that point.

In addition to the conjunctions represented by superscrips or those not represented here because we want to define their representation on the concatenation of the units, and not on the concatenation of words, there are some expressions which modify the content of one or several successive units. These can vary in linguistic form. They can be adverbs, such as: *exclusivement, seulement, principalement, principalement sinon exclusivement, spécialment dans le cas de, plutôt, au plus, en majeure partie, pas nécessairement.* We have for example:

(1) *En effet, il n'est pas possible de préciser si ces cellules servent seulement à la fixation et à la digestion préalable de l'antigène ...*

(2) *Les antigènes marqués sont incorporés principalement dans les cellules appartenant au S.R.E.*

(3) *L'élaboration des anticorps se ferait principalement sinon exclusivement dans les cellules réticulo-endothéliales.*

They can also take adjectival or nominal form, as in: *certaines de, la majorité d'entre, la majeure partie de, de nombreuses.* We have for example:

(4) *Certaines de ces cellules ne possédent qu'un cytoplasme tenu...*

Finally, there is the construction in *ne... que* as in (4) or in (5):

(5) *La cellule réticulaire jeune soumise à la stimulation antigènique ne diffère de la cellule réticulaire jeune au repos que par sa forte basophilie cytoplasmique.*

These expressions often combine within the same sentence, as in (3) or (4). They raise an interesting question about their representation. There is a choice as to whether we should introduce new categories to represent them, within the units. A complete solution will not be attempted here, but there are some arguments in favor of representing them as higher operators.

More precisely, they would be categories operating on the units and under the conjunctions. According to the terminology introduced in section *4*, they could be represented as 3-order categories, and conjunctions would then be considered as 4-order categories. Except for *ne... que*, these words can be permuted to leftmost position in sentences without altering their meaning.

This property of linearization is correlated with the fact that their intepretation modifies the interpretation of the whole unit or of several connected units and not of a category in particular. For example (3) can be replaced by (6):

(6) *Principalement sinon exclusivement, l'élaboration des anticorps se ferait dans les cellules réticulo-endothéliales.*

Though they can take various linguistic forms, these expressions could be represented by a few additional categories.

From a technical point of view, it will be noticed that we avoid undecidability problems of higher order predicate calculus because quantification on higher order variables is avoided. Here, as well, scope properties can be dealt with in terms of applications of hierarchized operators. These operators never operate on themselves.

6. Conclusion and applications of the method presented here

In addition to the main applications of the informational representation which are explained in chapter 1, the specific aspects of the method presented in this chapter lead to other applications in the design of question-answering systems. For example, it would be easy to implement the coding inside a programming language having itself an applicative structure such as LISP.

An interesting property of our representation is that recognition of information is independent of word order in actual sentences (which may differ from one language to another) but not of the order of the corresponding categories in the units (i.e. their applicative order) which is common to various languages insofar as they are concerned with the same subject matter.

The method proposed in this chapter consists in recognizing the words or word sequences listed in our dictionary of categories, and then associat-

ing a unit to the list of categories, by a reordering which matches the selectional properties of the categories. Using this solution, we do not have to recognize a sentence as such, and then transform it into a unit. By doing so, we also get an automatic verification of the correctness of the informational content of an actual sentence. This would be useful if our representation was applied to design a question-answering system in a data-base system where scientific articles would be coded.

Our pattern-matcher could provide side-tracking on questions formulated by non-specialist users or students. For example a conversational system could produce rectifying answers such as examples (b) and (c) to a "bad" question like (a) in the first paragraph of section *2*.

CHAPTER 8

THE CELLULAR SOURCE OF ANTIBODY: A REVIEW

1. BACKGROUND

From the time of the earliest awareness of the existence of immunity against infectious agents in the animal body, much interest was focussed on the source of this effect, and on the substances responsible for it, primarily antibodies. In the course of this search some major organ and cell systems of the animal body were considered as possible sites for the production of these vital substances, which are essential for the body to withstand infection.

The first tissue system which was considered to have an important role was the "reticulo-endothelial" system, a network of cells resembling white blood cells, which are scattered throughout the body. The chief cellular component of this system is the macrophage, an important scavenger of foreign material. The macrophages are found in all tissues of the body and they accumulate in individual organs where an inflammatory process is under way. It was known that they have the function of engulfing foreign materials which have entered the body through infection or wounds, and of digesting such materials by their intracellular enzymes. It seemed plausible, therefore, that such cells might also produce the antibody in response to such foreign materials.

The other major system which was considered as a possible source of immunity was the lymphatic system, another wide-spread system which is involved with foreign materials in the tissues. The lymphatic system is a tree-like system of vessels (tubes) interspersed with small organs of lymphatic tissue, the lymph nodes. The vessels contain a fluid, lymph, which circulates through this system, carrying with it foreign materials which have entered the tissues, and which are often filtered out by the lymph nodes. The lymph passes from the periphery of the body via the lymph vessels and through the lymph nodes in its path, entering each node by the afferent vessel of that node and leaving by its efferent vessel. The flow ends in the central organ of the lymphatic system, the spleen, an organ which has some resemblance to the lymph nodes in structure and organization. The lymph

consists of cells, mostly lymphocytes, suspended in a liquid, the lymph plasma.

The lymph nodes are bean-shaped structures, each consisting of an outer layer, the cortex, and an inner core, the medulla. The cortex is largely a mass of lymphocytes, the chielf cell type of the lymphatic system, organized into nodular groups called follicles. The medulla contains lymphocytes, and, especially after the injection of antigenic material in the area which it drains, plasma cells or plasmacytes. The plasma cell has a nucleus which resembles that of a lymphocyte, but the outer portion (the cytoplasm) is larger and contains many more structures which have come to be associated with protein synthesis. The spleen also has two major sections: the "white pulp", which roughly resembles the cortex of a lymph node in organization and cell type, and the "red pulp", which roughly resembles the medulla of the lymph node.

2. Early observations and experiments on the macrophage in relation to antibody formation

The capacity of microphages to ingest foreign material suggested several experimental approaches to the question of whether they had the function of the immune response. If macrophages were made to engulf excessive amounts of inert material, would they then be prevented from forming antibody when antigen would be injected subsequently? (An antigen is a foreign substance which, when it enters tissues, causes the production of antibodies which can react specifically with it. Antibodies are the altered serum globulins (proteins) which are produced in response to infection, or injection of an antigen, and which protect the body against future invasion by the same infecting agent.) In some experiments massive injections of particulate but inert foreign substances were given to rabbits for the purpose of "blockading", or choking, the phagocytic ("cell-eating") cells of the body, especially the macrophages. Such animals, on subsequent injection of antigenic material, were in fact found to produce substantially decreased amounts of antibody.

Another experimental approach to the relationship of the macrophage to antibody production was that of Sabin (1939), who injected a colored antigen (dye-conjugated protein) into rabbits, and noted that this colored material disappeared from the splenetic macrophages of these animals just

before a measurable amount of antibody to the protein antigen appeared in the serum.

In another study of the macrophage, Hartley (1940) produced in rabbits inflammatory nodules which consisted of accumulations of macrophages. When a virus suspension was injected directly into such a nodule, antibodies could often be detected in extracts of the nodule before their appearance in the serum. Hartley concluded that since macrophages were the predominant cell type in the nodule they were responsible for the production of antibody.

3. Early studies on the lymphatic system in the production of antibodies

The early studies on the lymphatic system in realtion to immunity also involved correlative observations which were later followed by direct experimental evidence. At the beginning of the twentieth century it was noted (Hektoen, 1915; Murphy and Sturm, 1925) that when the lymphatic tissue of experimental animals was severely injured by x-rays (the lymphatic system, especially the lymphocyte, is very sensitive to destruction by x-rays) there was a concomitant reduction in the production of antibodies following the injection of the antigen.

In the 1930's some workers began to suggest that the lymphatic system had a function in producing antibodies to antigens in the foreign materials that it took up. It was shown experimentally in the mouse that certain lymph nodes were sites of the production of antibodies to antigens injected near them. In these studies there was, however, no indication as to which cell type of those generally found within the lymph node was involved in the actual sysnthesis.

That plasma cells might be related to immune processes was suggested by Huebschmann (1913) on the basis of cellular changes in the spleen during infections. Klein (1914) and Arneth (1920) maintained that plasma cells, especially those found in chronic diseases, represented functional states of lymphocytes which, because of local conditions, are related to processes of immunity.

The direct experimental demonstration of antibody formation in lymphatic tissue began with the work of McMaster et al. (1935, 1937). These workers injected mice with various types of antigens (bacteria and viruses). They were then able to detect specific antibody to the antigens injected in

extracts of the regional lymph nodes at various intervals thereafter. In the early days following antigen injection, the concentration of antibody in these extracts was often higher, per gram of tissue extracted, than the concentration of antibody in the blood serum of the animal at that time, indicating a primary source of the antibody in that tissue.

Observations of a similar nature were reported by Burnet and Lush (1938), who infected mice with influenza virus by inhalation and then found neutralizing antibodies in the mediastinal (local) lymph nodes. Ehrich and Harris (1942) extended these observations by injecting cellular antigens into the hind feet of rabbits and at intervals thereafter collecting the local (popliteal) lymph nodes, as well as lymph from the afferent and efferent lymph vessels of that node. Antibody to the injected antigen was found in extracts of the lymph nodes and in lymph collected from the efferent lymphatic vessel of that node ("efferent lymph"). In the first day or two after the appearance of antibody, the titer (concentration) was often higher in these materials than in the blood serum at that time. Antibody was not found in the afferent lymph, except after the serum concentration had risen to high levels.

Finally, Dougherty et al. (1944) injected mice with large doses of sheep red blood cells, pooled all available lymph nodes and spleens of these animals, minced the tissue and washed away extracellular material. In extracts of the pooled cell mass thus obtained, antibodies to the antigenic material could be found in significant quantities.

A number of studies in the next few years (Soloviev, 1946; Habel et al., 1949; Craddock et al., 1949) failed to demonstrate a relationship of lymphatic tissue and antibody formation. However, an analysis of the technical factors in those experiments (Harris, T.N. and Harris, S., 1950) showed the importance of anatomic and temporal relationships between the injection of antigen and the lymphatic organ or tissue examined for antibody content. In time, the use of the hind foot pad of the rabbit for the injection of antigen, and the draining popliteal lymph node a few days thereafter as a source of antibody, became a classical model for studying many types of problems involving antibody formation.

4. Lymphocyte or plasma cell as the antibody-synthesizing cell

Both the widely distributed lymph nodes and the central spleen have complex structures including several cell types, largely lymphocytes and plasma cells (in contrast, for example, with a muscle, which consists of essentially a single kind of cell, the contractile muscle cell). The emerging consensus that the lymphatic system was the source of antibodies, therefore, did not identify either of these main cell types as the cell which synthesizes the antibody contained in, or produced by, the lymph node or spleen. Most of the work reviewed in this section was done on the popliteal lymph node, because of the experimental advantage of being able to study a lymphatic organ which is reacting to an antigen injected into the tissue which it drains. The work referred to on antibody formation in the lymphatic system – usually emphasizing the lymphocyte – was done largely in the United States up to the mid-1940's. With the conclusion of World War II, reports of studies became accessible from European laboratories, especially Scandinavian, which suggested the plasma cell as the site of antibody synthesis. In the next decade there were several series of studies carried out by different experimental approaches in the attempt to clarify this question. These will necessarily be dealt with very briefly.

5. Correlation of tissue-extract antibody with microscopic observations

A number of earlier experimental observations indirectly suggested a relationship of the lymphocyte to the process of antibody formation. These observations were made before the first direct comparison of extractable antibody and cytologic (cellular) composition of any tissue was made. Hellman and White (1930) examined microscopically the spleens and the lymph nodes of rabbits in relation to the injection or antigens and observed that in the days following such injections there was a marked increase in the number of germinal centers (nodules of early forms of the lymphocytic series, surrounded by mature lymphocytes, found in the cortex of active lymph nodes). In the lymphatic tissue of guinea pigs reared in a sterile environment Glimstedt (1936) found no germinal centers; however, these were numerous in such animals after exposure of the animals to bacteria. Oesterlind (1938) found many such germinal centers in lymph nodes

draining sites of injections of diptheria toxin in the rabbit, and the greatest number of these centers was observed at the time of the highest serum antitoxin concentration. Finally, Rich et al. (1939) were able to show that the rapid swelling of the spleen which had been described in infectious diseases could be induced in experimental animals by the injections of non-bacterial foreign protein, and that the predominant proliferating cell type was the lymphoblast (an immature lymphocyte).

Among studies involving the extraction of tissues and the titration (measurement) of antibody in such extracts for correlation with cytologic changes was that of Ehrich and Harris (1942) already referred to. Three days after the injection of typhoid antigen into the hind foot pads of rabbits, antityphoid antibodies were found in extracts of the draining popliteal nodes, the highest concentration being reached on about the fifth day. Histologically (microscopically), two days after the injection of antigen, the cortex of the lymph node had become greatly enlarged and consisted of a diffuse lymphatic tissue which contained many large lymphocytes and mitotic figures. A few days later the diffuse proliferation of cells in the cortex had become organized into groups (secondary nodules) of more mature lymphocytes. In the efferent lymph (leaving the lymph node) the cell count rose from a pre-injections level of 16,000 per cu. mm. to a range of 40,000 to 150,000 on the fourth to sixth day. Of these cells, lymphocytes comprised 99 per cent. At this time the antibody titer of the efferent lymph was at its peak. In a study by Harris, S. and Harris T.N. (1949), of the formation of antibody to influenza virus in the popliteal lymph node, similar histologic changes were observed. In addition, the time at which cortical cell proliferation was observed coincided with the time at which the maximum level of extractable antibody from that lymph node was obtained. Finally, in the work of Dougherty et al. (1944) it was reported that of the minced lymph node cell mass in which antibody had been found over 90 per cent of the cells were lymphocytes.

In studies of the plasma cell, also, there were experimental studies which preceded those involving extraction of tissues or cell masses. In 1938 Kolouch examined bone marrow biopsy specimens of rabbits rendered allergic to streptococcus viridans. The condition of the bone marrow was observed after the intravenous injection of a "shock dose" of the antigenic material. Within a few hours after this injection the bone marrow showed a great increase in precursors of plasma cells, and in the transformation of these cells into mature plasma cells; after five days small plasma cells were predominant in the bone marrow. It was suggested that there might be an

association between the cell transformation observed and the development of antibody found in the blood at the time.

In studies involving tissue extracts of antibody, Bjørneboe and Gormsen (1943) gave rabbits repeated large injections of pneumococci (bacteria) and produced an increase in the blood globulin (the family of serum proteins which includes antibodies). They also found an increase of plasma cells in various tissues, especially in the lungs, which appeared to be proportional to the concentration of antibody that could be extracted form these tissues. The authors suggested that the increase in the globulins of the blood was due to the increase in antibodies and that this, in turn, was related to the increase in plasma cells in the body. In a later study involving the extraction of various tissues Bjørneboe et al. (1947) again gave rabbits many injections of large doses of pneumococci and produced cellular infiltration of the fat of the kidney sinus. Since the extract of this cell-mass, which was estimated to contain 90 per cent plasma cells and 10 per cent lymphocytes, was found to contain considerable amounts of antibody, it was concluded that antibodies are produced by plasma cells.

Cytologic studies of the development of plasma cells in lymphatic tissue following the injection of antigen should be included here. In these investigations antibody determinations were carried out only in the blood serum and not in extracts of the tissues examined. Fagraeus (1948) studied the spleen microscopically in relation to the development of antibodies in the serum of rabbits, following repeated injections of bacterial or protein antigens. It was observed that reticulum cells (primitive cells of the lymphatic system) appeared in the spleen slightly before the appearance of detectable serum antibodies. These cells appeared to develop into immature plasma cells at the time of the most rapid rise in serum antibody concentration. This was followed by a gradual increase in the number of mature plasma cells. The author concluded that the formation of antibodies occurs with the development of the reticulum cells into plasma cells. Ringertz and Adamson (1950) studied the cellular changes in lymph nodes after the injection of various antigens. They described a strong lymphatic as well as plasmacytic reaction in response to those injections. They raised the possibility that "a large number of immature lymphocytes, under the influence of antigen, are being converted into antibody producing plasma cells instead of, as is normal, developing into mature lymphocytes". Marshall and White (1950) found that intravenous injection of antigenic material in the rabbit caused a stimulation of the primitive reticulum cells, after which plasma cells appeared in the spleen and in the lungs, liver, and bone

marrow. The formation of germinal centers was also noted, in this case confined to the spleen.

Similar observations on the development of plasma cells from cells in the cortex of the lymph node and spleen were made with the use of the electron microscope by Movat and Fernando (1965).

6. Extraction of cells

We have described studies involving the injection of antigens into the hind foot pads of rabbits and the collecting of lymph emerging from the popliteal lymph node draining the site of injection (Harris et al., 1945; Harris, S. and Harris, T.N., 1949). In these studies it was possible, because of the volume of "efferent lymph" obtained, and the relatively high cell count, to collect these cells, determine their volume, extract them in a given volume of diluent, test the resultant extracts for their content of homologous antibodies, and thus estimate the concentration of the antibodies within the cells. In experiments involving typhoid bacilli, sheep erthrocytes and influenza virus it was found that on the fifth day after the injection of antigen, the antibody content of the cells of the efferent lymph was of a concentration ranging from four to twelve times that found in the lymph plasma from which the cells had been separated. Data of other experiments indicated that these cells had not absorbed the antibody from the surrounding lymph plasma. It was considered, rather, that these cells were the site of synthesis of the antibodies found in the lymph. Microscopic examination of the efferent lymph in these studies and in the earlier study of the series (Ehrich and Harris, 1942) showed that lymphocytes constituted 99 per cent of the cells in these specimens of lymph.

7. Release of antibody from tissues and from cells cultivated in vitro

A number of workers studied the cellular source of antibody using in-vitro culture of tissues from animals injected with antigen. Fagraeus (1948) injected rabbits repeatedly with living typhoid bacilli, then excised the spleens and separated as far as was possible the red pulp (in which the plasma cells are relatively more concentrated) from the white pulp (which contains the follicular structure and is therefore relatively richer in lympho-

cytes). After cultivation of bits of each of the two types of splenic tissue in tissue culture medium at 37 degrees celsius, extracts of these tissues yielded titers of antibody significantly higher than those of control cultures (either maintained at 4 degrees celsius or treated with a cell-poison). Of the cultivated tissues only the fragments of red pulp were found to produce antibody. This was attributed to the presence of immature plasma cells in the red pulp. In the cytologic data of this study, cells of the plasma cells series were reported to make up approximately 10 per cent of the cells explanted; no percentages of other cell types were given.

Keuning and van der Slikke (1950) studied the in-vitro production of antibody by splenic tissue of rabbits which had been repeatedly injected with antigen, in a system generally similar to that of Fagraeus. They were able to confirm Fagraeus' finding of antibody production in cultures of red pulp but they also found evidence in some experiments of the production of antibody by the explants of white pulp as well. In the case of the red pulp the production of antibody was attributed to plasma cells; in the case of explants of the white pulp cytologic (microscopic) study led these authors to associate the antibody produced with "immature lymphoid cells", either lymphoblasts or developing reticulum cells or reticular lymphocytes. The authors suggested the possibility that following antigenic stimulation lymphoblastic cells give rise to both lymphocytes and plasma cells.

In a later study Thorbecke and Keuning (1953) compared the production of antibodies in cultures of fragments of liver, thymus, bone marrow, lymph nodes and spleens removed from rabbits three days ofter the last of a series of injections of paratyphoid vaccine. The authors found little or no antibody production in cultures of the liver or thymus, and no plasma cell reaction in either case. In cultures of bone marrow, lymph nodes and spleen (red and white pulp) antibody production was demonstrated, and this appeared to be correlated with a higher number of plasma cells. The finding in this study of antibody production in the white pulp of the spleen was explained by the authors to be due to aggregates of plasma cells contaminating the white pulp.

8. Studies involving aggregation of bacterial cells around tissue cells

Reiss et al. (1950) injected typhoid organisms into rabbits' feet, excised the draining lymph nodes and prepared cell suspensions from them. When such

cell suspensions were added in vitro to suspensions of the organisms used as antigen, aggregation (agglutination) of the organisms about some of the cells was observed. Many of the agglutinating cells were plasma cells but only some of the identifiable plasma cells showed agglutination. The cell which seemed to exhibit this phenomenon most often was a small cell too poorly differentiated for identification. The authors concluded that "the nature of this cell could not be established. In view of all other findings, however, it may be assumed that it belonged to the plasma cell series".

On the other hand, Hayes et al. (1951) injected bacterial suspensions into the skin of mice, then excised the site of injection and added suspensions of the bacteria to air-dried loose connective tissue and to imprints on glass slides of the tissue excised. They observed bacterial aggregates adhering to the cells of fragments of subcutaneous tissue. These cells were identified as lymphocytes.

Moeschlin and Demiral (1952) reported the agglutination of organisms by cells of the spleens of animals repeatedly injected with the bacterial antigens. By phase microscopy it was found that the cells which agglutinated the organisms contained cytoplasmic granules which the authors had previously described in developing plasma cells.

9. Histochemical staining for nucleic acid in lymph nodes in relation to formation of antibodies

In the 1940's data from several sources suggested that RNA-containing nucleoli and cytoplasmic granules were found in cells which were involved in the synthesis of protein. Since protein is being synthesized in a lymph node which is producing antibody, studies were conducted in which identification of the cell type producing antibody within a lymph node was sought by histochemical tests for nucleic acids. Two such studies were reported simultaneously. In both of these, analyses of extracts of nodes draining the site of injection of antigens indicated an increase of ribo-nuclueic acid (RNA) relative to the wet weight of the node. This increase was noted on the third day after the distal injection of antigen, and was maximal at about the fifth day.

As to the cell type which was involved in this increase of RNA, as judged by histochemical stains for that substance (e.g. pyronine) in tissue sections of the lymph nodes, the two studies were not in agreement. In the study of Ehrich et al. (1949) the medullary cords and the cortical tissue adjacent

to them were found to contain many "immature lymphoid cells" with heavily pyronine-stained cytoplasm two days after injection of the antigen. On the fourth (and especially on the fifth) day this part of the node showed predominantly mature plasma cells. Thereafter the number of plasma cells decreased. The cortex was found to be considerably enlarged on the fourth day, with many "immature lymphoid cells" which had pyronine-stained nucleoli and cytoplasmic particles. However, the cytoplasm of the cells was found to have less intensely pyronine-stained structures. The authors found the highest concentration of RNA and of mature plasma cells observed in this study at the time of maximum antibody production in the lymph node, which had been determined in an earlier study, and concluded that the antibody was formed by plasma cells.

In the other histochemical study, that of Harris, T.N. and Harris, S. (1949), cytologic observations were concentrated on the cortex, that part of the lymph node which had been described earlier (Ehrich and Harris, 1942) as being greatly enalrged in the reaction of the lymph node to injected antigen. Two days after the injection of antigen the cortex showed an intense and diffuse hyperplasia (multiplication) of young lymphocytes, interspersed with many reticulum cells containing pyronine-stained nucleoli and cytoplasmic particles. On successive days the cells containing these pyronine-stained structures became much more numerous and included many transitional forms with denser nuclei. By the fifth day the pyronine-stained cells were indistinguishable from the lymphocytes about them, except for slightly larger nuclei. At this time organization of the diffuse lymphoid hyperplasia into follicular structure was beginning to occur. The finding of pyronine-stained granules in this sequence of cells strongly indicated a gradual transition from reticulum cell to lymphocyte (a maturation observed (Harris, S. and Harris, T.N., 1950) in cultures of lymph node slices transplanted to the chorioallantoic membrane of hens' eggs). It was concluded in this study that the lymphocytes of the cortex, or transitional cells in the lymphocytic series, were probably the source of the antibodies found in these lymph nodes.

10. Fluorescence staining for antibody

A method for detecting antibody within cells of a given tissue was developed by Coons et al. (1950, 1955) and applied by them to the problem of the cellular source of antibodies. This method involves preparing very thin

sections of tissue where antibody is being produced, on a glass slide, and immersing the slide first in a solution of the corresponding antigen, and then in a solution of a fluorescein conjugate of the same antibody (obtained from serum). The antigen which was precipitated on the tissue antibody in the first immersion combines with the fluorescent antibody in the second bath, thus marking the site of the antibody produced in the tissue cells. The sensitivity of this method is limited by the high ratio of antigen to antibody required for the two to combine or form a precipitate. In their study, Leduc et al. (1955) gave repeated injections of antigen by vein, and at several intervals after the last injection, spleens and lymph nodes of such rabbits were examined for intracellular antibody by this technic. Since cells cannot be identified histologically in "fluorescence-stained" sections, it was necessary to treat some sections with the fluoresceinized antibody, and adjacent ones with conventional stains for histologic study. With this technic the following observations were made: In animals which had received two or more injections of antigen, groups of fluorescence-stained cells were found in the red pulp of the spleen (following intravenous injection) or in medullary cords of popliteal lymph nodes (after foot-pad injection) (Leduc et al., 1955). These groups of cells were identified as plasma cells by cytologic study of the sections of adjacent tissue. In the case of lymph nodes draining the site of only a single injection of antigen, cells showing fluorescence were very rare.

In these studies, as the authors stated, "the identification of the cell type responsible for the bulk of the antibody production depends on the circumstance that during the secondary response, or in animals a few days after the last of a series of repeated injections, antibody-containing cells are present in large groups". These are the groups of plasma cells previously referred to. The authors concluded that the plasma cell was the source of the antibody found in these preparations but that a minor contribution of lymphocytes to antibody synthesis could not be excluded.

11. Transfer of cells of lymph nodes, lymph and spleen

A technic which had been useful in the study of some aspects of antibody formation is that of the transfer of cells from tissues presumably engaged in the formation of antibodies (usually from donor animals injected previously with antigen) to recipient animals (which have not had contact with the antigen). Chase, who had by this means successfully transferred tuber-

culin hypersensitivity (1945), was later able to transfer another immunologic function, antibody production, by transferring lymph node cells from immunized donors to recipient animals (1951). Harris and Harris (1951) and Harris, T.N. et al., (1954) injected dysentery bacilli into the feet of rabbits, excised the draining popliteal lymph nodes, and transferred suspensions of cells obtained from these nodes into fresh rabbits. Antibodies to dysentery bacilli appeared in the sera of the recipients in a characteristic pattern. When the lymph node cells were injured by repeated freezing and thawing, heating, etc., prior to transfer, antibodies failed to appear in the sera of recipients. This indicated that the mechanism for the synthesis of antibody was being transferred within those cells. Wager and Chase (1952) and Stavitsky (1954) reported the appearance of diptheria antitoxin in recipients of cells obtained from spleens and lymph nodes of immunized donors.

In the course of determining the optimum interval between the injection of antigen into the donor and the collection of its lymph node cells, Harris, S. et al. (1954) found it necessary to eliminate the possibility of active formation of antibody by the tissue of the recipient. The recipients were therefore rendered incapable of active formation of antibody by irradiation with x-rays prior to the transfer. Despite the irradiation antibody appeared in the sera of these recipients on the days following the transfer. However, x-irradiated recipients which had received heated cells and antigen, or antigen alone, did not develop antibody in this period. This work led to the finding that lymph node cells could be incubated in vitro with the antigen, washed and transferred to x-irradiated recipients with the subsequent appearance of antibody. The possibility was considered that under these experimental conditions adequate contact between cell and antigenic material could have occurred in the recipient. In a later study a soluble form of the antigen was used for the in-vitro incubation wiht the lymph node cells, with results similar to those described. It was obvious that with the use of a soluble form of the antigen a greater fraction of the antigenic material incubated with the cells would be removed from the cell suspension in the course of successive washings.

The experiments with the injured transferred lymph node cells, the x-irradiation of the recipient rabbits, and the use of soluble antigen for in-vitro incubation of the cells with a soluble form of the antigen which could then be washed away clearly indicated that the mechanism for synthesis of antibody was present within the cells transferred. It was therefore of prime importance to study the histology of those cells. In some

of the investigations of antibody formation by the transfer of cells of the lymphatic system, cytologic data were obtained. In four studies of lymph node cell transfer, involving transfer of antibody formation (Rebuck et al., 1953; Harris et al., 1956) hypersensitivity (Chase, 1953) and tumor resistance (Mitchison, 1955) the percentage of lymphocytes among the cells transferred was found to be greater than 95, the average plasma cell percentage being reported between 0 and 1.9. In one study of antibody formation by transferred lymph node cells the corresponding percentages were found to be 85 and 3, respectively (Roberts and Dixon, 1955). Despite the uniformity of the cytologic data the question of their significance was raised by the consideration of what changes might have occurred in the trnasferred cells in their new host. One study directed at the examination of the cells after transfer injected the lymph node cells under the skin of the recipient, rather than into the blood stream. Subsequently histologic examinations were made, a few days later, of the recipient's tissue at the site of injection of the transferred cells. The authors reported finding numbers of plasma cells at the site (Roberts et al., 1957). This report left open the question of the appropriateness of the subcutaneous route of injection, as against the intravenous, to provide the optimum environment for the continued function of the transferred cells. The identification of the cells examined with those which had been transferred remained unresolved.

Another, major, stimulus to the study of the role of lymphocyte in antibody production was the development of a method for selectively removing the great majority of lymphocytes from the rat by inserting a tube into the final collecting vessel of the lymph (the thoracic duct) and thus draining the lymph over a period of several days. In rats so treated McGregor and Gowans (1963) found severe depression of the primary anitbody response. The antibody response was restored by replacement with small lymphocytes from other rats of the same inbred strain.

We have, then, the complex situation of a variety of experimental approaches to the question of the cellular source of antibody. In most of these approaches, some of the studies led the authors to conclude that the lymphocyte was the antibody-synthesizing cell, and others, the plasma cell. As this literature grew, an increasing preponderance of opinion favored the plasma cell. In general, numbers of small variations in the experimental technics and approaches made it difficult to explain the differences in conclusions among studies using the same approach. Only occasionally could one find a specific difference in experimental approach associated

with the differing conclusions, as in the studies using the histochemical staining for nucleic acids, where in one case the cortex, and in the other case the medulla, of the lymph node was emphasized in the microscopic examination. Only in the last two experimental approaches did the cytologic data predominantly point to one cell type or the other, the histochemical staining for antibody within cells, which identified very largely the plasma cell, and the cell-transfer studies, in which the cells transferred were found to be predominantly lymphocytes. It might have been considered significant that the fluorescent antibody-staining method, which singled out primarily antibody-containing cells, identified the plasma cells, whereas the technic of cell transfer, involving cells which carried the antibody-producing apparatus, yielded a preponderance of lymphocytes.

12. Resolution of the Problem: Electron Microscopic Studies of Antibody-Producing Cells

The resolution of the problem of identifying the antibody-producing cell depended substantially on the appliaton of new methods for isolating cells of antigen-stimulated lymph nodes or spleens and observing the effects of continuing synthesis of antibody by such cells. This was the contribution of two independent groups of investigators, in France (Ingraham and Bussard, 1964) and in the United States (Jerne and Nordin, 1963). In this method foreign blood cells were injected into an animal, and a few days later the local lymph node was removed. A cell suspension prepared from this lymph node was mixed with red blood cells of the kind injected, and with a warm solution of agar (a derivative of sea-weed which exists in liquid solution at higher temperatures but solidifies on cooling). The turbid mixture was poured into small, shallow, flat-bottomed dishes, and allowed to harden into a gel. On incubating the dishes at body temperature, the cells which had been involved in antibody production resumed the synthesis and secretion of antibody. As the antibody diffused from its source (in the presence of complement) it destroyed the red blood cells adjacent to it, producing a clear circular zone, or plaque, in the agar layer. By varying the experimental conditions of the injection of antigen and the collection of the lymph node, and counting the resulting hemolytic (blood-destroying) plaques, certain aspects of the dynamics of antibody production could be studied.

In the application of this technic to the problem of identifying and studying the antibody-synthesizing cell, it was necessary to develop methods for isolating a single cell and embedding it in a preparation suitable for the ultra-thin sections required for electron-microscope study and for finding them in those sections, since the fine differences in intracellular organelles which constitute the basic distinction between lymphocyte and plasma cell could only be recognized with the high resolution afforded by the electron microscope.

In the first study which applied this technical advance to the identification of the antibody-producing cell, it was possible to study the ultrastructure of a few lymph node cells, each of which was the sole cell at the center of a hemolytic plaque, produced as described above (Harris et al., 1966). The antibody-producing cells thus examined were found to fall into two classes, according to the current terminology: some were in the category of lymphocytes; and others, in the category of plasma cells. Within each class, cells were found to vary in certain characteristics, especially in the degree of development of such organelles as the nucleolus and the endoplasmic reticulum. The latter is a system of channels or sacs characteristic of secreting cells, in which the freshly synthesized product is assumed to be stored until it is secreted by the cell. In the case of the endoplasmic reticulum especially, it could be seen that a series of these plaque producing cells, ranked in order of increasing size and development of the endoplasmic reticulum, would extend over a considerable range from those lymphocytes with the least developed organelles to the mature plasma cells with the greatest development of these structures.

A more extensive study of this problem was made possible by the development of another technic for recovering individual lymph node cells at the center of plaques. By making the agar as dilute as was consistent with the semi-solid state (i.e. consistent with immobilizing the lymph node cells and the target red blood cells) the agar was rendered so soft that antibody-producing cells could be recovered in numbers by suction into a fine-tipped pipet under a relatively low level of microscopic magnification. Also, this method made possible the collecton of antibody-producing cells detected by another method – rosette formation. When cells from an antibody-producing lymph node are incubated with the target red blood cells in a liquid cell-suspension, those cells which are producing antibody, and therefore have on their surface antibodies which have not yet diffused away, will bind the target red cells to their surface in a formation which has been called by French observers a "rosette," a central antibody-producing cell

surrounded by target red cells. This test for anti-red-cell antibodies is more sensitive, since it requires the synthesis of only enough antibody to appear on the surface of the synthesizing cell, rather than enough to be secreted and diffuse a number of cell-widths away.

The earlier electron-microscopic study of plaque producing-cells had examined only a few cells, enough to demonstrate that antibody plaque-forming cells could be found in the morphologic categories of both lymphocyte and plasma cell. The newer method of collecting plaque-producing cells from the softer agar made possible the collection and examination of 162 such cells (Gudat et al., 1970). Again, plaque-producing cells were found in both cell types, with a wider range of development of the cell components that distinguish these cell types, and with far finer steps of gradations of these components. Some of the cells were so intermediate in the level of development of these intracellular structures that they could only be classified as "transitional lymphocytes". The plaques surrounding typical lymphocytes and typical plasma cells were of approximately equal diameter, suggesting that cells of the two types were synthesizing antibody for secretion at about the same rate. The plasma cells were, in addition, synthesizing antibody for storage within the cell. Rosette-forming cells were also found in both cellular categories, also with fine gradations of development of organelles in each group and with cells that could only be characterized as transitional.

The large number of antibody-producing cells which could be collected made it possible to study cells from both spleen and lymph nodes, of rabbits and mice. The observations made in the previous paragraph applied to both species and to both organs. Two differences were found between plaque- and rosette-forming cells. First, the plaque-forming cells were largely plasma cells and the rosette-forming cells were largely lymphocytes. Second, of 10 antibody-producing cells found which were undergoing cell-division, all were lymphocytes, in varying degrees of differentiation.

Morphologic heterogeneity among antibody-producing cells studied by electron-microscopy was also reported among plaque-producing cells by Neher and Siegel (1969) and among the rosette-forming cells by Storb et al. (1967) and by Cunningham et al. (1966).

Another application of electron microscopy to the identification of antibody-producing cells was done by histologic study of lymph nodes of rabbits following repeated injections of protein antigens, by Leduc et al. (1968). In this work ultrathin sections were prepared from the lymph node and treated with a special stain opaque to the electron beam, for the

detection of antibody. The authors found antibody within "differentiating and mature plasma cells", the "differentiating" plasma cells resembling substantially the "transitional lymphocytes" reported by Gudat et al. (1970) among the plaque-producing and rosette-producing cells. No cells identified as lymphocytes were reported in this study.

To better understand the difference between the results of the electron microscopic studies of Harris et al. (1966) and Gudat et al. (1970), on the one hand, and those of Leduc et al. (1968) on the other, the criterion of selecting the cells for study must be borne in mind. In the studies of Harris et al. and Gudat et al. the individual cells examined were selected on the basis of their having secreted, during the time of incubation, the antibody which caused the destruction of the red blood cells, thus forming a plaque of hemolysis. In the study of Leduc et al. only those cells which contained a theshold amount of antibody would be detected, thus omitting other cells which might be producing and secreting antibody but might not contain the sufficient antibody to be detected at the time of collection for staining. The essential difference, then, is between a criterion of antibody-producing cells and one of antibody-containing cells.

The detailed electron-microscopic study of several hundred plaque-producing cells described above (Gudat et al., 1970) was done entirely on antibody-producing cells obtained from organized lymphatic tissue – spleen and lymph node. It was of interest to examine antibody-producing cells free of the organized tissue of origin, circulating in lymphatic channels. Rabbits were injected in the hind foot pads with sheep red blood cells and, a few days later, lymph was collected from the efferent lymphatic vessel leaving the draining popliteal lymph node. Plaque-producing cells were collected by the soft agar method for electron microscopic examination (Harris et al., 1972; Hummeler et al., 1972). Of 71 plaque-producing cells from the lymph so examined, 93 per cent were lymphocytes. This was in sharp contrast to the plaque-forming cells of the lymph node and spleen which were approximately 10 percent lymphocytes, and 90 percent plasma cells. Most of the plaque-producing lymphocytes showed no signs of substantial levels of physiologic activity, but approximately one-fifth of them presented an appearance of senescence, with signs of degeneration which among the plaque-producing cells of the lymph node had previously been observed only in plasma cells. Thus, if there is a differentiation of antibody-producing lymphocytes to plasma cell, a possibility suggested by the earlier study (Gudat et al., 1970), it would appear that antibody-producing lymphocytes can develop along two paths. Some would emerge from the lymph

node to circulate as active lymphocytes. Others would remain in the organized tissue of lymph node or spleen for differentiation into plasma cells, with maximal rates of antibody production secreting antibody at approximately the same rate as lymphocytes, but, in addition, synthesizing antibody for storage within the cell until the antibody is released at the dissolution of the cell.

The observation in the two studies by electron microscopy of antibody-producing cells (Harris et al., 1966; Gudat et al., 1970) that cells which are actively synthesizing antibody can be found in two morphologically designated categories posed the question of whether there are two cell lines, each with the faculty of synthesizing antibody, or whether all of these cells are of one line, the morphologic differences reflecting differences in development of differentiation, or variations in the storage of antibody in addition to secretion.

The first part of an approach to this question would be to identify the youngest antibody-producing cells among those which could be isolated, by radioactive labeling of nascent cells in vivo, and then to see whether the distribution of these young cells between the lymphocytic and plasmacytic categories differed from the distribution which was found in the entire population of antibody-producing cells identified by the same method.

An appropriate radioactive label for identifying young cells is tritium-labeled thymidine. This is a nucleic acid component of DNA, and therefore identifies newborn cells by the fact that their DNA is labeled. An earlier study had shown the feasibility of this procedure by labeling young rosette-producing cells in the mouse spleen (Gudat et al., 1971a).

For the purpose of resolving the present question it was, however, necessary to label young plaque-producing cells since the majority of plaque-producing cells of the spleen had been found to be plasma cells (Gudat et al., 1970). Only among plaque-producing cells, therefore, would it be possible to show a significant increase in the percentage of cells of lymphocytic morphology if these did, in fact, represent an early form of the set of antibody synthesizing cells. Mice injected with sheep red blood cells and then, 4 days later, with tritium-labeled thymidine, were sacrificed on the day of the thymidine injection, or 1 or 2 days later. Hemolytic antibody plaque preparations were made of cells from the draining lymph nodes by the thin-plating procedure, permitting the collection of isolated plaque-forming cells for electron microscopic examination and photographic identification of radioactivity. Of cells obtained on the day of tritiated thymidine injections, 65 percent of the labeled plaque-forming cells were in the lym-

phocytic category, in comparison with 13 per cent found previously in the entire population of such cells in all of our studies. Cells obtained 1 day after the thymidine injections showed a shift to a majority of labeled cells in the plasma cell category. Some mature labeled plasma cells were now seen. The labeled plaque-forming cells obtained on day 2 gave no indication of further differentiation. The data from these experiments suggested a direct differentiation from antibody-synthesizing lymphocytes to plasma cells. Further, the experiments indicated that differentiation from the nascent lymphocyte to plasma cell could be essentially completed within 1 day, (Gudat et al., 1971b).

The next study was a mirror image of the one just described. Here the plan was to see whether a selection of the more mature forms of the antibody-forming cells of a lymph node or spleen would show disproportionately high frequency of plasmacytic forms. For this is was necessary to use rosette formation, since among rosette-forming cells of lymph node and spleen plasma cells had been found to constitute only about 10 to 13 per cent, a level from which it would be possible to show a significant increase, in contrast to the 87 to 90 per cent of plasmacellular plaque-forming cells in the population as a whole, if these did, in fact, represent a single cell-line. Mice were injected with sheep red blood cells, and 3 days later were injected with an inhibitor of cell-division. One day later, the mice were sacrificed and rosette-forming cells were isolated from the spleens for electron-microscopic examination to see whether the percentage of rosette-forming cells which were plasmacytic differed significantly from that which we found in the total population.

Rosette-forming cells from the spleens of such mice were, again, found in both morphologic categories, but the distribution differed. Whereas in normal populations of rosette-forming cells from mice so injected the plasmacellular forms have been present at 10 to 13 per cent, treatment with three mitotic inhibitors used produced plasmacellular rosette-forming cells at percentages of 32, 38, and 73, respectively. These data suggested that there is a single cell line of antibody producing cells, the plasma cells constituting the later or more highly differentiated forms. These results complemented the earlier findings that the youngest plaque-forming cells, identified by the incorporation of tritium-labeled thymidine, were found to be much higher in their percentage of lymphocytic forms than the population of these cells as a whole.

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In choosing the papers for analysis, we attempted to reflect the stages in our understanding of the problem of the cellular source of antibody, and the introduction of new concepts or experimental approaches.

We began with the first experimental evidence which localized the process of antibody formation to lymphatic tissue as a whole, that of McMaster and Hudack (1935). Then, representing the period when studies became directed at the individual cell type involved, we have two of the early studies indicating the lymphocyte (Dougherty et al., 1944; Harris and Harris, 1949), two suggesting the plasma cell (Bjørneboe et al., 1946; Fagraeus, 1948), and one study which attempted to find a developmental relationship between the two cell-types (Keuning and van der Slikke, 1950).

Reflecting newer knowledge and methodology into research on this problem, we have one study using specialized stains for identifying protein-synthesizing cells in antibody producing tissue (Ehrich et al., 1949), studies involving fluorescence-staining for intracellular localization of antibody (Coons et al., 1955; Leduc et al., 1955), and one using whole-body depletion of lymphocytes (McGregor and Gowans, 1963).

The resolution of the problem of the antibody-synthesizing cell, by electron-microscope identification of the cells which produce antibody is represented by two papers on antibody-producing cells (Harris, Hummeler, and Harris, 1966; Gudat et al., 1970) and one study of antibody-containing cells (Leduc et al., 1968).

Finally, a recapitulation of the current status is taken from a recent textbook in the field (Yoffey and Courtice, 1970).

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APPENDIX 1

TABLES OF IMMUNOLOGY REPORTS: ENGLISH

READING THE TABLES OF APPENDIX 1

Many rows of the tables can be read normally left to right. Material preceding three bars is always read first and words within each segment (i.e., between the bars) are read left to right. To indicate a different reading order of the segments within a row, we make use of three symbols. These are a capital letter beginning a word and two arrows, lower '←'and raised '←'. The capital letter has precedence over the two arrows and instructs that the sentence on the right side of the conjunction (enclosed by double bars) be read initially. A lower arrow (i.e., even with the line of print) signals that its segment be read, then proceeding leftwards. A raised arrow appears only in the conjunctional segment and provides that upon reading the conjunction, one reads the left sentence left to right. A raised arrow, in turn, has precedence over a lower one. These instructions are subject to the provisions regarding the reading of secondary (WH- conjoined) sentences. The different cases that arise are illustrated below.

case 1) The row is normally read left to right, beginning with any material written to the left of the three bars marking off conjunctions, sentence introducers, and other material, e.g.,

5, 204.2.2 row 4: *and then* ||| (*lymphocytic hyperplasia*) | *becomes organized into* | *the characteristic follicular structure*

case 2) A lower arrow instructs that the segments of the row be read from right to left, reading the words within segment boundaries (vertical bars) normally left to right, including across the conjunctional segment, e.g.,

14, 588.1.1-2 row 2: *sheep red blood cells* | *a single injection of* || *four days after* || *cells* | *appeared small but quite definite numbers of* | *in regional lymph nodes* ←

– i.e., "In regional lymph nodes appeared small but quite definite numbers of cells four days after a single injection of sheep red blood cells."

case 3) A lower arrow in the conjunctional segment instructs that the row, from that point, be read right to left until the leftmost segment (but not extending across three bars); the remaining portion of the row is then read left to right, e.g.,

4, 10.2.4 row 1: *the reinjection* || *on the 7th – 10 day after* ← || *of antibodies* | *the amount found was smaller throughout in the culture fluids* | *of the tissue*

– i.e., "On the 7th – 10th day after the reinjection, of antibodies, the amount found was smaller throughout in the culture fluids of the tissue."

case 3b) Where two arrows occur in a row, the one within the conjunctional segment has precedence over the other, e.g.,

4, 10.2.4 row 2: *when* ||| (*the reinjection*) || (*at this time after*) ← || *titer curve was leveling off* | *serum* | *the animal's* ←

i.e., "...when, at this time after the reinjection, the animal's serum titer curve was leveling off."

case 3c) A raised arrow in the conjunctional segment instructs "proceed to the leftmost segment and begin reading left to right" e.g.,

9, 67.2.1 row 1: *of antigen* | *only one injection is administered* || *when*← || *the course of events takes place on a very small scale*

– i.e., "When of antigen, only one injection is administered, the course of events takes place on a very small scale."

case 4) A word beginning with a capital letter has precedence over all other reading instructions and indicates the point at which the reading is initiated.

3, 128.4.1 row 2: *a single injection* | *immunization with* || *on*← || *Plasma cell* | *proliferation*

– i.e., "Plasma cell proliferation on immunization with a single antigen."

WH- PROVISION

Within the reading imposed by the conventions above, segments (words) to which a secondary sentence have been attached (by *WH-*) are read as follows (Cf. chapter 4, section 5):

i) ':$^{w}_{t}$ ' -when the secondary sentence is on a time word written within the colon (conjunctional) segment, the left argument of the colon (usually a GJB sentence) is read before the appended secondary, e.g.,

4,1.3.9, rows 1-2:

$GJ^{2}{:}^{w}_{t}C^{m}_{z}W_{i}$ *the injection || from 5 – 8 days after←* || *of mature plasma cells there was observed an increasing number←*

$GJ^{2}{:}_{t}AV^{»b}_{i}T_{b}$ *at WH* ||| (*the injection*) || (*time from 5 to 8 days after*) ← || *the (antibody)* | *titer curve (reached a) peak (in)* | *(the) serum*

– i.e., "From 5 to 8 days after the injection, at (which) (time from 5 to 8 days after the injection) the (antibody) titer curve (reached a) peak (in) (the) serum, there was observed an increasing number of mature plasma cells."

ii) Otherwise the secondary sentence is read upon encountering a word in the primary to which the secondary is attached: e.g.,
11,162.2.5, rows 5-7:

$A^{w}V_{i}C^{w}$ *and* ||| *of antibody* | *the presence in an amount necessary for detection by immunoflourescence in* | *cells*

AV_{p} WH ||| (*antibody*) | *(is) completed*

$AV^{c}_{p}C$ WH ||| (*are*) *immunocompetent* | (*cells*)←

– i.e., "and of antibody (which is) completed, the presence in an amount necessary for detection by immunoflouresence in cells (which are) immunocompetent."

"The Formation of Agglutinins within Lymph Nodes", Philip D. McMaster and Stephen S. Hudack, *The Journal of Experimental Medicine*, (1935) vol. 61, No. 6, 783-805

783.1.1
In human skin the superficial lymphatic plexus is so rich that every scratch or puncture wound serves to rupture some of the minute lymphatic capillaries.

783.1.2
Peripheral lymph flow is far more rapid than is generally supposed, and dye substances injected intradermally are carried to neighboring lymph nodes in a few minutes, even in a resting limb.

783.1.3
Work on the physiology of lymphatics in the ear of the mouse has shown that lymphatic capillaries remain open many hours after an incision.

783.1.4
Whenever the continuity of the skin is broken there exists therefore a ready route for infection.

Paper 1

	783.1.1
$T_{\ell'}W_i^+T_{\ell'}B$	(lymphatic capillaries) | is so rich (in) | the superficial lymphatic plexus, in human skin ←
$J{:}T_{\ell'}W_{c'}$	that ‖‖ every scratch or puncture wound ‖ serves (to cause) ‖ some of the minute lymphatic capillaries | to rupture
	783.1.2
$T_{\ell}W_u^{i+}$	Peripheral lymph | flows far more rapidly than is generally supposed
$G_a{\sim}JB{:}G_a{\sim}U^tT_n^B$	, and ‖‖ (dye substances) | (are) injected | intradermally ‖ $WH^{\leftarrow}$ ‖ Dye substances | are carried in a few minutes, even in a resting limb, | to neighboring lymph nodes
	783.1.3
M	Work on the physiology of lymphatics in the ear of the mouse has shown that
$J{:}_tT_{\ell'}W_{c}{}'$	an incision ‖ many hours after← ‖ Lymphatic capillaries | remain open
	783.1.4
$JB{:}G_fU$	therefore ‖‖ the continuity is broken | of the skin ‖ whenever ‖ infection | There exists a ready route for ←

783.1.5
Along the path of the infection, between the open lymphatic capillaries of the skin and the entrance of the larger channels into the blood stream, stand the regional lymph nodes; and when such infection occurs with or without lymphangitis they become enlarged and painful.

783.1.6
A reaction of lymph nodes to infection is recognized in a multitude of diseases, – *e.g.* in plague, in typhoid and frequently in tonsillar infection.

783.1.7
Pathogenic bacteria carried on the lymph stream are often arrested in the glands through which this stream passes, with result that the infection travels no further.

783.2.1
It seems possible that within the lymph glands there may occur some formation of antibodies to antigens arriving by the lymph stream.

	783.1.5
$G_fU^{ft_y}T\gamma'_{\gamma}T_bT_nB$	The infection | has a path | between the lymphatic capillaries of the skin | and the entrance of the larger channels into the blood stream | along which path stand the regional lymph nodes
$T_{\ell'}W_{c'}$	WH ||| (the lymphatic capillaries) | (are) open
$G_fJ{:}T_nBW_{g,f}$	; and ||| such infection occurs || When ← || they become enlarged and painful
$G_fJ{:}T_{\ell'}W_f$	(such infection occurring) || with || (lymphangitis)
$G_fJ{:}T_{\ell'}W_{\tilde{f}}$	or ||| (such infection occurring) || with || -out lymphangitis
	783.1.6
$G_fJ{:}T_nW_a$	(occurrence of) infection || to || lymph nodes | a reaction of ←
M	is recognized in a multitude of diseases
$G_fJ{:}T_nW_a$	, as *e.g.* in ||| (occurrence of) plague || (to) (lymphodes) | (a reaction of) ←
$G_fJ{:}T_nW_a$	in ||| (occurence of) typhoid || (to) || (lymph nodes) | (a reaction of)←
$G_fJ{:}T_nW_a$	and frequently in ||| (occurence of) tonsillar infection || (to) || (lymph nodes) || (a reaction of) ←
	783.1.7
$G^wU_IT^w_n$	Pathogenic bacteria | are often arrested | in the glands
GU^yT_{ℓ}	WH ||| (pathogenic bacteria) | (are) carried | on the lymph stream
$T_{\ell}W^y_uT_n$	which ||| this stream | passes through | (the glands)
$G_fU^{\sim}$	, with result that ||| the infection | travels no further
	783.2.1
M	It seems possible that
$GU^yT_{\ell}{:}A^GV_pT_n$	(antigens) | arrive | by the lymph stream || WH$^{\leftarrow}$ || antibodies to antigens | there may occur some formation of | within the lymph glands ←

783.3.1
A group of 30 mice of about 25 gm. body weight was injected intradermally in both ears with about 0.02 cc. of the *enteritidis* bacterin.

787.3.2-3
7 days after the last injection the enlarged lymph nodes of the neck were removed from the etherized animals and they were bled for serum. In every instance the nodes were inflamed and much enlarged.

788.2.1
In these experiments agglutinins were found in both nodes and sera.

788.2.2
They were much stronger in the former.

789.1.1
A large number of mice about 30 gm. body weight were injected intradermally in the right ear only on 2 successive days with approximately 0.03 cc. of the paratyphoid bacterin used in the previous experiment.

789.1.2-3
On the 1st, 2nd, 3rd, 5th, 7th, 8th, 10th and 12th days after the last injection, random groups of ten animals were anesthetized with luminal, bled for serum and the cervical lymph nodes on both the injected and control sides were removed. In every instance the nodes on the injected side were greatly enlarged and hemorrhagic, while those draining the uninjected ears appeared normal.

787.3.1

GJ^2B about 0.02 cc. of the *enteritidis* bacterin | was injected (on 2 successive days) with | intradermally in both ears, a group of 30 mice of about 25 gm. body weight ←

787.3.2-3.3

$GJ^2B:_tT_n^{wB}W_f,W_g^+$ the last injection || 7 days after ← || the lymph nodes of the neck were removed from the etherized animals and bled for serum, and | were in every instance inflamed and much enlarged

T_nW_g WH ||| (lymph nodes) | (were) enlarged

788.2.1

M In these experiments

$GJ^2B:AV_iT_n$ both ||| agglutinins | were found in | nodes

$GJ^2B:AV_iT_b$ and ||| (agglutinins) | (were found in) | sera

788.2.2

$GJ^2B:AV_i\gtrdot T_n$ The agglutinins | were much stronger in | the nodes

$GJ^2B:AV_iT_b$ (than) ||| (the agglutinins) | (were strong in) | (sera)

789.1.1

GJ^2B approximately 0.03 cc. of the paratyphoid bacterin used in the previous experiment | were injected on 2 successive days with | intradermally in the right ear only, a large number of mice of about 30 gm. body weight ←

789.1.2-3

$GJ^2B:_tT_n^BW_g^+,W_f$ the last injection | on the 1st, 2nd, 3rd, 5th, 7th, 8th, 10th and 12th days after ← || cervical lymph nodes on both the injected and control sides removed (in) random groups of ten animals anesthetized with luminal, bled for serum | were in every instance greatly enlarged and at times hemorrhagic

$GJ^2B:_tT_n^B\sim W_{g\sim},_{f\sim}$ while ||| the nodes draining the uninjected ears | appeared normal

789.2.1
As the table shows, no antibody was found until the 7th day following the last injection.

789.2.2
It then appeared simultaneously in the lymph nodes of the injected side and in the serum, but in much higher concentration in the former.

789.2.3
The lymph nodes of the uninjected side contained no demonstrable agglutinins.

789.2.4
As the experiment progressed the antibody concentration in nodes and serum increased, with always a little more in the former.

	789.2.1
M	As the table shows
$GJ^2B:_tAV_i^{\sim}$	the last injection || until the 7th day following ← || Of antibody | none was found
	789.2.2
$GJ^2B:_tAV_iT_n^B$	Then ||| antibody | appeared in | the lymph nodes of the injected side
$GJ^2B:_tAV_iT_b$	and simultaneously ||| (antibody) | (appeared) in | the serum
$GJ^2B:_tAV_i^{>}T_n^B$	, but ||| (antibody) | (appeared) in much higher concentration in | the former
$GJ^2B:_tAV_iT_b$	(than) ||| (antibody) | (appeared in concentration in) | (the serum)
	789.2.3
$GJ^2B:_tAV_i^{\sim}T_n^{B\sim}$	agglutinins | contained no demonstrable | lymph nodes of the uninjected side ←
	789.2.4
$GJ^2B:_tAV_i^{\uparrow}T_n$	(GJ^2B) || as the experiment progressed (following) ← || antibody | concentration increased in | nodes
$GJ^2B:_tAV_i^{\uparrow}T_b$	and ||| (GJ^2B) || (as the experiment progressed following) ← || (antibody) | (concentration increased in) | serum
$GJ^2B:_tAV_i^{>}T_n$	, with ||| (GJ^2B) || (as the experiment progressed following) ← || (antibody) | always a little more in | nodes
$GJ^2B:_tAV_iT_b$	(than) ||| (GJ^2B) || (as the experiment progressed following) ← || (antibody) | (concentration in) | (serum)

789.2.5
On the 10th day agglutinins were found in the extract of ear tissue on the injected side but not until the 12th day did they appear in the nodes of the uninjected side.

789.2.6
At this time too, they first appeared in the spleen, a fact not shown in the table.

789.2.7
They were not found in the liver nor in the ear tissue on the uninjected side.

789.4.1
This experiment served to demonstrate the early appearance of agglutinins in the regional lymph nodes and serum after intradermal injection of antigens, and its later presence in the ear tissue on the injected side and in the spleen.

789.4.2
But nothing can be concluded from it as to the site of antibody formation.

789.2.5

$GJ^2B:_tAV_iT_e^{xB}$ (GJ²B) || on the 10th day (following) ← || agglutinins | were found in | the extract of ear tissue on the injected side

$GJ^2B:_tAV_iT_n^{B\sim}$ but ||| (GJ²B) || until the 12th day (following) ← || agglutinins | did not appear in | the nodes of the uninjected side

789.2.6

$GJ^2B:_tAV_i^eT_s$ Too ||| (GJ²B) || at this time (following) ← || agglutinin | first appeared in | the spleen

M , a fact not shown in the table

789.2.7

$GJ^2B:AV_i\sim T_v$ agglutinins | were not found in | the liver

$GJ^2B:AV_i\sim T_e^{B\sim}$ and ||| agglutinins | (were) not (found) in | the ear tissue on the uninjected side

789.4.1

M This experiment served to demonstrate

$GJB:^eAV_iT_n^B$ antigens | injection of | intradermal || early after ← || Of agglutinins, | the appearance in | the regional lymph nodes

$GJB:^eAV_iT_b$, and ||| (antigens) | (injection of) | (intradermal) || (early after) ← || (of agglutinins) | (the appearance in) | serum

$GJB:^{e\sim}AV_iT_e^B$ and ||| (antigens) | (injection of) | (intradermal) || later (after) ← || agglutinins | presence in | the ear tissue on the injected side

$GJB:^{e\sim}AV_iT_s$ and ||| (antigens) | (injection of) | (intradermal) || (later after) ← || (agglutinins) || (presence) in | the spleen

789.4.2

M But nothing can be concluded from this experiment as to

AV_pT antibody | of formation of | the site ←

789.4.3
The lymph nodes on the right side were found inflamed and hypertrophic, those on the left normal.

789.4.4
The former contained a slightly higher concentration of agglutinins than the serum, and until the 12th day none was found in the lymph glands of the left side, yet it is conceivable that the inflamed nodes took up from the blood antibody which had been formed elsewhere, while the normal lymph nodes failed to do so.

791.2.1
Three types of experiment were devised to control the possibilities just discussed.

791.3.1
In the first type, inflammation was induced in the cervical nodes of both sides and in both ears by the injection of paratyphoid bacterin on one side and diptheria toxin on the other.

	789.4.3
$GJ^2B{:}T_n^BW_{f,g}$	the lymph nodes on the right side | were found inflamed and hypertrophic
$GJ^2B{:}T_n^BW_{f\sim}$	, ||| those on the left (side) | were normal
	789.4.4
$GJ^2B{:}AV_i^{>}T_n^B$	agglutinins | contained a slightly higher concentration of | the lymph nodes on the right side ←
$GJ^2B{:}AV_iT_b$	than ||| (agglutinins) | (contained a concentration of) | the serum ←
$GJ^2B{:}_tAV_i{\sim}T_n^{B\sim}$	, and ||| (GJ^2B) || until the 12th day (following) ← || (of agglutinin) | none was found in | the lymph glands of the left side
$A^wV_u^{ft}T_bT_n^w$	, yet it is conceivable that ||| antibody | was taken up | from the blood | by the nodes
$AV_pT_{n\sim}$	which ||| (antibody) | (had been formed) | elsewhere
T_nW_f	WH ||| (nodes) | (are) inflamed
$AV_u^{\sim ft}T_bT_n^w$	, while ||| antibody | failed to be taken up | from the blood | by the lymph nodes
$T_nW_{f\sim}$	WH ||| (lymph nodes) | (are) normal
$AV_pT_{n\sim}$	WH ||| (antibody) | (had been formed) | (elsewhere)
	791.2.1
M	Three types of experiments were devised to control the possibilities just discussed.
	791.3.1
M	In the first type,
GJB_1	paratyphoid bacteria | injection | on the side
$G_{a\sim}JB_2$	and ||| diptheria toxin | (injection) | on the other (side) ||
$:T_n^{B_1, B_2}W_f$	induced || in the cervical lymph nodes of both sides and in both ears | inflammation

792.1.1
The latter was utilized to produce local inflammation without introducing an agglutinin-forming antigen.

792.1.2
In these experiments the ears and nodes on both sides became inflamed and swollen but not quite to the same degree, the nodes on the side injected with paratyphoid bacterin becoming slightly larger.

792.2.1
In these experiments yielding the results recorded in Table IV, about 0.03 cc. of the paratyphoid B bacterin was injected intradermally on 2 successive days into the right ears of 20 mice.

792.2.2
Schick test toxin 0.03 cc. was injected intradermally at the same time into the left ears.

792.3.1
As Table IV shows, paratyphoid agglutinins were present in the extract from the right nodes, that is to say, on the side injected with killed paratyphoid organisms.

	792.1.1
$G_{a\sim}JB{:}T^{B}W_{f}$	diptheria toxoid | was utilized || to produce || local | inflammation
$G^{w}J^{\sim}$	with- ||| an antigen | -out introducing ←
$G{:}AV_{p}$	WH ||| (antigen) || (causes) || agglutinin | formation
	792.1.2
M	In these experiments,
$GJ^{2}B{:}T^{B}_{n}W_{f,g}$	the ears and the nodes on both sides | become inflamed and swollen
$GJ^{2}B{:}T^{B}_{n}W^{<}_{f,g}$	but ||| (the ears and the nodes on one side) | became inflamed and swollen) not quite to the same degree
$GJ^{2}B{:}T^{B}_{n}W_{f,g}$	(as) ||| (the ears and the nodes on the other side) | (became inflamed and swollen)
$GJB{:}T^{B}_{n}W^{>}_{g}$	, ||| paratyphoid bacterin | (was) injected with | (side) || WH ← || The nodes on the side | becoming slightly larger
$G_{a\sim}JB{:}T^{B}_{n}W_{g}$	(than) ||| (diptheria toxin) | (injected with) | (side) || WH ← || (the nodes on the other side) | (become large)
	792.2.1
M	In the experiment yielding the results recorded in Table IV,
$GJ^{2}B$	about 0.03 cc. of the paratyphoid B bacterin | was injected on 2 successive days | intradermally into the right ears of 20 mice
	792.2.2
$G_{a\sim}J^{2}B$	Schick test toxin 0.03 cc. | was injected at the same time | intradermally into the left ears
	792.3.1
M	As Table IV shows,
$GJ^{2}B{:}A^{G}V_{i}T^{xB}_{n}$	killed paratyphoid organisms | (was) injected with | (side) || WH ← || Paratyphoid agglutinins | were present in | the extract from the right nodes, that is to say, on the side

792.3.2

$GJ^2B{:}AV_i^+$ agglutination | was strongly positive at a dilution of 1 to 120 and faintly positive at 1 to 240

792.3.3

$GJ^2B{:}AV_i{:}T_b$ of agglutinin | much less was present, tests being positive at 1 to 60 and negative at 1 to 120, in | the serum

792.3.4

$G_a{\sim}J^2B{:}AV_i{\sim}T_n^{xB}$ diptheria toxin | (was) injected with | (side) || WH ← || Of agglutinins | none were demonstrable in | the extract of the nodes on a side

792.3.5

$G_a{\sim}J^2B{:}T_e^BW_f^<$ (diptheria toxin | (was injected with) | (side) || WH ← || The ears on a side | were markedly inflamed but slightly less so

$GJ^2B{:}T_e^BW_f$ than ||| (paratyphoid bacterin) | (was injected with) | (side) || WH ← || (The ears) on the opposite side | (were inflamed)

792.4.1
If, in the earlier experiments, agglutinins formed elsewhere in the body were taken out of the blood by the inflamed nodes on the injected side or had seeped through the permeable blood vessels of the inflamed ear to be drained to the lymph nodes and accumulate there, surely some should have been found in the present experiment on the side on which diptheria toxin was injected.

792.4.2
This was not the case and so the findings indicate that the antibodies present in the right lymph nodes had been formed there.

794.5.1
A third type of experiment was devised to show finally whether or not agglutinin formation takes place with lymph nodes.

792.4.1

M	In the earlier experiments,
$GJ^2B{:}A^wV_u^{ft}T_bT_n^{wB}$	if ||| (was) injected | (side) ||| (WH) ← || Agglutinins | were taken out of the blood | by the nodes on a side
$AV_pT_{n\sim}^{B\sim}$	WH ||| (agglutinins) | (were) formed | elsewhere in the body
T_nW_f	WH ||| (nodes) | (were) inflamed
$GJ^2B{:}A^wV_u^yT_bT_e^w$	or ||| (agglutinins) | had seeped | through the permeable blood vessels of the ear
$AV_pT_{n\sim}^{B\sim}$	WH ||| (agglutinins) | (were formed) | (elsewhere in the body)
T_eW_f	WH ||| ear | (was) inflamed
$AV_u^tT_n$	(for) ||| (agglutinins) | to be drained | to the lymph nodes
$AV_i^{\uparrow}T_n$	and (for) ||| (agglutinins) | (to) accumulate | there
M	, ||| surely in the present experiment
$G_{a\sim}J^2B{:}AV_iT_n^B$	diptheria toxin | (was) injected with | (side) || WH || Of the agglutinins | some should have been found (in) | (the nodes) on a side on

792.4.2

$G_{a\sim}J^2B{:}AV^{\sim i}T_n^B$	diptheria toxin | (was) injected with | (side) || WH || Agglutinins | were not found (in) | (the nodes) on a side
M	and so the findings indicate that
$GJ^2B{:}A^wV_pT_n^B$	(paratyphoid bacterin) | (was injected with) | (side) || WH || Antibodies | had been formed | in the lymph node of the right (side)
$GJ^2B{:}AV_iT_n^B$	(paratyphoid bacterin) | (was injected with) | (side) || WH || (Antibodies) | (were) present in | the lymph nodes of the right (side)

794.5.1

M	A third type of experiment was devised to show finally whether or not
AV_pT_n	agglutinin | formation takes place | within lymph nodes

794.5.2
Different antigens of a similar nature were employed; that is to say, suspensions of various killed organisms which would call forth agglutinin formation, and at the same time induce approximately the same degree of inflammation in the injected ears and in the regional lymph nodes.

796.2.2
In the right ears 0.02 cc. of *B. enteritidis* suspension was injected and in the left the same amount of killed *B. prodigiosus.*

796.4.1
The highest concentration of *B. enteritidis* agglutinin was found in the extracts of the lymph nodes from the side injected with that antigen, two to four times as much as in the serum.

794.5.2

GJ	Different antigens of a similar nature | were employed
$G^{w}J$	; that is to say, ||| suspensions of various killed organisms | (were employed)
$G{:}AV_{p}$	which ||| (suspensions of various killed organisms) || would call forth || agglutinin | formation
$GJB{:}T^{B}_{e,n}W_{f}$	, and (which) ||| (suspensions of various killed organisms) || (would) induce at the same time || in the injected ears and the regional lymph nodes | approximately the same degree of inflammation

796.2.2

$GJ^{3}B$	0.02 cc. of *B. enteritidis* suspension | was injected [three times on successive days] | [intradermally] in the right ears [of forty-five mice, approximately 30 gm. in weight]
$GJ^{3}B$	and ||| 0.02 cc. of killed *B. prodigiosus* | was injected [three times on successive days] | [intradermally] in the left (ears) [(of) forty-five mice, approximately 30 gm. in weight]

796.4.1

$GJB{:}A^{G}V_{i}^{>}{>}T_{n}^{xB}$	*B. enteritidis* | (was) injected with | (side) || WH | Of *B. enteritidis* agglutinin | the highest concentration, two to four times as much, was found in | the extracts of the lymph nodes from a side
$GJB{:}A^{G}V_{i}T_{b}$	as ||| (*B. enteritidis*) | (was injected with) | (that side) || (after) ← || (*B. enteritidis* agglutinin) | (was found) in | the serum

796.4.2
The serum in turn contained more agglutinin for *B. enteritidis* than did the extract of the nodes from the other side.

796.4.3
This despite the fact that the nodes were equally inflamed, as judged by their size and appearance in the gross and in microscopic sections.

796.4.4
In a corresponding manner the extract of lymph nodes from the side injected with killed *B. prodigiosus* contained the highest concentration of *B. prodigiosus* agglutinin with much less in the serum and least in the lymph node extract from the side injected with *B. enteritidis*.

796.5.3
Had agglutinins been formed elsewhere than in the nodes, this distribution could not have occurred.

796.4.2

GJB:$A^{G}V_{i}^{>}T_{b}$	In turn ||| (*B. enteritidis*)	(was injected with)	(the side) || (after) || agglutinin for *B. enteritidis*	contained more	the serum ←
GJB:$A^{G}V_{i}T_{n}^{xB}{\sim}$	than ||| (*B. enteritidis*)	(was injected with)	(the side) || (after) || (agglutinins for (*B. enteritidis*)	did (contain)	the extracts of the nodes from the other side ←

796.4.3

GJB:$T_{n}^{B}W_{f}$	This despite the fact that ||| (GJB) || (:) || the nodes on one side	were inflamed equally
GJB:$T_{n}^{B}{\sim}W_{f}$	as ||| (GJB) || (:) || the nodes on the other side	were inflamed
M	as judged in the gross and in microscopic sections
$T_{n}W$	by their	size and appearance

796.4.4

GJB:$A^{G}V_{i}^{>}{>}T_{n}^{xB}$	In a corresponding manner ||| killed *B. prodigiosus*	(was) injected with	(side) || WH ← || *B. prodigiosus* agglutinin	contained the highest concentration of	the extract of lymph nodes from the side ←
GJB:$A^{G}V_{i}^{<}T_{b}$	with ||| (killed *B. prodigiosus*)	(was injected with)	(the side) || (after) ← || (Of *B. prodigiosus* agglutinin) || much less (contained) in	the serum
GJB:$A^{G}{\sim}V_{i}^{<}{<}T_{n}^{\times B}$	and ||| *B. enteriditis*	(was) injected with	(side) || WH ← || (Of *B. prodigiosus* agglutinin) || least (contained) in	the lymph node from a side

796.5.3

$AV_{p}T_{n}{\sim}$	If ||| agglutinins	had been formed	elsewhere than in the nodes
~796.4.4	the 796.4.4 distribution could not have occurred

798.3.4
When antigen was injected only once or twice and the concentration of antibody in serum and lymph node extract sought shortly thereafter, far more agglutinin was found in the latter than in the former.

798.3.5
But when repeated injections of antigen were made and the interval between the time of the first injection and examination was delayed, for example for 12-21 days, the titre of antibody both in lymph node extract and serum was greatly increased but the concentration of agglutinins rose more rapidly in the serum, eventually in one instance exceeding that of the nodes.

801.2.1
That local injections produce speedy, remote reactions by vascular absorption is of course a truism as shown by the action of injected drugs; but the rapid lymphatic distribution of antigen is perhaps not so generally recognized.

798.3.4

$GJ^{1,2}{:}^{e}AV_iT_{b,}T^{x}_{n}$	When ||| antigen | was injected only once or twice || shortly after$^{\leftarrow}$ || antibody | concentration was sought in | serum and lymph node extract
$GJ^{1,2}{:}^{e}AV_i^{>}T^{x}_{n}$	, ||| (antigen) | (was injected only once or twice) || (shortly after)$^{\leftarrow}$ || of agglutinin | far more was found in | lymph node extract
$GJ^{1,2}{:}^{e}AV_iT_b$	than ||| (antigen) | (agglutinin) | (was found in | serum

798.3.5

$GJ^{3}B$	But when ||| of antigen | repeated injections were made
$GJ^{1}B{:}_{t}T^{x}_{n,b}W_{\ell}$	and ||| the first injection || The interval was delayed, for example, for 12-21 days between $^{\leftarrow}$ and || (lymph node extract and serum) | examination
$GJ^{3}B{:}AV_i^{\uparrow}T^{x}_{n,b}$	, ||| ($GJ^{3}B$) || (:) || of antibody | the titre was greatly increased | both in lymph node extract and serum
$GJ^{3}B{:}AV_i^{\uparrow i>}T_b$	but ||| ($GJ^{3}B$) || (:) || of agglutinins | the concentration rose more rapidly in | the serum
$GJ^{3}B{:}AV_i^{\uparrow i}T^{x}_{n}$	(than) ||| ($GJ^{3}B$) || (:) || (of agglutinins) | (the concentration rose rapidly in) | (the lymph node extract)
$GJ^{3}B{:}AV_i^{>}T_b$	, in one instance ||| ($GJ^{3}B$) || (:) || (of agglutinins) | (the concentration) eventually exceeding (in) | (the serum)
$GJ^{3}B{:}AV_iT_n$	($GJ^{3}B$) || (:) || agglutinin | concentration of | nodes

801.2.1

M	It is of course a truism
$GJB{:}TW_a$	injections (which) | (are) local || produce || remote, | speedy reactions
$GU^{y}T_b$	by ||| antigen | being absorbed | vascularly
$GJ{:}TW_a$	as shown by ||| drugs | injected || of || the action $\leftarrow$
$GU^{iy}T_{\ell'}$	; but ||| antigen | rapid distribution of | lymphatic$\leftarrow$
M	is perhaps not so generally recognized

801.2.5
These authors attribute the escape of antigen from the ear to rapid absorption by the blood.

801.2.6
From our findings it seems probable that antigen was directly injected into the lymphatics in such experiments and distributed to regional lymph nodes where antibodies were formed.

801.4.1
As early as 1898, Pfeiffer and Marx titrated the bacteriolysin content of various organs and of the blood of rabbits intravenously injected with killed cholera spirilla.

801.4.2
They reported the antibody titre in the spleen, bone marrow, lymph glands, lungs and blood.

801.4.3
Bacteriolysin was at times found in higher concentration in the spleen than in the blood and in two or three instances appeared first in the spleen on the 2nd day after injection.

	801.2.5
M	Oshikawa and Reitler attribute
$GU^{f}T_{e}$	antigen's | escape | from the ear
$GU^{iy}T_{b}$	to ||| (antigen's) | rapid absorption | by the blood
	801.2.6
M	From our findings it seems probable that in such experiments
GJB	antigen | was injected | directly into the lymphatics
$GJB{:}GU^{t}T_{n}^{Bw}$	and ||| (GJB) || (after) ← || (antigen) | (was) distributed | to regional lymph nodes
$GJB{:}AV_{p}T_{n}^{B}$	where ||| (GJB) | (after) ← || antibodies | were formed | (in regional lymph nodes)
	801.4.1
M	As early as 1898, Pfeiffer and Marx titrated
$GJB{:}A^{G}V_{i}T,T_{b}^{B}$	killed cholera spirilla | injected with | intravenously (rabbits) || WH || The bacteriolysin | content | of various organs and of the blood of rabbits
	801.4.2
M	They reported
$GJB{:}AV_{i}T_{s,o,n,q,b}^{B}$	(killed cholera spirilla) | (injected with) | (intravenously rabbits) || (WH) || The antibody | titre in | the spleen, bone marrow, lymph glands, lungs, and blood (of rabbits)
	801.4.3
$GJB{:}A^{G}V_{i}^{>}T_{s}$	Bacteriolysin | was at times found in higher concentration in | the spleen
$GJB{:}A^{G}V_{i}T_{b}$	than ||| (bacteriolysin) | (was found in a concentration) in | the blood
$GJB{:}_{t}A^{G}V_{i}^{e}T_{s}$	and in two or three instances ||| injection || on the 2nd day after ← || (Bacteriolysin) | appeared first in | the spleen

802.2.5
Seegal and Seegal showed that the injection of typhoid vaccine into the anterior chamber of the rabbit's eye resulted in a concentration of agglutinins in certain tissues of the eye.

802.4.1
The evidence cited, for local formation of antibodies, though highly suggestive, fails to prove their formation within the tissues investigated: for the mere finding of antibody in high concentration within an organ does not prove its formation therein.

802.6.1
Lymph nodes have long been known to sieve out bacteria and hold them, and definite inflammatory reaction occurs in the nodes when toxins and bacteria are injected intradermally or subcutaneously.

802.6.2
As early as 1890 Oertel noticed that lymph glands were affected in diptheria, that edema of the glands occurred and histologically the germinal centers became involved.

	802.2.5
M	Seegal and Seegal showed that
GJB:AV_iT^B	typhoid vaccine | injection | into the anterior chamber of the rabbit's eye || resulted in || agglutinins | having a concentration in | certain tissues of the eye
	802.4.1
M	Though highly suggestive, the evidence cited, for
GJB:AV_pT^B	antibodies | formation of | local ←
M	fails to prove
GJB:AV_pT	the antibodies' | formation | within the tissues investigated
AV_i^+T	: for ||| of antibody | the mere finding in high concentration within | an organ
M	does not prove
GJB:AV_pT	the antibody's | formation | in that organ
	802.6.1
M	It has long been known that
GU^tT_n	bacteria | seive out | lymph nodes ←
GU_iT_n	and ||| bacteria | hold | (lymph nodes) ←
GJB:T_nW_f	, and ||| toxins and bacterins | are injected | intradermally or subcutaneously || when ← || in the nodes | Definite inflammatory reaction occurs ←
	802.6.2
M	As early as 1890 Oertel noticed that
$G_fJ:T_nW_a$	(occurrence of) diptheria || in || Lymph glands | were affected
$G_fJ:T_nW_f$	, that ||| (occurence of diptheria) || (in) || of the glands | edema occurred ←
$G_fJ:T_rW_a$	and ||| (occurence of diptheria) || (in) || The germinal centers | became histologically involved

803.2.1
Councilman called attention to the possible relationship of collections of lymphoid cells to the production of immunity, and, in the following years the significance of these collections of lymphocytes has been much investigated.

803.4.1
For many years, too, morphological evidence has been accumulating to show that the lymphatic system participates in the processes of immunization.

803.4.2
Matko described marked changes in the lymph glands within 3 days following vaccination with typhoid "vaccine".

803.4.3
Hellman and his coworkers showed that there occurred an increase in the total lymphatic tissues of rabbits of different ages during the process of immunization to paratyphoid bacilli.

803.4.7
In 1929, Ehrich described the changes in lymph glands after subcutaneous and intravenous injection of killed staphylococci.

803.4.8
Enormous enlargement of the cortex of the lymph glands developed, hand in hand with changes in the number of circulating lymphocytes.

	803.2.1
M	Councilman called attention to
$AV^{r}_{p}C_{\ell}$	immunity | possible relationship to the production of | collections of lymphoid cells' ←
M	and, in the following years the significance of these collections of lymphocytes has been much investigated
	803.4.1
M	For many years, too, morphological evidence has been accumulating to show that
$AV^{r}_{p}T_{\ell'}$	participates in the processes of immunization | the lymphatic system←
	803.4.2
M	Matko described
$GJB:_{t}T_{n}W^{+}_{c}$	typhoid "vaccine" | vaccination with || within 3 days following || the lymph glands | marked changes in ←
	803.4.3
M	Hellman and his coworkers showed that
$G:AV_{p}$	during ||| paratyphoid bacilli || to || The process of immunization
$GJB:T^{B}_{\ell'}W^{\uparrow}_{i}$	(GJB) || (after) || the total lymphatic tissue of rabbits of all ages | there occurred an increase in ←
	803.4.7
M	In 1929, Ehrich described
$GJB:T_{n}W_{c}$	killed staphylococci | injection of | subcutaneous and intravenous || after || lymph glands | the changes in ←
	803.4.8
$T_{x}T_{n}W^{+}_{g}$	of the cortex of the lymph glands | enormous enlargement developed
$C_{y}W^{\Delta}_{i}T_{b}$	, hand in hand with ||| of lymphocytes, | changes in the number | circulating

"The Demonstration of Antibodies in Lymphocytes," Thomas F. Dougherty, Jeanne H. Chase, and Abraham White, *Proc. Soc. Exp. Biol. Med.*, vol. 57, 1944, 295-298

295.1.2
Reticulo-endothelial cells in general and lymphoid tissue in particular have been suggested as a probable site of antibody production, and we have recently shown that the rate of liberation of antibody from lymphoid tissue is under the control of pituitary-adrenal cortical secretion.

296.1.1
The evidence therefore points to lymphocytes as a storehouse of antibody protein.

296.2.1
Normal mice of both sexes (NHO strain, Strong), 6 to 8 weeks old at the beginning of the study, received intraperitoneal injections of a 4% solution of fresh, washed sheep erythrocytes on alternative days for 5 weeks.

297.3.2
The agglutinin and hemolysin titers obtained with the extracts of lymphoid cells from both groups of immunized mice demonstrate that these extracts contained significant quantities of antibody protein.

Paper 2

	295.1.2
AV_pC_r	(antibody) | (production of) | reticulo-endothelial cells in general (as a probable site of) ←
$AV_pT_{\ell'}$	and ||| antibody | production of | lymphoid tissue in particular as a probable site of ←
M	have been suggested, and we have recently shown that
$AV_u^{of}T_{\ell'}$	of antibody | the rate of liberation | from lymphoid tissue is under the control of pituitary-adrenal cortical secretion
	296.1.1
M	The evidence therefore points to
AV_iC_y	antibody protein | as a storehouse of | lymphocytes←
	296.2.1
GJ^3B	a 4% solution of fresh, washed sheep erythrocytes | received injections on alternate days for 5 weeks of | intraperitoneally, normal mice of both sexes (NHO strain, Strong), 6 to 8 weeks old at the beginning of the study ←
	297.3.2
$GJB{:}A^GV_iC_{\ell}T^{xB}$	(were) immunized | (mice, both groups) || WH ← || The agglutinin and hemolysin | titers obtained with | the extracts of lymphoid cells from both groups of mice
$AV_i^+C_{\ell}T^x$	demonstrate that ||| antibody protein | contained significant quantities of | these extracts←

297.3.3
The titers in the extracts of lymphoid cells from immunized mice were approximately eight-fold higher than those in the corresponding sera on the basis of nitrogen contents.

297.3.4
The absence of titer in the final washings of the lymphoid cells is proof that the antibody titer in the extracts was derived from cells and not from adherent lymph.

297.3.5
Salivary gland or muscle tissue, from the same immunized mice which had yielded antibody-containing lymphoid cells, showed no extractable agglutinins or hemolysins.

297.3.6
Also, lymphoid cell extracts and sera from non-immunized mice were negative when tested for antibodies.

297.3.3

GJB:$AV_i^{>} C_{\ell} T^{xB}$	(were) immunized | (mice) ‖‖ WH ← ‖ The | titers were approximately eight-fold higher (on the basis of nitrogen contents) in | the extracts of lymphoid cells from mice
GJB:$AV_i T_b^B$	than ‖‖ (were immunized) | (mice) ‖ WH ← ‖ The | titers (were high) on the basis of nitrogen contents, in | the corresponding sera (from mice)

297.3.4

GJB:$AV_i^{\sim} T_{\ell''}$	antibody | titer absence in | the final washings of the lymphoid cells
$AV_i C_{\ell} T^x$	is proof that ‖‖ the antibody | titer in | the extracts (of lymphoid cells)
$AV_i C_{\ell}$	was derived from ‖‖ (antibody) | (in) | cells
$AV_i C_{\ell} T^x$	and ‖‖ (the antibody) | (titer in) | (the extracts of lymphoid cells)
$AV_i T_{\ell''}$	(was) not (derived) from ‖‖ (antibody) | (in) | adherent lymph

297.3.5

$GJB^w:A^G V_i^{\sim} T_{g,c}^B$	(were) the same immunized | (mice) ‖ WH ← ‖ Of agglutinins or hemolysins | none extractable were shown in | salivary gland or muscle tissue from mice
GJB:$AV_i C_{\ell}$	, which ‖‖ (immunized) | (mice) ‖ had yielded ‖ antibody | -containing | lymphoid cells

297.3.6

GJ~B:$AV_i^{\sim} C_{\ell} T^{xB}$	Also, ‖‖ (were non-immunized) | (mice) ‖ WH ‖ (antibodies) | (were negative when tested for) ‖ lymphoid cell extracts (from mice) ←
GJ~B:$AV_i^{\sim} T_b^B$	and ‖‖ (were) non-immunized | (mice) ‖ WH ‖ antibodies | were negative when tested for ‖ sera from mice ←

297.6.6
The evidence obtained is overwhelmingly in support of the conclusion that the antibody is concentrated chiefly within lymphocytes.

297.6.7
The actual production of antibodies by lymphocytes has not been established.

"Further Experimental Studies on the Role of the Plasma Cells as Antibody Producers", M. Bjørneboe, H. Gormsen and Fr. Lundquist, *Journal of Immunology*, vol. 55 (1947), 121-129

121.1.1
In three previous papers we have given an account of some experimental serologic-histological investigations that appear to indicate the plasma cells as antibody producers.

121.1.2
Rabbits were immunized strongly for several weeks with a formalized mixture of 8 pneumococcus types, and this resulted in a marked degree of hyperglobulonemia, due to very high concentrations of antibody.

121.1.3
On autopsy these animals showed a pronounced plasma cell proliferation in practically all organs, and the degree of plasma cell proliferation appeared proportional to the concentration of antibody protein.

	297.6.6
M	The evidence obtained is overwhelmingly in support of the conclusion that
AV_iC_y	the antibody | is concentrated chiefly within | lymphocytes
	297.6.7
AV_pC_y	of antibodies | the actual production | by lymphocytes
M	has not been established.

Paper 3

	121.1.1
M	In three previous papers we have given an account of some experimental serologic-histological investigations that appear to indicate
AV_pC_z	antibody | as producers of | the plasma cells ←
	121.1.2
GJ^3B	a formalized mixture of 8 pneumococcus types | were immunized strongly for several weeks with | rabbits ←
$GJ^3B{:}A_gV_i^+T_b$	, and ||| this || resulted in || a marked degree of hyperglobulonemia
AV_i^+	, due to ||| antibody | very high concentration of ←
	121.1.3
$C_zW_p^+TB$	plasma cells | showed a pronounced proliferation of | in practically all organs on autopsy these animals ←
C_zW_p	and ||| plasma cells | the degree of proliferation of ←
AV_i	appeared proportional to ||| antibody protein | the concentration of ←

121.1.4
A constant finding in the highly immunized animals was a diffuse, and, especially, perivascular, almost pure plasma cell proliferation in the adipose tissue of the renal sinus.

121.7.1
Ehrich and Harris have demonstrated high titers of antibody in the regional lymph nodes after injection of antigen.

121.7.2
They injected the antigen (typhoid vaccine and sheep blood cells) into the foot of a rabbit and examined the regional lymph nodes (in the popliteal region), their weight, histological features and output of lymphocytes.

122.1.1
They found that the tissue reaction accompanying the antibody formation is chiefly a "lymphocyte reaction," and from this they conclude that the lymphocytes constitute a factor in antibody production.

122.2.1
Recently Dougherty, Chase and White have thought they were able to demonstrate that antibody is formed in the lymphocytes and that the pituitary – via the adrenal cortex – regulates the antibody production.

	121.1.4
M	A constant finding was
$GJ^3B:C_zW_pT_k^B$	(were) highly immunized | (animals) || WH ← || Of plasma cells | diffuse and,especially, perivascular, almost pure, proliferation in | the adipose tissue of the renal sinus in animals
	121.7.1
M	Ehrich and Harris have demonstrated
$GJB:AV_i^+T_n^B$	antigen | injection of || after ← || Of antibody | high titers in | the regional lymph nodes
	121.7.2
$GJB:T_n^BW_\ell$	the antigen (typhoid vaccine and sheep blood cells) | was injected | into the foot of a rabbit || and || the regional lymph nodes (in the popliteal region) | were examined for weight, histological features
$GJB:C_yW_u^fT_n^B$	and ||| (GJB) || (and) || lymphocytes | (were examined for) output of | the regional lymph nodes ←
	122.1.1
M	They found that
AV_p	the antibody | formation
TW_a	was accompanied by ||| the tissue | reaction
TW_a	which ||| (tissue) | (reaction)
C_yW_a	chiefly is ||| a "lymphocyte | reaction"
M	and from this they conclude that
$AV_p^rC_y$	antibody | constitute a factor in production of | the lymphocytes ←
	122.2.1
M	Recently Dougherty, Chase and White have thought they were able to demonstrate that
AV_pC_y	antibody | is formed in | the lymphocytes
AV_p^rT	and that ||| antibody | regulates the production of | the pituitary – via the adrenal cortex ←

122.4.1
In this paper an account will be given of further studies on the relation of plasma cells to the antibody production by means of antibody determination in extracts of tissue rich in plasma cells from highly immunized animals bled to death.

122.4.2
In some instances the extracts were made from tissues showing almost exclusively plasma cell infiltration.

122.4.3
In rabbits immunized with the aforementioned technique, employed previously by us, there is an almost pure, often massive, plasma cell infiltration of the adipose tissue in the renal sinus, whereas only diffuse and scanty plasma cell infiltration in the retroperitoneal adipose tissue has been observed, and that extremely seldom.

122.4.4
The following studies, therefore, have been aimed especially at the estimation of the antibody content of extracts from the kinds of adipose tissue mentioned.

	122.4.1
M	In this paper an account will be given of further studies on
$AV_p^rC_z$	antibody | relation to the production of | plasma cells' ←
$GJ^3B{:}AV_iT^{xwB}$	by means of determination of ||| (were) highly immunized | (rabbits) || WH ← || Antibody | in | extracts of tissue from rabbits bled to death
$C_zW_i^+T^x$	WH ||| plasma cells | (were) rich in | (extracts of tissue) ←
	122.4.2
$C_zW_i^+T^x$	plasma cells | showed in some instances almost exclusively infiltration of | tissues from which the extracts were made ←
	122.4.3
$GJ^3B{:}C_zW_i^+T_k^B$	(were) immunized with the aforementioned technique, employed previously by us | (rabbits) || WH ← || Of plasma cells, | there is an almost pure, often massive infiltration of | the adipose tissue of the renal sinus in rabbits
$GJ^3B{:}C_zW_iT_p^B$	whereas ||| (were immunized with the aforementioned technique, employed previously by us) | (rabbits) || WH || of plasma cells | only diffuse and scanty infiltration has been observed, extremely seldom | in retroperitoneal adipose tissue (in rabbits) ←
	122.4.4
M	The following studies, therefore, have been aimed especially at the estimation of
$AV_iT_{k,p}^x$	the antibody | content of | extracts from the kinds of adipose tissue mentioned [Tables 1,2 show higher antibody content in T_k than in T_p or T_t]

125.5.1
Microscopic examination revealed no plasma cells in the muscles and only very few in the thymus – scattered interstitially.

125.8.1
In the retroperitoneal fat a few scattered plasma cells were found in 3 animals, a moderate plasma cell proliferation in 1 animal, and no plasma cells in 5 animals.

126.1.1
In the pelvic fat, as is evident from microphotos 1 and 2, diffuse and perivascular plasma cell proliferation, was found in all the animals, and in 3 of the animals even as a massive proliferation.

126.2.1
Besides plasma cells, only lymphocytes were found, in numbers representing about 10 per cent of the number of plasma cells (the differential count of 500 cells in the pelvic fat from rabbits 2099, 9291, 9293, 2999, and 3000 showed respectively 12, 5, 14, 8 and 10 per cent lymphocytes).

126.3.1
Considering this histological evidence, it seems very probable that the plasma cells constitute the source of the antibody protein.

	125.5.1
M	Microscopic examination revealed (that)
$C_zW_i^{\sim}T_k$	of plasma cells | none were in | the muscles
$C_zW_i^{-}T_t$	and ||| of plasma cells | only very few scattered interstitially (present) in | the thymus
	125.8.1
$C_zW_i^{-}T_pB_3$	Of plasma cells | a few scattered were found in | the retroperitoneal fat in 3 animals
$C_zW_pT_pB_1$	, ||| of plasma cells | a moderate proliferation (in) | (the retroperitoneal fat) in 1 animal
$C_zW_i^{\sim}T_pB_5$	, and ||| of plasma cells | none (were found in) | (the retroperitoneal fat) in 5 animals
	126.1.1
M	As is evident from microphotos 1 and 2,
$GJ^3B{:}C_zW_pT_k^B$	of plasma cells, | diffuse and perivascular proliferation was found in | the pelvic fat in all the animals
$GJ^3B{:}C_zW_p^{+}T_k^{B_3}$	and even ||| (plasma cells) | (were found) as a massive proliferation (in) | (the pelvic fat) in 3 of the animals
	126.2.1
$C_zW_iT_k$	Besides ||| plasma cells | (in) | (the pelvic fat)
$C_yW_i^{<}T_k$	, only ||| lymphocytes | were found, in numbers representing about 10 percent (in) | (the pelvic fat)
$C_zW_iT_k$	of ||| plasma cells' | number (in) | (the pelvic fat)
M	(the differential count of 500 cells showed respectively
$GJ^3B{:}C_yW_i^{-}T_k^B$	lymphocytes | (were) 12, 5, 14, 8, and 10 per cent in | the pelvic fat from rabbits 2099, 9291. 2999, and 3000)
	126.3.1
M	Considering this histological evidence, it seems very probable that
AV_pC_z	the antibody protein | constitute the source of | the plasma cells ←

128.3.1
Several authors have recently concluded that lymphocytes act as antibody producers.

128.3.2
The presence of plasma cells in the experimental objects is not mentioned in any of these papers.

128.3.3
This fact can however hardly be assumed to mean that the lymphatic tissue investigated was free from plasma cells as these cells co-occur nearly constantly in all lymphatic tissue – except perhaps thymus.

128.3.4
If the plasma cell is supposed to be a highly active cell type the presence of even a small number may be of decisive importance.

128.4.1
In our previous publication we have shown that plasma cell proliferation can be demonstrated also on immunization with single antigen.

	128.3.1
M	Several authors have recently concluded that
$AV_p^rC_y$	antibody | act as producers of | lymphocytes ←
	128.3.2
C_zW_iT	plasma cell | presence in | the experimental objects
M	is not mentioned in any of these papers
	128.3.3
M	This fact can however hardly be assumed to mean that
$C_zW_i\tilde{}T_{\ell'}$	plasma cells | was free from | the lymphatic tissue investigated ←
$C_zW_iT_{\ell'}$	as ||| plasma cells | occur nearly constantly | in all lymphatic tissue
$C_zW_i\tilde{}T_t$	except perhaps ||| (plasma cells) | (do not occur) | (in) thymus
	128.3.4
$C_zW_i^-$	(plasma cells) | the presence of even a small number (of) ←
M	may be of decisive importance, if it is supposed that
$C_zW_a^+$	the plasma cell is a cell type (that) | (is) highly active
	128.4.1
M	In our previous publication we have shown that one can demonstrate also
$GJ^1B{:}C_zW_p$	a single antigen | immunization with || on ← || Plasma cell | proliferation

128.4.2
On immunization with several antigens simultaneously however the concentration of antibody in the blood becomes much higher and plasma cell proliferation in the tissues much more intensive and therefore more easily observable.

128.4.3
Most previous investigators have not immunized their animals as intensively as we have and none seems to have used more than one antigen.

128.4.4
Thus it was not to be expected that any distinct plasma cell proliferation should have appeared in their experiments.

128.5.1
So far we can only state that the possibility that plasma cells produce antibodies is just as good as the possibility that lymphocytes do.

	128.4.2
$G^+JB{:}AV_i^{>}T_b$	However ||| several antigens | immunization simultaneously with || on ← || antibody | concentration becomes much higher in | the blood
$G^+JB{:}C_zW_p^{>}T$	and ||| (several antigens) | (immunization simultaneously with) || (on) ← || plasma cell | proliferation (becomes) much more intensive in | the tissues
M	and therefore more easily observable
	128.4.3
M	Most previous investigators have
$GJ^{3>}{\sim}B$	not as intensively immunized | their (animals)
M	as we have
GJ^3B	(intensively immunized) | (animals)
M	and none seems to have
G^+J	more than one antigen | used ←
	128.4.4
M	Thus it was not to be expected that there should have appeared in their experiments
C_zW_p	plasma cells | any distinct proliferation of ←
	128.5.1
M	So far we can only state that the possibility is just as good that
AV_pC_z	antibodies | produce | plasma cells ←
AV_pC_y	as that ||| (antibodies) | do (produce) | lymphocytes ←

128.6.1
At this point however one should consider the fact that extracts of thymi from our highly immunized animals contained *no* larger amount of antibody than did extracts of muscles, which may be looked upon as almost free from lymphocytes.

128.7.1
According to investigations by Andreasen and Ottesen the thymus lymphocytes are identical with other lymphocytes and the thymus appears to be the most important lymphocytopoietic organ.

128.8.1
This is a strong argument against the theory that lymphocytes are antibody producers.

	128.6.1
M	At this point however one should consider the fact that
$GJ^3B{:}AV_iT_t^{xB}$	(were) highly immunized | (animals) || WH ← || antibody | contained *no* larger amount of | extracts of thymi from our animals ←
$GJ^3B{:}AV_iT_c^{xwB}$	than ||| (were highly immunized) | (animals) || WH || (antibody) | did (contain an amount of) | extracts of muscles (from our animals) ←
$C_yW_i\tilde{}T_c^x$	, which ||| lymphocytes | may be looked upon as almost free from | (extracts of muscles) ←
	128.7.1
M	According to investigators by Andreasen and Ottesen
$C_yW_iT_t$	the lymphocytes | in | the thymus
$C_yW_iT_t$	are identical with ||| the lymphocytes | in | other (tissues)
$C_yW_pT_t$	and ||| lymphocytopoietic | the thymus appears to be the organ most importantly ←
	128.8.1
M	This is a strong argument against the theory that
AV_pC_y	antibody | are producers of | lymphocytes ←

128.8.2
We therefore consider it improbable that the ca. 10 percent lymphocytes present in the fat of the renal sinus in our animals would give rise to the high antibody protein concentration of the extract of this tissue; and we hold that it must by the plasma cells, by far the predominant cell type in this tissue, that are responsible for the high antibody protein concentration.

128.9.1
It is however a possibility that both lymphocytes and plasma cells produce antibodies and it may be mentioned that according to many investigators lymphocytes and plasma cells are closely related, though several recent investigations seems to indicate that plasma cells at least in spleen, lymph nodes, and bone marrow descend directly from reticulum cells.

129.1.1
With the technic employed we have not been able to find indications that lymphocytes produce antibodies in the rabbit, and both the present and our earlier work point to the plasma cells as the producers of antibodies.

	128.8.2
M	We therefore consider it improbable that
$A^{w}V_{p}C_{y}^{w}$	antibody protein | would give rise to | the lymphocytes ←
$C_{y}W_{i}^{-}T_{k}B$	WH ||| (lymphocytes) | (were) present (in) ca. 10 percent in | the fat of the renal sinus in our animals
$AV_{i}^{+}T_{k}^{x}$	WH ||| (antibody protein) | in high concentration of | the extract of this tissue
M	; and we hold that it must be
$A^{w}V_{p}^{r}C_{z}^{w}$	the antibody protein | are responsible for (producing) | the plasma cells that ←
$C_{z}W_{i}^{+}T_{k}$	, WH- ||| (plasma cells) are the cell type | by far predominant in | this tissue
$AV_{i}^{+}T_{k}^{x}$	WH- ||| antibody protein | concentration is high (in) | (the extract of this tissue)
	128.9.1
M	It is however a possibility that both
$AV_{p}C_{y}$	(antibodies) | (produce) | lymphocytes ←
$AV_{p}C_{z}$	and ||| antibodies | produce | plasma cells ←
M	and it may be mentioned that according to many investigators
$C_{y}YC_{z}$	lymphocytes | are closely related to | plasma cells,
M	though several recent investigators seem to indicate that
$C_{z}Y_{c}^{f}C_{r}$	plasma cells | descend directly from | reticulum cells
$C_{z}^{w}Y_{c}^{f}C_{r}$	at least ||| (plasma cells) | (descend directly from) (reticulum cells)
$C_{z}W_{i}T_{s,n,o}$	WH ||| (plasma cells) | (are) in | spleen, lymph nodes, and bone marrow
	129.1.1
M	With the technic employed, we have not been able to find indication that
$AV_{p}C_{y}$	antibodies | produce in the rabbit | lymphocytes ←
M	, and both the present and our earlier work point to
$AV_{p}C_{z}$	antibodies | as the producers of | the plasma cells ←

"The Plasma Cellular Reaction and Its Relation to the Formation of Antibodies in Vitro", Astrid Fagraeus, *Journal of Immunology*, vol. 58, 1948, 1–13

1.2.1.
As is well known the response of the antibody-forming mechanism to repeated injection of an antigen is usually different from that evoked by the first contact.

1.2.2.
Characteristic of the so called secondary response is a more rapid onset of the reaction and a more prolific formation of antibodies than after the first injection of the antigen.

1.2.3
In a previous paper the present writer, taking advantage of the more extensive reaction connected with the secondary response, described the cellular changes in the spleen after intravenous injections of horse serum into rabbits sensitized to this serum.

Paper 4

	1.2.1
M	As is well known
GJ^{2}:AV_{p}	an antigen | repeated injection of || to || the response of the antibody-forming mechanism ←
GJ^{1}:AV_{p}	is usually different from ||| (an antigen) | the first contact (with) || evoked by || the response of the antibody-forming mechanism ←
	1.2.2
M	Characteristic of the so-called secondary response is
GJ^{3}:$CW_{a}^{bi>}$	(an antigen) | (repeated injection of) || (after) || a more rapid onset of the reaction ←
GJ:CW_{a}^{b}	(than) ||| (an antigen) | (the first injection of) || (after) || (the onset of the reaction) ←
GJ^{3}:$AV_{p}^{>}$	and ||| (an antigen) | (repeated injection of) || (after) || of antibodies | a more prolific formation ←
GJ^{1}:AV_{p}	than ||| an antigen | the first injection of || after || (of antibodies) | (the) (formation) ←
	1.2.3
M	In a previous paper the present writer, taking advantage of
$CW_{a}^{>}$	(of cells) | the more extensive reaction ←
GJ^{2}:AV	connected with ||| secondary (injection) || (to) || the response ←
M	, described
GJB^{w}:$CW_{c}T_{s}$	horse serum | was injected | intravenously into rabbits || after ← || the cellular | changes | in the spleen
$GJ^{1}B$	WH ||| this serum | (were) sensitized to | (rabbits) ←

1.3.4
From these investigations it appeared that on the 2nd or 3rd day after the reinjection, before the antibody content had begun to increase, it was possible to observe the occurrence of cells of characteristic appearance in the reaction centers, as well as in the periphery of the lymph follicles (Malpighian bodies) and in the red pulp.

1.3.5
The cells were large and had a cytoplasm which stained moderately red in Unna-Pappenheim (methyl green pyronine), and light blue in Giemsa.

1.3.6
The nucleus was large and light with nucleoli.

1.3.7
These cells, which obviously originated from reticulum cells, were called transitional cells, for some days later, in the same places in the periphery of the follicles and in the red pulp, there appeared numerous cells, which were usually smaller and had a redder cytoplasm and a nucleus, which was more abundant in chromatin (immature pl.c.).

	1.3.4
M	From these investigations it appeared that it was possible to observe
$GJ^{2}:_{t}^{w}CW_{i}T_{r,m,d}$	, the reinjection, || (at a time) on the 2nd or 3rd day after || of cells of characteristic appearance | the occurrence | in the reaction centers, as well as in the periphery of the lymph follicles (Malpighian bodies) and in the red pulp ←
$GJ^{2}:^{e}AV_{i}^{\uparrow b}$	, WH ||| (GJ^{2}) || (time is) before (the time when after) ← || the antibody | content had begun to increase
	1.3.5
CW_{g}	the cells | were large
$CS_{c}W_{s}$	and ||| (the cells) had a cytoplasm which | stained moderately red in Unna-Pappenheim (methyl green pyronine), and light blue in Giemsa
	1.3.6
$S_{n}CW_{g}$	the nucleus (of the cells) | was large
$S_{u}W_{i}S_{n}C$	and ||| nucleoli | (was) light with | (the nucleus of the cells) ←
	1.3.7
$C^{w}YC^{c}$	These cells | were called | transitional cells
$CY_{c}^{f}C_{r}$	, which ||| (cells) | obviously originated from | reticulum cells,
$GJ^{2}:_{t}^{e\sim}C^{w}W_{i}^{+}T_{m,d}$	, for ||| (the reinjection) || some days later (than 2 or 3 days after) ← || cells | there appeared numerous |, in the same places in the periphery of the follicles and the red pulp, ←
$CW_{g\sim}^{>}$	, which ||| (cells) | were usually somewhat smaller
$CS_{c}W_{s}^{>}$	and (which) ||| (cells) had a cytoplasm (which) | (was) redder
$S_{t}W_{i}^{>}CS_{n}$	and (which) ||| chromatin | was more abundant in | (cells had) a nucleus, which ←
$CYC_{z}^{m\sim}$	WH ||| (cells) | (are called) | immature plasma cells

1.3.8
Simultaneously a considerable increase in the amount of circulating antibodies was found.

1.3.9
From 5-8 days after the injection, at the peak of the serum titer curve, there was observed an increasing number of mature pl.c. with the typical red cytoplasm and the eccentrically situated nucleus.

2.3.1-2
A suspension of formalin-killed *S. typhi* (strain I.S.57) was mixed with an equal volume of 2 percent agar. 4-5 ml. of the mixture, containing about 100 mill. of bacteria, were deposited subcutaneously in the backs of the rabbits.

2.4.1
14-25 days later a large dose of living bacteria of the same strain was administered intravenously.

3.4.1
The cells were classified as transitional cells (large reticulum cells), immature pl.c. and mature pl.c.

3.4.2
As the transitions between the different stages of development were numerous, differentiation was sometimes difficult.

1.3.8

$GJ^2{:}_tAV_i^{\uparrow}T_b$ (the reinjection) || simultaneously (after) ← || of antibodies | a considerable increase was found in the amount | circulating

1.3.9

$GJ^2{:}_t^wC_z^{mw}W_i^{\uparrow}$ the injection || from 5 to 8 days after ← || of mature plasma cells | there was observed an increasing number ←

$GJ^2{:}_tAV_i^{>>b}T_b$ at WH ||| (the injection) || (time from 5 to 8 days after) ← || the (antibody) | titer curve (reached a) peak (in) | (the) serum

$C_z^mS_cW_s$ WH ||| (mature plasma cells) with the cytoplasm (which) | (was) typically red

$C_z^mS_nW_e$ and (which) ||| (mature plasma cells) (with) the nucleus (which) | (was) eccentrically situated

2.3.1-2

GJB a suspension of formalin-killed *S. typhi* (strain I.S.57) was mixed with an equal volume of 2 percent agar; 4-5 ml. of the mixture, containing about 100 mill. bacteria, | were deposited | subcutaneously in the backs of rabbits

2.4.1

GJ^2B 14-25 days later ||| a large dose of living bacteria of the same strain | was administered | intravenously

3.4.1

$CYC^{cw},C_z^{m\sim},C_z^m$ the cells | were classified as | transitional cells, immature plasma cells and mature plasma cells

$C^cYC_r^g$ WH ||| (transitional cells) | (are called) | large reticulum cells

3.4.2

M Differentiation was sometimes difficult, as

$CY_c^+C^c,C_z^{m\sim},C_z^m$ the (cells') | transitions were numerous between | the different stages of development

3.4.3
All cells with a low nucleus plasma relation and eccentricity of the nucleus were regarded as mature pl.c.

3.4.4
Among cells thus classified, however, the nucleus might exhibit a certain variation in its degree of maturity, as judged by its chromatin and nucleoli contents.

3.5.1
In most cases the spleen was only moderately or inappreciably enlarged.

3.5.2
The histological preparations exhibited a very strong cellular reaction in the spleen, confined almost entirely to the red pulp.

3.5.3
In the early stages a moderate proliferation of the reaction centers in the lymph follicles was found, although never of the same order of magnitude as after the injection of horse serum.

	3.4.3
$C^{w}YC_{z}^{m}$	(of the) cells | all were regarded as | mature plasma cells
$CS_{n}W_{g\sim}$	WH ||| (cells) with nucleus | plasma relation (which was) low
$CS_{n}W_{e}$	and (which) ||| (cells with) the nucleus | having eccentricity
	3.4.4
$C^{w}S_{n}W_{m}^{\Delta}$	however, ||| among the cells the nucleus | might exhibit a certain variation in its degree of maturity
CYC_{z}^{m}	WH ||| (cells) | thus classified (as) | (mature plasma cells)
$S_{t},S_{u}W_{i}S_{n}C$	, as judged by ||| chromatin and nucleoli | contents (of) | the nucleus's ←
	3.5.1
$T_{s}W_{g}^{-}$	In most cases ||| the spleen | was only moderately or inappreciably enlarged
	3.5.2
M	The histological preparations exhibited
$CW_{a}^{++}T_{d}$	of cells | a very strong reaction | in the spleen, confined almost entirely to the red pulp
	3.5.3
$GJ^{2}:^{e}T_{r}W_{p}T_{f}$	(the reinjection) || in the early stages (after) ← || of the reaction centers | a moderate proliferation | in the lymph follicles was found ←
$GJ^{2}:^{e}T_{r}W_{p}T_{f}$	although ||| (GJ^{2}) || ($:^{e}$) ← || (the reaction centers') | (moderate proliferation was) never of the same order of magnitude | (in the lymph follicles)
$GJ:T_{r}W_{p}^{\geq}T_{f}$	as ||| horse serum | the injection of || after ← || (the reaction centers) | (magnitude of proliferation) | (in the lymph follicles)

3.5.4
The cells exhibited the same stages of development as after serum injections.

3.5.5
Thus on the 2nd or 3rd day, when the titer curve had still hardly begun to rise, the large reacting reticulum cells (called transitional cells) were met with.

3.5.6
They were found in the reaction centers as well as in the periphery of the follicles and in the tissue of the red pulp.

4.1.1
While the development in the reaction centers apparently ceased with the formation of these cells, increasing numbers of mature pl.c. appeared some days later in the periphery of the follicles and in the red pulp.

3.5.4

$GJ^2{:}CY_cC^c,C_z^{m\sim},C_z^m$	(the reinjection) || (after) ← || the cells | exhibited | the same stages of development
$GJ^2{:}CY_cC^c,C_z^{m\sim},C_z^m$	as ||| serum injections || after ← || (the cells) | (exhibited) | (stages of development)

3.5.5

$GJ^2{:}{}_t^wC_r^wW_i$	Thus ||| (the reinjection) on the 2nd or 3rd day (after) ← || the reticulum cells | were met with
$GJ^2{:}AV_i^{\uparrow b-}$	, when ||| (the reinjection) || (on the 2nd or 3rd day after) ← || the (antibody) | titer curve had still hardly begun to rise
$C_rW_a^w$	WH ||| (reticulum cells) | (were) reacting
$C_r^aW_g^w$	WH ||| (reacting reticulum cells) | (were) large
$C_r^{ag}YC^c$	WH || (large reacting reticulum cells) | (are) called | transitional cells

3.5.6

$C_r^{ag}W_iT_{r,m,d}$	the large reacting reticulum cells | were found in | the reaction centers as well as the periphery of the follicles and the tissue of the red pulp

4.1.1

$T_rW_c^s$	While ||| in the reaction centers | the development apparently ceased ←
$C_r^{ag}W_p$	with ||| these (large reacting reticulum) cells | the formation of ←
$GJ^2{:}{}_t^eC_z^{m\sim}W_i^{\uparrow}T_{m,d}$	, ||| (the reinjection) || some days later (than the 2nd or 3rd day after) || Of mature plasma cells | increasing numbers appeared in | the periphery of the follicles and in the red pulp

5.1.1
The predominant localization of pl.c. in the red pulp after the injection of *S. typhi* rendered it technically possible, by means of incisions, to cut out from the splenic tissue pieces of red pulp, which were abundant in pl.c. and contained only relatively few lymphocytes, and pieces of mainly follicular tissue abundant in lymphocytes but containing only few pl.c.

5.1.2
Experiments were made to investigate *in vitro* whether there was any difference in antibody formation capacity between the red pulp containing pl.c. and the follicular tissue abundant in lymphocytes.

6.7.1
It appears from table 2 that the red pulp proved constantly to be considerably superior to the follicular tissue in capacity of forming antibodies *in vitro*.

	5.1.1
$GJ{:}C_zW_i^{>>}T_d$	*S. typhi* | the injection of || after || plasma cells | the predominant localization of | in the red pulp ←
M	rendered it technically possible, by means of incisions, for
$T_d^w, T_f^w W / T_s$	pieces of red pulp and pieces of mainly follicular tissue | to be cut out | from the splenic tissue
$C_zW_i^+T_d$	, which ||| plasma cells | were abundant in | (pieces of red pulp) ←
$C_yW_i^-T_d$	and (which) ||| lymphocytes | contained only relatively few | (pieces of red pulp) ←
$C_yW_i^+T_f$	, WH ||| lymphocytes | (were) abundant in | (pieces of mainly follicular tissue) ←
$C_zW_i^-T_f$	but (which) ||| plasma cells | (were) containing only few | (pieces of mainly follicular tissue) ←
	5.1.2
M	Experiments were made to investigate whether there was any difference
$AV_p^{vk}T_d^w$	between ||| antibody | in capacity of formation *in vitro* of | the red pulp ←
$C_zW_iT_d$	WH ||| plasma cells | containing | (red pulp) ←
$AV_p^{vk}T_f^w$	and ||| (antibody) | (in capacity of formation *in vitro* of) | the follicular tissue ←
$C_yW_i^+T_f$	WH ||| lymphocytes | (is) abundant in | (follicular tissue) ←
	6.7.1
M	It appears from table 2 that
$AV_p^{vk>}T_d$	antibodies | proved constantly to be considered superior in capacity of forming *in vitro* | the red pulp ←
$AV_p^{vk}T_f$	to ||| (antibodies) | (in capacity of forming *in vitro*) | the follicular tissue ←

6.8.1
From table 2 it also appears that the capacity of the red pulp to form antibodies was greater if the splenic tissue was tested on the 4th or 5th day after the reinjection than on the 7th-10th day.

6.9.1
Differential counts of imprints from the spleen, made when the cultures were initiated, showed that a strong antibody formation capacity *in vitro* was always connected with an increased amount of transitional cells and probably above all of immature pl.c. in the piece of tissue from which the culture was made.

7.1.1
On the other hand, at a later stage of antibody formation in the rabbit (7th-10th day), when the mature pl.c. predominated, the antibody formation capacity of the pieces receded.

6.8.1

M — From table 2 it also appears that if the splenic tissue was tested

$GJ^{2}{:}_{t}^{e}AV_{p}^{k>}T_{d}$ — the reinjection || on the 4th or 5th day after ← || antibodies | the capacity was greater to form | of the red pulp ←

$GJ^{2}{:}_{t}AV_{p}^{k}T_{d}$ — than ||| (the reinjection) || on the 7th-10th day (after) || (antibodies) | (the capacity to form) | (of the red pulp) ←

6.9.1

M — Differential counts of imprints from the spleen, made when the cultures were initiated, showed that

$AV_{p}^{vk}T_{s}^{u}$ — of antibody | (having) a strong formation capacity *in vitro* | (the piece of tissue from which the culture was made) ←

$C^{c}W_{i}^{\uparrow}T_{s}^{u}$ — was always connected with ||| of transitional cells | an increased amount (in) | (the piece of tissue from which the culture was made)

$C_{z}^{m}{\sim}W_{i}^{\uparrow}T_{s}^{u}$ — and probably above all (was always connected with) ||| of immature plasma cells | (an increased amount) in | the piece of tissue from which the culture was made

7.1.1

$GJ^{2}{:}_{t}^{we}{\sim}AV_{p}B$ — On the other hand, ||| (the reinjection) || at a later stage (7th-10th day) (after) ← || of antibody | formation | in the rabbit

$GJ^{2}{:}_{t}C_{z}^{m}W_{i}^{++}T_{s}$ — when ||| (the reinjection) || (at this stage after) ← || the mature plasma cell | predominated (in) | (the piece)

$AV_{p}^{k\downarrow}T_{s}$ — , ||| the antibody | formation capacity receded | of the pieces

8.2.1
After the injection of diazotized horse serum, the intensive red colour of which makes it visible in histological sections, the antigen was detected almost exclusively in the red pulp.

9.1.1
20-25 minutes after the injection of bacteria, the total bacterial content had in most cases fallen considerably and at a greater rate in the red than in the white pulp, indicating that the bacteria perished more quickly in the red pulp.

9.3.1
In the experiments described above the cellular reaction in the rabbit spleen during the secondary response was studied.

9.3.2
After intravenous reinjections of the antigen, a very strong plasma cellular reaction was obtained, especially when living bacteria were employed, a reaction, which was confined almost exclusively to the red pulp.

	8.2.1
$GJ{:}GU_iT_d$	diazotized horse serum, the intensive red color of which makes it visible in histological sections, | the injection of || after ← || the antigen | was detected almost exclusively in | the red pulp
	9.1.1
$GJ{:}_tGU^{\downarrow o>}T_d$	bacteria, | the injection of || 20-25 minutes after ← || of bacteria | the total content had in most cases fallen considerably and at a greater rate in | the red (pulp)
$GJ{:}_tGU_i^{\downarrow o}T_f$	than ||| (bacteria) | (the injection of) || (20-25 minutes after) ← || (of bacteria | the total content had fallen at a rate) in | the white pulp
$GU_d^{i>}T_d$	, indicating that ||| the bacteria | perished more quickly | in the red pulp
GU_dT_f	(than) ||| (the bacteria) | (perished) | (in the white pulp)
	9.3.1
M	In the experiments described above was studied
CW_aT_sB	the cellular | reaction | in the spleen of the rabbit
$GJ^2{:}AV$	during ||| secondary (injection) || (to) || the response ←
	9.3.2
$GJ^2B{:}C_zW_a^{+\,+}$	the antigen, | reinjections of | intravenous || after ← || of plasma cells | a very strong reaction was obtained
$GJ^2{:}C_zW_a^{+\,+}$	, especially ||| living bacteria | were employed || when ← || (of plasma cells) | (a very strong reaction was obtained)
$C_zW_a^{+\,+}T_d$	, ||| (of plasma cells) | a reaction, which | was confined almost exclusively to the red pulp

9.3.3
In the earliest stages of the reaction, in the first phase of antibody formation, large reticulum cells of characteristic appearance were found.

9.3.4
These were called transitional cells, as it proved that, in those places where such cells were met with, immature plasma cells (pl.c.) appeared 1-2 days later, and after a further few days mature pl.c. were found in increasing numbers.

10.1.1
There were numerous transitions between the different stages of development.

10.1.2
On the other hand pl.c. were usually not detected in the lymph follicles.

10.1.3
In culture fluids, where small pieces of spleen tissue had been kept, the presence of varying amounts of antibodies could be demonstrated.

9.3.3

$GJ^2{:}C_r^gW_i$ (the reinjection) || (at a time after) ← || Large reticulum cells | of characteristic appearance were found

$GJ^2{:}CW_a^{e>>}$ in ||| (the reinjection) || (in the period) (after) || the stages of the reaction (which were) earliest ←

$GJ^2{:}AV_p^e$ in ||| (the reinjection) || (in the period after) || Of antibody | the phase of formation (which is) first

9.3.4

$C_r^gYC^c$ these (large reticulum cells) | were called | transitional cells

$C_r^gW_iT^w$, as it proved that, ||| such cells | were met with in | those places

$GJ^2{:}_t^e{\sim}C_z^m{\sim}W_iT$ where ||| (the reinjection) || 1-2 days later (than the time of 3.3 after) ← || immature plasma cells (pl.c.) | appeared (in) | (those places)

$GJ^2{:}_t^e{\sim}C_zW_i^{\uparrow}T$ and (where) ||| (the reinjection) || after a further few days (after 1-2 days later than the time of 3.3 after) ← || plasma cells | were found in increasing numbers (in) | (those places)

10.1.1

$CY_c^+,C_z^m{\sim},C_z^m$ (of cells) | there were numerous transitions between | the different stages of development

10.1.2

$C_zW_i{\sim}T_f$ On the other hand ||| plasma cells | were usually not detected in | the lymph follicles

10.1.3

$AV_i^{\Delta}T_s^u$ of antibodies | the presence of varying amounts could be demonstrated in | culture fluids, where small pieces of spleen tissue had been kept

10.1.4
Plain extracts of identical tissue pieces, made under conditions, where growth or metabolism of the cells was suppressed or impossible, i.e. in the cold or in the presence of formalin or toluol, contained only 1/20-1/200 of the amount of antibody obtained in the tissue cultures.

10.1.5
This is suggestive evidence that the antibody found in the tissue culture fluid had actually been produced by the tissue *in vitro* and not merely extracted from disintegrating cells.

10.2.1
In several cases small pieces of red pulp, abundant in pl.c., as well as lymph follicles containing lymphocytes were excised and the antibody-forming capacity of the pieces was determined separately.

10.1.4

$AV_i^{<}T_s^x$	antibody | contained only 1/20-1/200 of the amount of | plain extracts of identical tissue pieces, made under conditions, where growth or metabolism of the cells was suppressed or impossible, i.e. in the cold or in the presence of formalin or toluol, ←
$AV_iT_s^u$	(as) ‖ (of antibody) | (the amount) obtained in | cultures of the tissue

10.1.5

M	This is suggestive evidence that
$A^wV_p^vT_s$	the antibody | had actually been produced *in vitro* | by the tissue
$AV_iT_s^u$	WH ‖ (antibody) | (was) found in | tissue culture fluid
$A^wV_u^{f\sim}C^d$	and ‖ (the antibody) | (had) not (been merely extracted from | disintegrating cells
$AV_iT_s^u$	WH ‖ (antibody) | (was found in) | (tissue culture fluid)

10.2.1

$T_d^wW_\ell$	In several cases | small pieces of red pulp | were excised
$C_zW_i^+T_d$	, WH ‖ pl.c. | (is) abundant in | (red pulp) ←
$T_f^wW_\ell$	, as well as ‖ lymph follicles | (were excised)
$C_yW_iT_f$	WH ‖ lymphocytes | containing | (lymph follicles) ←
$AV_p^kT_{f,d}$	and ‖ the antibody | -forming capacity of | the pieces was determined separately

10.2.2
The amount of antibody found in tissue of red pulp was considerably larger than in lymph follicle cultures and, as a matter of fact, of an order of magnitude as to account for a reasonable portion of the total amount of circulating antibodies.

10.2.3
It also appeared that the capacity of the red pulp to form antibodies *in vitro* was greater if the splenic tissue was tested at a time when the rate of antibody production in vivo was rising or at its maximum.

10.2.4
On the 7th-10th day after the reinjection, when the animal's serum titer curve was leveling off, the amount of antibodies found in the culture fluids was smaller thoughout.

11.1.1
In pieces, removed on the 3rd or 4th day, immature cells predominated.

11.1.2
Tissue, containing only transitional cells, had a comparatively poor antibody-forming capacity.

10.2.2

$AV_i^{>}T_d^u$ of antibody | the amount found was considerably larger in | cultures of tissue of red pulp

$AV_iT_f^u$ than ||| (of antibody) | (the amount found) in | cultures of lymph follicles

$AV_i^{v>}T_d^u$ and, as a matter of fact, ||| (of antibody) | (the amount found was) of such an order of magnitude (in) | (cultures of) (tissue of red pulp)

AV_iT_b as to account for ||| of antibodies | a reasonable portion of the total amount | circulating

10.2.3

M It also appeared that

$AV_p^{vk>}T_d$ antibodies | the capacity was greater to form *in vitro* | of the red pulp ←

M if the splenic tissue was tested at a time when

$AV_p^{o\uparrow}B$ of antibody | the rate of production was rising | in vivo

$AV_p^{o>>}B$ or ||| (of antibody) | (the rate of production was) at its maximum | in vivo

10.2.4

$GJ^2:_t^wAV_i^{<}T_s^u$ the reinjection || on the 7th-10th day after ← || of antibodies | the amount found was samller throughout in | the culture fluids (of the tissue)

$GJ^2:_tAV_i^{\uparrow-}T_bB$, when ||| (the reinjection) || (at this time after) ← || titer curve was leveling off | serum | the animal's ←

11.1.1

$GJ^2:_tC^m{\sim}W_i^{+\ +}T_s$ (the reinjection) || on the 3rd or 4th day (after) || Immature cells | predominated in | pieces, removed

11.1.2

$AV_p^{k-}T_s^w$ antibody | had a comparatively poor capacity of forming | tissue ←

$C^cW_iT_s$, WH ||| transitional cells | containing only | (tissue) ←

11.1.3
The appearance of more mature cells was associated with an increase in the antibody content of the culture fluid.

11.1.4
That the maturation process was capable of proceeding in the tissue cultures, also, is suggested by the fact, that under appropriate conditions the rate of antibody formation *in vitro* increased during the first 24 hours of incubation.

11.1.5
From the curves for S. 188 (figure 1) it also appears, that the transitional cells decrease in number with increasing antibody content of the serum and at the same time the number of immature pl.c. is growing.

11.1.6
The maximal content of the latter distinctly coincides with the maximum capacity of the tissue to form antibody *in vitro*.

11.1.7
The transition of the immature pl.c. into mature cells leads to a decline in this capacity.

11.1.3

$C^{w}W_{i}$	cells | the appearance of ←
$CW_{m}^{>}$	WH ||| (cells) | (were) more mature
$AV_{i}^{\uparrow}T_{s}^{u}$	was associated with ||| (of) antibody | an increase in the content of | the culture fluid

11.1.4

$CW_{m}^{v}T_{s}$	That ||| the (cell) maturation process was capable of proceeding in the cultures of | the tissue
M	, also, is suggested by the fact, that under appropriate conditions
$AV_{p}^{vo\uparrow}$	(of) antibody | the rate of increased formation *in vitro*
M	during the first 24 hours of incubation

11.1.5

M	From the curves for S. 188 (figure 1) it also appears, that
$C^{c}W_{i}^{\downarrow}$	the transitional cells | decrease in number
$AV_{i}^{\uparrow}T_{b}$	with ||| (of) antibody | increasing content | of the serum
$C_{z}^{m}{\sim}W_{i}^{\uparrow}$	and at the same time ||| of immature plasma cells | the number (present) is growing

11.1.6

$C_{z}^{m}{\sim}W_{i}^{>>}$	the immature plasma cells | the maximal content of ←
$AV_{p}^{vk>>}T_{s}$	distinctly coincides with ||| antibody | the maximum capacity to form *in vitro* | of the tissue ←

11.1.7

$C_{z}^{m}{\sim}Y_{c}^{t}C_{z}^{m}$	of the immature plasma cells | the transition into | mature (plasma) cells
$AV_{p}^{vk\downarrow}T_{s}$	leads to ||| antibody | a decline in the maximum capacity to form *in vitro* | of the tissue ←

11.1.8
On the evidence presented it seems justified to conclude, that *reticuloendothelial elements under the conditions described, produce antibodies, thereby developing into a type of cell with the morphological characteristics of pl.c.*

11.2.1
If the appearance of pl.c. were conditioned by the antigen injected one would expect an accumulation of the antigen at the site where subsequently pl.c. appear.

11.2.2
In experiments to trace the antigen this proved to be the fact, i.e. the antigen was found in the periphery of the follicles and in the red pulp, while but little antigen could be distinguished in the follicles.

11.2.3
The great development of pl.c. in the red pulp of the spleen after the injection of *S. typhi* thus proved to be preceded by a considerable concentration of bacteria there.

12.4.1
On the other hand, nothing has emerged which speaks directly in favour of the participation of the lymphocytes in the formation of antibodies.

	11.1.8
M	On the evidence presented it seems justified to conclude, that,
$AV_p^vC_r$	antibodies | under the conditions described, produce | reticuloendothelial elements ←
$C_rY_c^tC^w$	, thereby ||| (reticuloendothelial elements) | developing into | a type of cell
CYC_z	WH ||| (type of cell) | (is) with the morphological characteristics of | pl.c.
	11.2.1
$GJ{:}C_zW_i$	If ||| the antigen | injected || conditioned || pl.c. | appearance
$GU_i^{\uparrow}T^w$	one would expect ||| of the antigen | an accumulation at | the site
C_zW_iT	where subsequently ||| pl. c. | appear |(at the site) ←
	11.2.2
M	In experiments to trace the antigen this proved to be the fact, i.e.
$GU_iT_{m,d}$	the antigen | was found in | the periphery of the follicles and in the red pulp
$GU_i^-T_f$	, while ||| (of) antigen | but little (amount) could be distinguished in | the follicles
	11.2.3
$GJ{:}C_zW_p^+T_d$	*S. typhi* | the injection of || after || Of pl.c. | the great development | in the red pulp of the spleen
$GU_i^{\uparrow +}T_d$	thus proved to be preceded by ||| of bacteria | a considerable concentration in | the red pulp of the spleen
	12.4.1
M	On the other hand, nothing has emerged which speaks directly in favour of
$AV_p^rC_y$	antibodies | participation in the formation of | the lymphocytes' ←

12.4.2
The lymph follicles in the spleen exhibit throughout a very poor capacity to form antibodies *in vitro* and thymus, where the chief production of lymphocytes takes place has an insignificant antigenphagocytzing capacity and lacks entirely the capacity to form antibodies *in vitro*.

12.4.3
It is also worthy of note, that in spite of the disintegration of lymphocytes, occurring in lengthy culture experiments, only insignificant amounts of antibody were detected in the follicle culture fluids.

12.4.2

$AV_p^{vk-+}T_f$	antibodies | exhibit throughout a very poor capacity to form *in vitro* | the lymph follicles in the spleen ←
$GU_d^{k-}T_t^w$	and ||| antigen | has an insignificant phagocytizing capacity (for) | thymus ←
$C_yW_p^+T_t$	, where ||| of lymphocytes | the chief production takes place | (in thymus) ←
$AV_p^{vk\sim}T_t$	and ||| antibodies | lacks entirely the capacity to form *in vitro* | (thymus) ←

12.4.3

M	It is also worthy of note, that in spite of
$C_yW_dT_s^u$	of lymphocytes | the disintegration, occurring in | lengthy culture experiments
$AV_i^-T_f^u$	, ||| of antibody | only insignificant amounts were detected in | the follicle culture fluids

"Influenzal Antibodies in Lymphocytes of Rabbits following the Local Injection of Virus", Susanna Harris and T.N. Harris, *Journal of Immunology*, vol. 61 (1949). 193-207

204.2.1
The data presented show that following the injection of inactivated influenzal virus into the foot-pad of rabbits there is a general burst of activity of the local lymphatic system, characterized by a marked enlargment of the sole draining lymphnode of the area and an increase in the total number of lymphocytes in the efferent lymph from that node.

204.2.2
The enlargement of the node is due to lymphocytic hyperplasia which is at first diffuse and then becomes organized into the characteristic follicular structure.

204.2.3
At the same time antibodies to the viral protein injected appear in the substance of the lymphnode and in the lymph emerging from that node.

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	204.2.1
M	The data presented show that
GJB:$T_{\not\gamma}^{B}W_a$	inactivated influenzal virus | injection | into the foot-pad of rabbits || following ← || of the local lymphatic system | there is a general burst of activity ←
GJB:$T_n^B W_g^+$	characterized by ||| (GJB) || (following) || the sole draining lymphnode fo the area | a marked enlargement of ←
GJB:$C_y W_i^{\uparrow} T_{\not\gamma}^{f} T_n^B$	and ||| (GJB) || (following) ← || Of lymphocytes | an increasing in the total number in | the efferent lymph from that node
	204.2.2
$T_n W_g$	the node | the enlargment of ←
$C_y W_i^{\uparrow w}$	is due to ||| lymphocytic | hyperplasia
$C_y^+ W_i$	which at first ||| (lymphocytic hyperplasia) | is diffuse
$C_y^+ W_c^t T_f$	and then ||| (lymphocytic hyperplasia) | becomes organized into | the characteristic follicular structure
	204.2.3
GJB:$A^B V_i T_n$	At the same time ||| (viral protein) | (was) injected || WH ← || Antibodies to the viral protein | appear in | the substance of the lymph node
GJB:$A^G V_i T_{\not\gamma}^{f} T_n$	and ||| (viral protein) | (was injected) || (WH) ← || (Antibodies to the viral protein) | (appear) in | the lymph emerging from that node

204.2.4
The antibodies in these tissues are frequently found earlier and, in early days, in higher concentration than in the blood-serum.

204.2.5
No antibodies to influenzal virus were found under the condition of these seriological tests in lymphnodes of legs opposite to the leg injected, lymphnodes of unmanipulated rabbits, lymphnodes derived from rabbits which had received antigens other than influenzal virus and sera taken prior to injection with influenzal virus.

204.2.6
The set of observations extends findings made previously in the same system with bacterial and other cellular agents.

204.2.4

GJB:$^{e>}AV_iT^{f}_{\ell'}T_n$	(GJB) || earlier (after) ← || The antibodies | are frequently found in | these tissues
GJB:AV_iT_b	(than) ||| (GJB) || (after) ← || (Antibodies) | (are found in) | (the blood serum)
GJB:$^{e}_{t}AV_i^{>}T^{f}_{\ell'}T_n$	and, ||| (GJB) || in early days (following) ← || (antibodies) | (are found) in higher concentration (in) | (these tissues)
GJB:$^{e}_{t}AV_iT_b$	than ||| (GJB) || in early days (following) ← (antibodies) || (are found in a concentration) in | the blood serum

204.2.5

GJB:$A^{G}V_i^{\sim}T^{B}_{n}{}^{\sim}$	(GJB) || (after) ← || Of antibodies to influenzal virus | none were found under the conditions of these serological tests in | lymphnodes of legs opposite to the leg injected
GJ~B:$A^{G}V_i^{\sim}T^{B}_{n}$	, ||| (were) unmanipulated | (rabbits) || WH ← || (Of antibodies to influenzal virus) | (none were found under the conditions of these serological tests in) | lymphnodes of rabbits
G~JB:$A^{G}V_i^{\sim}T^{B}_{n}$	, ||| antigens other than influenzal virus | had received | (rabbits) || WH ← || (Of antibodies to influenzal virus) | (none were found under the conditions of these serological tests in) | lymphnodes derived from rabbits
GJB:~$A^{G}V_i^{\sim}T_b$	and ||| influenzal virus | injection with || prior to ← || (Of antibodies to influenzal virus) | (none were found under the conditions of these serological tests in) | sera taken

204.2.6

M	The set of observations extends findings made previously in the same system
GJB	bacterial and other cellular agents | (injected) | (into the foot-pad of rabbits)

204.2.7
The use of influenzal virus inactivated beyond the range of infectivity eliminates the question of multiplication of the agent and provides data for a representative of another group of proteins, that of viral agents.

204.4.1
The antibody-titers reported here have primarily a relative significance, since their measurement is used to point to the primary site or source of antibodies found.

204.5.1
Further evidence of specificity was afforded by the experiments in which opposite legs of each rabbit received injection of different serological types of influenzal virus.

	204.2.7
M	The use of influenzal virus inactivated beyond the range of infectivity eliminates the question of
GU_p	the agent | multiplication of ←
M	and provides data for a representative of another group of proteins, that of viral agents
	204.4.1
AV_i	The antibody – | titers
M	reported here have primarily a relative significance, since their measurement is used to point to
A^wV_pC	(of the antibodies,) | the primary | site
AV_i	WH ||| (antibodies) | (are found)
A^wV_pC	or ||| the antibodies' | source
AV_i	WH ||| (antibodies') | (are) found
	204.5.1
$GJ:AV_i$	Further evidence of ||| (antigen) | (injected) || specificity (to) ← || (Antibody) | (titer)
M	was afforded by the experiments in which
GJB	different serological types of influenzal virus | received injection of | opposite legs of each rabbits ←

204.5.2
The difference in titers to the homologous and heterologous virus are claearly marked and in relation to the existing titer in the serum to that antigen, the concentration of heterologous antibody is quite in accordance with what would be expected as result of Freund's investigations on the distribution of serum-antibodies in the tissues.

205.1.1
In fact it may be noted, in following the homologous-antibody titers of extracts of a given lymphnode through successive days, that the mean titers begin to decline toward the end of the first week, only to increase in a measure thereafter.

204.5.2

GJB:$A^{G}V_{i}T_{n}^{B}$	(virus) | (injected) | (into a side) || WH ← || The antibody to the homologous virus | has a titer clearly markedly different, (in) | (the homologous lymphnode)
GJB:$A^{G}{\sim}V_{i}T_{n}^{B}{\sim}$	from ||| (virus) | (injected) | (into the opposite side) || WH ← || The antibody to the heterologous virus | titer (in) | (the heterologous lymphnode)
GJB:$A^{G}{\sim}V_{i}T_{n}^{B}{\sim}$	and ||| (virus) | (injected) | (into the opposite side) || WH ← || Of heterologous antibody, | the concentration (in) | (the heterologous lymphnode)
GJB:$A^{G}{\sim}V_{i}T_{b}$	in relation to ||| (virus) | (injected) | (into the opposite side) || WH ← || Antibody to the heterologous virus | existing titer in | the serum
M	is quite in accordance with what would be expected as a result of Freund's investigations on
$A^{w}V_{i}T$	antibodies' | distribution | in the tissues
$AV_{i}T_{b}$	WH ||| (antibodies) | (are) of | serum

205.1.1

M	In fact it may be noted, in following
GJB:$_{t}A^{G}V_{i}T_{n}^{x}$	(GJB) || through successive days (following) || Homologous-antibody | titers of | extracts of a given lymphnode
GJB:$_{t}A^{G}V_{i}^{\downarrow b}T_{n}^{x}$	that ||| (GJB) || toward the end of the first week (after) ← || (homologous-antibody) | mean titers begin to decline | (in the lymphnode)
GJB:$_{t}A^{G}V_{i}^{\uparrow}T_{n}^{x}$	, only (for) ||| GJB || after (toward the end of the first week after) ← || (homologous-antibody) | (mean titers) to increase again in a measure | (in the lymphnode)

205.1.2
It may well be that the later rise represents a summation of the declining rate of antibody-production within the node itself plus an increasing rate of concentration of antibody from the serum.

205.1.3
The demonstration of antibodies in higher titer in the local lymphatic system than in the serum, in the early days of antibody-production, is not a necessary condition for the demonstration of antibody-production by the lymphatic tissue for two reasons.

205.1.4
First, the concentration of a substance at a given time need not be higher at a site of production than in a reservoir into which it is being drained.

205.1.5
Second, unless the amount of antigen injected is quite small there is very probably antibody-formation in lymphnodes proximal to the popliteal as a result of antigen-specific soluble material passing through the popliteal node.

	205.1.2
M	It may well be that the
GJB:$_{t}A^{G}V_{i}^{\uparrow}T_{n}$	(homologous-antibody) | (mean titer) later rise | (in the lymphnode)
M	represents a summation of
$AV_{p}^{o\downarrow}T_{n}$	antibody | the declining rate of production of | within the node itself ←
$AV_{u}^{o\uparrow f}T_{b}$	plus ||| antibody | an increasing rate of concentration of | from the serum ←
	205.1.3
M	The demonstration of
GJB:$AV_{i}^{>}T_{\ell'}^{B}$	antibodies | in higher titer in | the local lymphatic system
GJB:$AV_{i}T_{b}$	than ||| (antibody) | (in titer) in | the serum
GJB:AV_{p}^{e}	, in ||| antibody | the early days of production of ←
M	is for two reasons not a necessary condition for the demonstration of
$AV_{p}T_{\ell'}$	antibody | production | by the lymphatic tissue
	205.1.4
$A_{a}V_{i}^{>}{\sim}T^{w}$	First, ||| of a substance | the concentration at a given time need not be higher at | a site
$A_{a}V_{p}T$	WH ||| (the substance) | (is) of production (of) | (the site)
$A_{a}V_{i}T_{b}^{w}$	than ||| (the substance) | (concentration at that time) in | a reservoir
$A_{a}V_{u}^{t}T_{b}$	which ||| the substance | is being drained | into (a reservoir)
	205.1.5
GJ	Second, unless ||| the amount is quite small of antigen | injected
$AV_{p}T_{n}B$	of antibody | there is very probably formation | in lymphnodes proximal to the popliteal node
GJB:$GU^{y}T_{n}^{B}$	as a result of | antigen-specific soluble material | passing | through the popliteal node

205.1.6
Under these circumstances the finding of antibodies earlier and in higher concentration in the local lymphatic system than in the serum is particularly significant.

205.1.7
It should be noted that in the case of the experiment summarized in fig. 1 both legs were injected with the same antigen, so that the serum was receiving antibody simultaneousdly from two sources of supply.

205.1.8
The greater antibody-titer in lymph and lymphnode-extract than in the serum in the early days of this experiment has, then, even a greater significance as to the lymphatic source of the antibodies found.

205.2.1
The concluding proof of the formation of antibody to viral protein in the lymphatic system is the evidence for the lymphocyte itself as a primary source of the antibody

	205.1.6
M	Under these circumstances it is particularly significant that
$GJB:^{e>}AV_iT^{B}_{\ell'}$	(GJB) || earlier (after) ← || Antibodies | are found (in) | (the local lymphatic system)
$GJB:AV_iT_b$	(than) ||| (GJB) || (after) ← || (Antibodies) | (are found in) | (the serum)
$GJB:AV_i^{>}T^{B}_{\ell'}$	and ||| (GJB) || (after) ← || (Antibodies) | (are found) in higher concentration in | the local lymphatic system
$GJB:AV_iT_b$	than ||| (GJB) || (after) ← || (Antibodies) | (are found in a concentration) in | the serum
	205.1.7
M	It should be noted that in the case of the experiment summarized in fig. 1
$GJB_{1,2}:AV^{ft}_uT^{B1,2}_nT_b$	the same antigen | were injected with | Both legs ← || so that || antibody | was being received simultaneously | from two sources of supply | by the serum
	205.1.8
$GJB:^{e}_{t}AV_i^{>}T_{\ell'}T^{x}_n$	(GJB) || in the early days of this experiment (following) || Of antibody | the greater titer in | lymph and lymphnode-extract
$GJB:^{e}_{t}AV_iT_b$	than ||| (GJB) || (in the early days of this experiment following) || (Antibody) | (titer) in | the serum
M	has, then, even a greater significance as to
$A^{w}V_pT_{\ell'}$	the antibodies | the lymphatic source of ←
AV_i	WH ||| (the antibodies) | (are) found
	205.2.1
$GJB:A^{G}V_pT_{\ell'}$	of ||| antibody to viral protein | formation | in the lymphatic system
M	the concluding proof is the evidence for
AV_pC_y	the antibody | as a primary source of | the lymphocyte itself ←

205.2.2
The titers in contents of lymphocytes was found to be as high as 8192, and even this observed value is probably not as high as the true titer, since the volumes on which calculations of volumes were based was derived from a graph which agreed closely with one based on hematocrit-readings of packed cells.

205.2.3
Inasmuch as packed cells contain interstitial fluid caught among them, the true volume of lymphocytes is certainly lower than the packed-cell volume, and the true titer of lymphocyte-contents is correspondingly higher.

205.2.4
Even the values recorded, hwoever, show a ratio of as much as 16 to to the titer of lymph-plasma of the same specimens.

205.2.2

$AV_i^+ C_y$	Antibody | titers was found to be as high as 8192 in contents of | lymphocytes
$AV_i^+ C_y$	and ||| (of antibody) | even this observed value is probably not as high as the true titer (in contents of) | (lymphocytes)
M	since the volumes on which calculations of volume were based were derived from a graph which agreed closely with one based on hematocrit-readings of packed cells.

205.2.3

$T\gamma'' W_i T^j$	Inasmuch as ||| interstitial fluid | contain | packed cells ←
$T_\ell'' W_i T^j$	WH ||| (interstitial fluid) | (is) caught among | them
$C_y W_i^<$	of lymphocytes | the true volume is certainly lower
$T^j W_i$	than ||| the packed-cell | volume
$AV_i^> C_y$	and ||| (Of antibody) | the true titer is correspondingly higher of | contents of lymphocytes
$AV_i T^j$	(than) ||| (antibody) | (titers in contents of) || (packed cells)

205.2.4

$AV_i^> T^j$	However, even ||| antibody | values recorded show a ratio of as much as 16 in (contents of) | packed cells
$AV_i T_\ell''$	to ||| antibody | titer of | lymph plasma of the same specimens

205.2.5
It is considered of additional significance that this ratio is greatest at the time of the greatest increase of antibody in the lymphatic system, for it would be logical to expect, at that time, the greatest ratio between the concentration of antibody in its primary source and that in its secondary site.

205.2.6
No repetition was undertaken here of the demonstration that the antibodies in the lymphocytes were not, in all probability, concentrated in some way by those cells from the lymph-plasma, since this rather laborious demonstration had comprised the major portion of a previous communication.

205.2.5

M	It is considered of additional significance that
AV_iT^j	antibody | titer ratio is greatest (in) | (packed cells)
$AV_iT_{\ell''}$	(to) ||| (antibody) | (titer in) | (lymph-plasma)
$AV_i^{\uparrow o>>}T_{\ell'}$	at the time of ||| antibody's | greatest rate of increase in | the lymphatic system
M	, for it would be logical to expect, at that time,
AV_iC^w	of antibody, | the greatest ratio of the concentration in | a source
AV_pC	WH ||| (antibody) | (is) primary (for) | (source)
$AV_iT_{\ell''}$	to ||| antibody | concentration in | a secondary site

205.2.6

M	No repetition was undertaken here of the demonstration that in all probability
$A^wV_u^{ft\sim}T_{\ell''}C_y$	the antibodies | were not concentrated in some way | from the lymph-plasma | by the lymphocytes
AV_iC_y	WH ||| (antibodies) | (were) in | the lymphocytes
M	, since this rather laborious demonstration had comprised the major portion of a previous communication.

"Nucleic Acids and the Production of Antibody by Plasma Cells", William E. Ehrich, David L. Drabkin, and Carolyn Forman, *Journal of Experimental Medicine*, vol. 40 (1949), 157-167

157.1.1
The formation of antibody in lymph nodes of mice and rabbits is an established phenomenon.

157.1.2
Following the injection of antigen into the foot-pads of rabbits antibody in the popliteal lymph node was found to reach a maximum by the 5th and 6th days, followed by a rapid decline.

157.1.3
On the 5th day the lymphoid cells of the efferent lymph of this node contained 5 to 7 times as much antibody as the supernatant lymph plasma; on the 7th day the ratio had dropped to 2 to 3.

Paper 6

157.1.1

AV_pT_nB antibody | formation | in lymph nodes of mice and rabbits

M is an established phenomenon

157.1.2

$GJB:_tAV_i^{>}{}^{>}T_n^B$ antigen | injection | into the footpads of rabbits || by the 5th and 6th days following ← || antibody | (amount) was found to reach a maximum in | the popliteal lymph node

$GJB:_tAV_i^{\downarrow i}T_n^B$, ||| (antigen) | (injection | (into the footpads of rabbits) || (following the 5th and 6th days) following ← || (antibody) | (amount had) a rapid decline (in) | (the popliteal lymph node)

157.1.3

$GJB:_tAV_i^{>}C\ell T_\ell^f T_n^B$ (antigen) | (injection) | (into the footpads of rabbits) || on the 5th day (following) ← || antibody | contained 5 to 7 times as much | the lymphoid cells of the efferent lymph of this node ←

$GJB:_tAV_iT_{\ell''}$ as ||| (antigen) | (injection) | (into the footpads of rabbits) || (on the 5th day following) ← | (antibody) | (contained an amount of) | the supernatant lymph plasma ←

$GJB:_tAV_i^{>}{}^{\downarrow}C\ell T_\ell^f T_n^B$; ||| (antigen) | (injection) | (into the footpads of rabbits) || on the 7th day (following) ← | Antibody | ratio had dropped to 2 to 3 (in) | (the lymphoid cells of the efferent lymph of this node)

$GJB:_tAV_iT_{\ell''}$ (to) ||| (antigen) | (injection) | (into the footpads of rabbits) || (on the 7th day following) ← || (Antibody) | (in) | (the supernatant lymph plasma)

157.1.4
Lymphoid cells from minced lymph nodes also contained high concentrations of antibody.

157.1.5
It was concluded from these findings that the lymphoid cells[1] are concerned with antibody production.

157.1.5 fn. 1
The lymphoid cells in lymph are generally regarded as lymphocytes which led us to use the term *lymphocytes.* The lympoid cells in lymph nodes are known to include plasma cells; therefore, Dougherty, Chase, and White were correct in their use of the term *lymphoid cells.*

157.3.1
Recent studies have led to the thesis that the synthesis of protein is related to the nucleic acids.

157.3.2
With special spectrographic and cytologic methods Caspersson and others have obtained evidence from which it would appear that the multiplication of chromosomes is associated with the formation of desoxyribose nucleic acid (DNA), whereas the production of cytoplasmic protein is linked with that of ribose nucleic acid (PNA).

	157.1.4
$GJB{:}AV_i^+ C_\ell T_n^x$	Also ||| antibody | contained high concentrations of | lymphoid cells from minced lymph nodes ←
	157.1.5
M	It was concluded from these findings that
$AV_p^r C_\ell$	antibody | are concerned with production of | the lymphoid cells[1] ←
	157.1.5 fn. 1
$C_\ell T_\ell Y C_y$	The lymphoid cells in lymph | are generally regarded as lymphocytes
M	which led us to use the term *lymphocytes.*
$C_\ell T_n Y_i C_z$	The lymphoid cells in lymph nodes | are known to include | plasma cells
M	; therefore Dougherty, Chase and White were correct in their use of the term *lymphoid cells.*
	157.3.1
M	Recent studies have led to the thesis that
$A_p V_p$	protein | synthesis
DV_i	is related to ||| the nucleic acids | (presence)
	157.3.2
M	With special spectrographic and cytologic methods Caspersson and others have obtained evidence from which it would appear that the
DV_p	chromosome | multiplication
$D_d V_p$	is associated with ||| desoxyribose nucleic acid (DNA) | formation
$A_p V_p S_c$	, whereas ||| protein | production in | cytoplasm
$D_r V_p$	is linked with ||| ribose nucleic acid (PNA) | production

158.2.1
As the relationship of nucleic acids to the synthesis of proteins appears to be pertinent in the problem of antibody production, we have undertaken to compare the formation of this protein with the changes in nucleic acids in lymph nodes.

157.3.2
Forty-one animals received 0.5 ml of "febrile antigen typhoid 0" (Lederle) into each foot-pad.

158.8.1
The variations in the amounts of the two nucleic acids observed in our experiments correspond to those of the antibody titers reported previously.

164.3.1
If the chemical results are compared with the histologic findings, it is evident that during the first 4 days when the increase in DNA was greatest the cellular reaction was one of multiplication especially of palsmoblasts.

164.3.2
Mature plasma cells began to appear in large numbers only on the 4th day; they were the predominating cells on the 5th and 6th days; thereafter they diminished rapidly.

158.2.1

$A_pV_p^rD_{d,r}$	As ||| protein | relationship to the synthesis of | nucleic acids' ←
AV_p	appears to be pertinent in the problem of ||| antibody | production
M	, ||| we have undertaken to compare
AV_p	this protein | the formation of ←
$D_{d,r}V_i^{\Delta}T_n$	with ||| nucleic acids | the changes in (amounts of) | in lymph nodes, ←

158.3.2

GJB	0.5 ml. of "febile antigen typhoid 0" (Lederle) | received | into each foot-pad, forty-one animals ←

158.8.1

$D_{r,d}V_i^{\Delta}$	of the two nucleic acids | the variations in the amounts
M	observed in our experiments
AV_i^{Δ}	correspond to ||| of antibody | the variations of the titers reported previously ←

164.3.1

M	If the chemical results are compared with the histologic findings, it is evident that
$GJB:_t^wC_z^bW_p$	(GJB) || (at a time which was) during the first 4 days (after) ← || plasmoblasts | the cellular reaction was one of multiplication especially of ←
$GJB:_tD_dV_i^{\uparrow>>}$	when ||| (GJB) || (time after) || DNA | increase was greatest

164.3.2

$GJB:_tC_z^mW_i^{+b}$	(GJB) || only on the 4th day (after) || Mature plasma cells | began to appear in large numbers
$GJB:_tC_z^mW_i^{++}$	, ||| (GJB) || on the 5th and 6th days (after) || They were the cells | predominating
$GJB:_tC_z^mW_i^{\downarrow i}$	;||| (GJB) || after (on the 5th and 6th days after) || they | diminished rapidly

164.3.3
Thus, the greatest rise in PNA concentration occurred when the plasma cells reached maturity.

164.3.4
The highest figures of PNA were observed when the cells were fully mature.

164.4.1
The lymphocytes began to proliferate in significant numbers on the 3rd and 4th days, and germinal centers began to appear on the 4th and 5th days; the latter were fully active only on the 9th day.

164.4.2
It is worth noting that the rise in lymphocytes did not prevent the PNA from dropping.

164.4.3
This accords well with the repeatedly demonstrated comparatively low PNA content of lymphocytes.

164.5.1
It has been mentioned earlier that it has been demonstrated that following a single injection of vaccine antibody formation in the regional lymph nodes occurs chiefly between the 4th and 6th days.

	164.3.3
$D_rV_i^{\uparrow>>}$	Thus, ||| in PNA, | the greatest rise in concentration occurred
$C_zW_m^b$	when ||| the plasma cells | reached maturity
	164.3.4
$D_rV_i^{>>}$	of PNA | the highest figures were observed
$C_zW_m^+$	when ||| the cells | were fully mature
	164.4.1
$GJB:_tC_yW_p^{+b}$	(GJB) || on the 3rd and 4th days (after) || The lymphocytes | began to proliferate in significant numbers
$GJB:_tT_rW_i^b$	, and ||| (GJB) || on the 4th and 5th days (after) || Germinal centers | began to appear
$GJB:_tT_rW_a^+$	; ||| (GJB) || only on the 9th day (after) || Germinal centers | were fully active
	164.4.2
M	It is worth noting that
$C_yW_i^{\uparrow}$	lymphocytes | the rise in (numbers of) ←
$D_rV_i^{\downarrow}$	did not prevent ||| the PNA | (amount) from dropping
	164.4.3
M	This accords well with the repeatedly demonstrated
$D_rV_iC_y$	PNA | comparatively low content of | lymphocytes
	164.5.1
M	It has been mentioned earlier that it has been demonstrated that
$GJ^1B:_tAV_pT_n^B$	vaccine | a single injection of || chiefly between the 4th and 6th days following ← || Antibody | formation occurs | in the regional lymph nodes

164.5.2
The highest concentrations were found on the 5th and 6th days.

164.5.3
This is precisely the time when the concentration of PNA was highest and mature plasma cells were found to be present in largest numbers.

164.5.4
On the other hand the lymphocytes at this time were in an early stage of proliferation; they reached their greatest development only several days after the peak of antibody formation.

164.5.5
These observations would appear to leave little doubt that in these lymph nodes the antibody was formed by plasma cells.

164.6.1
Our previous finding of antibody in the lymphoid cells of the efferent lymph has been interpreted to signify that the lymphocytes may likewise form antibody.

	164.5.2
$GJ^1B:_tAV_i^{>>}T_n^B$	(GJ^{1}B) || on the 5th and 6th days (following) || Antibody | highest concentrations were found (in) | (the regional lymph nodes)
	164.5.3
$GJ^1B:_tD_rV_i^{>>}$	(GJ^{1}B) || precisely at this time (following) ← || PNA | concentration was highest
$GJ^1B:_tC_z^mW_i^{>>}$	and ||| (GJ^{1}B) || (precisely at this time following) ← || mature plasma cells | were found to be present in largest numbers
	164.5.4
$GJ^1B:_tC_yW_p^e$	On the other hand ||| (GJB^{1}B) || at this time (following) ← || The lymphocytes | were in an early stage of proliferation
$C_yW_p^{>>}$	; ||| they | reached their greatest development
$AV_p^{>>}$	only several days after ||| antibody | the peak of formation of ←
	164.5.5
M	These observations would appear to leave little doubt that
$AV_pC_zT_n$	the antibody | was formed by | plasma cells in these lymph nodes
	164.6.1
M	Our previous finding of
$AV_iC_{\ell}T_{\ell}^f$	antibody | in | the lymphoid cells of the efferent lymph
M	has been interpreted to signify that
AV_pC_y	antibody | may likewise form | the lymphocytes ←

164.6.2
Against this interpretation stands the fact that lymphatic leukemias in contrast to plasma cell myeloma are not associated with hyperglobulonemia.

164.6.3
Also, Harris, Rhoads, and Stokes were unable to extract signicant quantities of antibody from the thymus of immunized animals.

164.6.4
The present study of methyl green- and pyronine-stained sections through efferent lymph vessels suggests that some of the lymphoid cells that leave the lymph nodes during the period of antibody formation are plasmoblasts and plasma cells.

165.1.1
It is possible also that large shed fragments of cytoplasm of plasma cells were contained in the efferent lymph and spun down with the lymphoid cells when they were separated from the lymph plasma.

	164.6.2
M	Against this interpretation stands the fact that
$G_f{:}\sim A_g V_i^+ T_b$	lymphatic leukemias || are not associated with || hyperglobulonemia
$G_f{:}A_g V_i^+ T_b$	in contrast to ||| plasma cell myeloma (which) || (is associated with) || (hyperglobulonemia)
	164.6.3
M	Also, ||| Harris, Rhoads, and Stokes were unable to extract
$GJB{:}AV_i^+ T_t^B$	(were) immunized | (animals) || WH ← || antibody | significant quantities of | from the thymus of animals ←
	164.6.4
M	The present study of methyl green-and pyronine-stained sections through efferent lymph vessels suggests that
$C\ell YC_z^b,C_z$	of the lymphoid cells, | some are | plasmoblasts and plasma cells
$C\ell W_u^f T_n$	which ||| (lymphoid cells) | leave | (from) the lymph nodes
AV_p	during the period of ||| antibody | formation
	165.1.1
M	It is possible also that
$S_c C_z W_i T_\ell^f$	large shed fragments of cytoplasm of plasma cells | were contained in | the efferent lymph
$S_c C_z C\ell W_\ell$	and ||| they and lymphoid cells | were spun down
$C\ell W_\ell^f T_{\ell''}$	when ||| the lymphoid cells | were separated from | the lymph plasma

"The Role of Immature Plasma Cells, Lymphoblasts, and Lymphocytes in the Formation of Antibodies, as Established in Tissue Culture Experiments", F.J. Keuning and L.B. van der Slikke, *Journal of Laboratory and Clinical Medicine* (1950), vol. 36, 167-182

1.2.1
In recent years much attention has been given – mainly by American investigators – to the lymphocyte as a possible producer of antibodies, whereas in Europe great importance has been attributed to the plasma cell.

1.3.1
The whole problem has gained much wider perspective since antibodies have been identified as plasma beta and gamma globulins endowed with specific characteristics that can be established only by immunologic methods.

1.3.2
The synthesis of immune globulins will in all probability therefore be intimately connected with plasma-globulin metabolism.

1.5.1
McMaster and Hudack gave unequivocal evidence of the direct importance of lymphoid tissue in antibody formation.

Paper 7

	1.2.1
M	In recent years much attention has been given – mainly by American investigators – to
$AV^r_pC_y$	antibodies | as a possible producer of | the lymphocyte ←
M	, whereas in Europe great importance has been attributed to
$AV^r_pC_z$	(antibodies) | (as a possible producer of) | the plasma cell ←
	1.3.1
M	The whole problem has gained much wider perspective since
AYA_g	antibodies | have been identified as | plasma beta and gamma globulines
M	endowed with specific characteristics that can be established on by immunologic methods
	1.3.2
AV_p	immune globulins | the synthesis of ←
M	will in all probability therefore be intimately connected with
A_gZ	plasma-globulin | metabolism
	1.5.1
M	McMaster and Hudack gave unequivocal evidence that
$AV^r_pT_{\ell'}$	antibody | is directly important in formation (of) | lymphoid tissue ←

1.5.2
After subcutaneous injection of the antigen it was mainly the regional lymph nodes that were responsible for this production.

2.1.1
Harris and co-workers contended that after intravenous administration of antigen the spleen played the major role.

2.2.1-2
Ehrich, Harris, Grimm, and Mertens in a series of investigations extended the experiments of McMaster and Hudack. By cannulating the afferent and efferent lymph vessels of a lymph node regional to the antigen injection site, they could detect antibody in efferent lymph before its appearance in blood serum or afferent lymph.

2.2.3
Together with the synthesis of antibodies by the lymph node a marked lymphopoiesis and increased output of lymphocytes was found.

2.2.4
In the node lymphoid cells appeared with a marked basophilia, suggesting high content of ribonucleic acid.

	1.5.2
GJB:$AV_p^{r+}T_n^B$	the antigen | injection of | subcutaneous || after || antibody | were mainly responsible for produciton of | it was the regional lymph nodes that ←
	2.1.1
M	Harris and co-workers contended that
GJB:$AV_p^{r+}T_s$	antigen | administration of | intravenous || after || (antibody) | played the major role (in production of) | the spleen ←
	2.2.1-2
M	Ehrich, Harris, Grimm, and Mertens in a series of investigations extended the experiments of McMaster and Hudack. By cannulating the afferent and efferent lymph vessels of a lymph node regional to the antigen injection site, they could detect
GJB:$^{e>}AV_iT_{\ell}^{f}$	(GJB) || before (at a time after) || Antibody | in | efferent lymph
GJB:AV_iT_b,T_{ℓ}^{t}	(GJB) || (at a time after) || antibody's | appearance in | blood serum or afferent lymph
	2.2.3
$C_yW_p^+$	a lympho- | -poiesis (which was) marked
$CW_u^{f\uparrow}T_n$	and ||| of lymphocytes | increased output (from) | (the lymph node)
AV_pT_n	together with ||| of antibodies | the synthesis | by the lymph node
M	was found
	2.2.4
$C_{\ell}W_s^+T_n$	lymphoid cells | appeared with a marked basophilia | in the node
$D_rV_i^+C_{\ell}T_n$	, suggesting ||| of ribonucleic acid | a high content (in) | (the lymphoic cells in the lymph node)

2.2.5
On the basis of the work of Caspersson and many others, this high nucleic acid content was considered indicative of protein synthesis.

2.2.6
In the efferent lymph the greater quantity of antibody was present in the fluid but the cell fractions contained relatively even higher amounts.

2.2.7
As 95 per cent of these cells were lymphocytes, the conclusion was reached that "the lymphocyte was instrumental in the formation of antibody."

2.3.1
Dougherty and White then demonstrated in lymphoid tissue of normal animals, the tissue largely consisting of lymphocytes, the presence of protein components electrophoretically identical with serum beta and gamma globulin, while the same tissue of immunized animals contained large quantities of antibody.

2.2.5

M — On the basis of the work of Casperson and many others,

$D_rV_i^+ C\ell T_n$ — of nucleic acid | the high content in | the lymphoid cells in the lymph node

$A_pV_pC\ell T_n$ — was considered indicative of ||| protein | synthesis | (in the lymphoid cells in the lymph node)

2.2.6

$AV_i^> T_\ell^{f\,\prime\prime}$ — of antibody | the greater quantity was present in | the fluid in the efferent lymph

$AV_i^> {}^+CT_\ell^f$ — but ||| (antibody) | contained relatively even higher amounts (of) | the cell fractions (in the efferent lymph) ←

2.2.7

$C^wY^+ {}^+C_y$ — As ||| of the cells | 95 per cent were | lymphocytes

$CW_iT_\ell^f$ — WH ||| (cells) | (in) | (the efferent lymph)

M — , the conclusion was reached that

$AV_p^rC_y$ — "antibody | was instrumental in the formation of | the lymphocyte" ←

2.3.1

M — Dougherty and White then demonstrated

$GJ\sim B{:}A_p^wV_iT^w{}_{\ell'}{}^B$ — (were) normal | (animals) || WH || protein components | the presence of | in lymphoid tissue of animals ←

$C_yW_i^+T_{\ell'}$ — , WH ||| lymphocytes | largely consisting of | (lymphoid tissue) (is) the tissue ←

$A_pYA_g^w$ — WH ||| (protein components) | electrophoretically identical with | beta and gamma globulin

$A_gV_iT_b$ — WH ||| beta and gamma globulin | (of) | serum

$GJB{:}AV_i^+T^B{}_\ell$ — , while ||| (were) immunized | (animals) || WH ← || antibody | contained large quantities of | the same tissues of animals ←

2.6.1
The occurence of large quantities of plasma cells is well known in chronic infectious diseases, in conditions of hyperimmunization, and in a number of hyperproteinemic states.

2.6.2
Bjørneboe and co-workers could demonstrate very high antibody titers in extracts of plasma cell infiltrations in hyperimmune animals.

2.6.3
In these infiltrates the lymphocyte were only sparse (less than 10 per cent).

2.6.4
These investigators inferred that in the afore-mentioned experiments of Ehrich, Dougherty and White, and others, the cell suspensions used were contaminated with varying amounts of plasma cells, which could be held responsible for the antibody titers found.

3.4.1
We, therefore, undertook to retest the role of lymphocytes and plasma cells respectively.

	2.6.1
$G_f{:}C_zW_i^+$	chronic infectious diseases || in || plasma cells | the occurrence of large quantities of ←
$GJ^3G{:}C_zW_i^+$	, ||| conditions of hyperimmunization || in || (plasma cells) | (the occurence of large quantities of) ←
$G_f{:}C_zW_i^+$	, and ||| a number of hyperproteinemic states || in || (plasma cells) | (the occurrence of large quantities of) ←
M	is well known
	2.6.2
M	Bjørneboe and co-workers could demonstrate
$GJ^3B{:}AV_i^{+\ +}C_zT^{xB}$	(are) hyperimmune | (animals) | WH ← || Of antibody | very high titers in | extracts of plasma cell infiltrations in animals
	2.6.3
$C_yW_i^-T^w$	lymphocytes | were only sparse (less than 10 per cent) in the tissues
$C_zW_i^{\uparrow}T$	WH ||| plasma cells | were infiltrated with | (tissues) ←
	2.6.4
M	These investigators inferred that in the aforementioned experiments of Ehrich, Dougherty and White, and others,
$C_z^wW_i^{\Delta}T^s$	plasma cells | were contaminated with varying amounts of | the cell suspensions used ←
$A^wV_p^rC_z$	, which ||| antibody | could be held responsible for (producing) the titers of | (plasma cells) ←
AV_i	WH ||| (antibody) | (was) found
	3.4.1
M	We, therefore, undertook to retest respectively
$AV_p^rC_y$	(antibody) | the role (in formation of) | of lymphocytes ←
$AV_p^rC_z$	and ||| (antibody) | (the role in formation of) | (of) plasma cells ←

3.5.1
In the first series of experiments we reinvestigated the antibody production in vitro of red and white splenic pulp, largely following the technique of Fagraeus.

3.5.2
In a second series the role of individual types of splenic cells in antibody formation was studied, by explanting splenic cell suspensions separated into different fractions by means of sedimentation.

5.1.1
In all animals, from one to four days after the last antigen administration, Malpighian corpuscles were well developed.

	3.5.1
M	In the first series of experiments we reinvestigated, largely following the technique of Fagraeus
$AV_p^vT_{d'f}$	the antibody | production in vitro | of red and white splenic pulp
	3.5.2
M	In a second series
$AV_p^rC\not{f}T_s$	(of) antibody | the role in formation | of individual types of splenic cells ←
M	was studied, by explanting
$CT_s^sW\not{f}T_s^{sI,II}$	splenic cell suspensions | separated by means of sedimentation into | different fractions
	5.1.1
$GJ^3B:_tT_mW_c^{+B}$	antigen, | the last administration (of) || from one to four days after || Malpighian corpuscles | were well-developed in all animals

5.1.2
Reaction centers were large and apparently in a state of active lymphopoiesis; numerous mitoses were found and the predominant type of cell was the large and middle-sized immature lymphoid cell with strongly pyroninophilic (basophilic) cytoplasm and a large bright nucleus with conspicuous, pyroninophilic nucleoli.

5.1.4
This cell might be called a lymphoblast or reticular lymphocyte.

8.2.1
It appeared that, contrary to the results of Fagraeus, a production of agglutinin was always found in explants from both white pulp and red pulp.

5.1.2

$GJ^{3}{:}_{t}T_{r}W_{g}$	(antigen) | (the last adminsitration of) || (from one to four days after) || Reaction centers | were large
$GJ^{3}{:}_{t}C\mathcal{W}_{p}^{+}T_{r}$	and ||| (antigen) | (the last administration of) || (from one to four days after) ← || were apparently in a state of active lymphopoiesis | (reaction centers) ←
$GJ^{3}{:}_{t}CW_{o}^{+}$	; ||| (of cells) | numerous mitoses were found
$GJ^{3}{:}_{t}CY^{+}{}^{+}C\mathcal{Y}^{n\sim,gw}$	and ||| the type of cell (which) | (was) predominant was | the large and middle-sized immature lymphoid cell
$C\mathcal{Y}^{n\sim,g}S_{c}W_{s}^{+}$	WH ||| (large and middle-sized immature lymphoid cell) | (was) with cytoplasm (which) | (was) strongly pyroninophilic (basophillic)
$C\mathcal{Y}^{n\sim,g}S_{n}^{w}W_{g}$	and (which) ||| (large and middle-sized immature lymphoid cell was with) a bright nucleus (which) | (was) large
$S_{u}^{w}W_{i}S_{n}C\mathcal{Y}^{n\sim,g}$	WH ||| nucleoli | (was) with | (bright nucleus) ←
$S_{u}W_{s}$	WH ||| (nucleoli) | (were) pyroninophilic, conspicuous

5.1.4

$C\mathcal{Y}^{n\sim,g}YC_{y}^{b},C_{y}^{r}$	this cell | might be called a | lymphoblast or reticular lymphocyte

8.2.1

	It appeared that, contraty to the results of Fagraeus,
$AV_{p}T_{f},T_{d}$	of agglutinin | a production was always found | in explants from both white pulp and red pulp

8.3.1
The antibody content of the red pulp at the moment of explanation was, however, some two times that of a comparable quantity of white pulp, as estimated from quantities of tissue used and respective extract titers.

8.3.2
This means that the absolute quantity of newly produced agglutinin in red pulp explants was also much greater than that in white pulp.

11.2.1
The splenic cell suspensions prepared from the bled animals were subjected to differential sedimentation to separate them, if possible, into a fraction I, containing most of the large cells, and a fraction II, containing only a few large cells and thus consisting mainly of small lymphocytes.

	8.3.1
M	however, as estimated from quantities of tissue used and respective extract titers
$AV_i^{v>}T_d$	(of) antibody | the content at the moment of explanation was some two times (greater) | of the red pulp
AV_iT_f	(than) ‖ of antibody | the content at the moment of explantation of a comparable quantity | of white pulp
	8.3.2
M	This means that also
$A^wV_i^{v>+}T_d$	of agglutinin | the absolute quantity was much greater in explants of | red pulp
AV_p^v	WH ‖ (agglutinin) | (was) newly produced
$A^wV_iT_f$	than ‖ (of agglutinin) | (the absolute quantity) in | white pulp
AV_p^v	WH ‖ (agglutinin) | (newly produced)
	11.2.1
$CT_s^sW_i^-T_s^{sIw},T_s^{sIIw}$	The splenic cell suspensions prepared from the bled animals | were subjected to differential sedimentation to separate them, if possible, into | a fraction I and fraction II
$C^gW_i^{>>}T_s^{sI}$	, WH ‖ the large cells | containing most of | (fraction I) ←
$C^gW_i^-T_s^{sII}$	, WH ‖ large cells | containing only a few | (fraction II) ←
$C_y^{g\sim}W_i^+T_s^{sII}$	and thus ‖ small lymphocytes | consisting mainly of | (fraction II) ←

11.3.1
In extracts of the cellular elements of these suspensions a significant difference in agglutinin content between fraction I and fraction II was never observed.

11.3.2
If the extract titers of the two fractions in every single experiment are compared (different experiments cannot be compared), it can be seen that these titers are largely proportional to the total numbers of white cells irrespective of the differentiation into large and small cells.

11.3.3
This seems to indicate that both the large cells and the smaller ones, the lymphocytes, do contain antibody.

12.1.1
In tissue culture, however, the two fractions behaved quite differently, fraction I generally showing significantly higher production of agglutinins than fraction II.

	11.3.1
M	A significant difference was never observed in
$AV_iCT_s^{sI,IIx}$	agglutinin | content in | extracts of the cellular elements of these suspensions
$AV_iCT_s^{sIx}$	between ||| (agglutinin) | (content in) | (extracts of the cellular elements of) fraction I
$AV_iCT_s^{sIIx}$	and ||| (agglutinin) | (content in) | (extracts of the cellular elements) of fraction II
	11.3.2
$AV_iCT_s^{sI,IIx}$	If ||| antibody | titers in | extracts (of the cellular elements) of the two fractions
M	in every single experiment are compared (different experiments cannot be compared), it can be seen that
$AV_iCT_s^{sI,IIx}$	the antibody | titers in | extracts of the cellular elements of the two fractions
C_wW_i	are largely proportional to ||| of white cells | the total numbers (present)
$C_wYC^g{\cdot}C^{g\sim}$	irrespective of ||| the white cells | being differentiated into | large and small cells
	11.3.3
M	This seems to indicate that
AV_iC^g	both ||| (antibody) | (do contain) | the large cells ←
$AV_iC^{g\sim},C_y$	and ||| antibody | do contain | the smaller ones, the lymphocytes ←
	12.1.1
M	In tissue culture, however, the two fractions behaved quite differently,
$AV_p^{v>}T_s^{sI}$	agglutinins | generally showing significantly higher production (in culture) of | fraction I ←
$AV_p^vT_s^{sII}$	than ||| (agglutinins') | (production in culture of) | fraction II

12.1.2
If the new productions again in terms of agglutinin present in control extracts of the cellular sediments – i.e. the "increase" of the two fractions in each single experiment – are compared, the respective production of agglutinin is strikingly proportional to the percentages of large cells in the two fractions.

12.2.1
From these observations it may be concluded that the production of agglutinin in these cultures is completely dependent on the presence of large cells.

12.2.2
The smaller ones, lymphocytes, although probably containing antibody, are not capable of producing or multiplying it under the conditions of the experiment.

14.2.1
In conclusion we can state that the role of immature plasma cells in antibody formation is beyond any doubt; the role of lymphoblasts proper, i.e. during lymphocytogenesis, is sitll questionable.

14.3.1
It seems logical, however, that some relation between the two processes, plasmacytogenesis and lymphocytogenesis, exists during antibody formation.

	12.1.2
$AV_pT_s^{sI,II}$	if ||| the new productions | (in the two fractions)
AV_iCT^x	are compared again in terms of ||| agglutinin | present in | control extracts of the cellular elements
$AV_i^{\uparrow}T_s^{sI,II}$	– i.e. ||| the "increase" | of the two fractions in each single experiment
$AV_pT_s^{sI,II}$	,||| agglutinin | production of | the respective ←
$C^gW_iT_s^{sI,II}$	is strikingly proportional to ||| of large cells | the percentages in | the two fractions
	12.2.1
M	From these observations it may be concluded that
$AV_p^vT_s^{sI,II}$	of agglutinin | the production in cultures | of these two fractions
C^gW_i	is completely dependent on ||| large cells | the presence of ←
	12.2.2
$AV_p^{vk}{\sim}C^g{\sim},C_y$	antibody | are not capable of producing or multiplying, under the conditions of the experiment | the smaller ones, lymphocytes ←
$AV_iC^g{\sim},C_y,$	although ||| antibody | probably contain | (the smaller ones, lymphocytes) ←
	14.2.1
M	In conclusion we can state that
$AV_p^rC_z^m{\sim}$	antibody | the role is beyond any doubt in formation (of) | of immature plasma cells ←
$AV_p^rC_y^b$	: ||| (antibody) | the role is still questionable (in formation of) | of lymphoblasts proper ←
C_yW_p	, i.e. during ||| lymphocyto- | -genesis
	14.3.1
M	It seems logical, however, that
C_zW_p	some relation exists between ||| the plasmacyto- | -genesis process
C_yW_p	and ||| the lymphocyto- | -genesis process
AV_p	during ||| antibody formation

14.3.2
Rich c.s. demonstrated that the "acute splenic tumour cell" occuring in acute infections, etc., was identical with the lymphoblast in its amoeboid movements.

14.3.3
Sundberg, studying lymphocytogenesis in human lymph nodes, states that the reticular lymphocytogenesis (lymphoblast according to our nomenclature) is to be considered the stem cell for both lymphocyte and plasma cell.

15.9.1
The experiments clearly refute the idea of antibody production by mature lymphocytes.

	14.3.2
M	Rich c.s. demonstrated that
$C_s^wYC_y^b$	the "acute splenic tumor cell" | was identical in its ameboid movements with | the lymphoblast
$G_f^+ :C_sW_i$	WH ||| acute infections, etc., || in || ("Acute splenic tumor cell") | occurs
	14.3.3
M	Sundberg, studying
$C_yW_pT_nB$	lymphocyto- | -genesis | in human lymph nodes
M	, states that
$C_y,C_zY_c^fC_y^{rw}$	both lymphocyte and plasma cell | is to be considered as the stem cell for | the reticular lymphocyte ←
$C_y^rYC_y^b$	WH ||| (the reticular lymphocyte) | (is) (called) according to our nomenclature | lymphoblast
	15.9.1
M	The experiments clearly refute the idea of
$AV_p^{\sim}C_y^m$	antibody | (no) production by | mature lymphocytes

"Studies on Antibody Production I. Method for the Histochemical Demonstration of Specific Antibody and its Application to a Study of the Hyperimmune Rabbit", Albert H. Coons, Elizabeth H. Leduc, and Jeanne M. Connolly, *Journal of Experimental Medicine*, vol. 102 (1955), no. 1, 49-60.

49.1.2
These data indicate that the major site of antibody formation is a family of cells which first appear as a response to the stimulus.

49.1.3
The response consists of cell multiplication, cell differentiation, and the concurrent synthesis of a specific protein, antibody.

49.1.4
The mature member of this cell family is the plasma cell.

54.4.1
Antibody was demonstrable in the cytoplasm of cells around the periphery of the lymphoid follicles, in the red pulp, and in a cuff around some of the small arteries.

54.4.4
There were occasional single antibody-containing cells.

Paper 8

	49.1.2
M	These data indicate that
$AV_p^+ C^{\swarrow w}$	of antibody | the major site of formation is | a family of cells
$GJ:C^{\swarrow}W_i^i$	which ||| the stimulus || as a response to || (Family of cells) | first appear
	49.1.3
$GJ:AVC^{\swarrow}$	(the stimulus) || (to) || the response ←
CW_p	consists of ||| cell | multiplication
CW_c	, ||| cell | differentiation
$GJ:A^GV_pC$	, and concurrently ||| (GJB) || (:) || a specific protein, antibody, | synthesis of | the (cellular) ←
	49.1.4
$C^{\swarrow}Y_c^tC_z$	of this cell family | the mature member is | the plasma cell
	54.4.1
$AV_iS_cCT_{f,d,n'}$	antibody | was demonstrable in | the cytoplasm of cells around the periphery of the lymphoid follicles, in the red pulp, and in a cuff around some of the small arteries
	54.4.4
AV_iC^1	antibody | (were) containing | there were occasional single cells (which) ←

57.5.1
The evidence is unequivocal that the islands of cells which appear in the spleen and in other organs in hyperimmune animals, and which all workers who examined them have identified as plasma cells, do in fact contain high concentrations of antibody.

57.5.2
Earlier work has already established a clear correlation between the presence of these cells and active *in vitro* synthesis.

57.5.3
The demonstration that they individually contain antibody confirms these observations.

58.3.1
A study of the hyperimmune rabbit on the first few days after the last of a series of intravenous antigen injections reveals that antibody against human gamma-globulin or ovalbumin is present in groups of plasma cells in the red pulp of the spleen,the medullary areas of lymph nodes, the submucosa of the ileum, and the portal connective tissue of the liver.

58.3.3
Small amounts of antibody were occasionally visible in cells in the lymphoid follicles of the spleen and lymph nodes, so that a minor contribution of lymphocytes to antibody synthesis cannot be excluded.

	57.5.1
M	The evidence is unequivocal that
$AV_i^+ C^w$	antibody | do in fact contain high concentrations of | the islands of cells ←
$GJ^3B{:}CW_iT_s^B$	which ||| (are) hyperimmune | (animals) || WH || (Islands of cells) | appear in | the spleen and other organs in animals
CYC_z	, and which ||| (islands of cells) | all workers who have examined them have identified as | plasma cells
	57.5.2
M	Earlier work has already established a clear correlation between
C_zW_i	these plasma cells | the presence of ←
AV_p^{V+}	and ||| (antibody) | active *in vitro* synthesis (of) ←
	57.5.3
M	These observations are confirmed by the demonstration that
$AV_iC_z^1$	antibody | contain | the plasma cells individually ←
	58.3.1
M	A study of the hyperimmune rabbit reveals that
$GJ^3B{:}_t^eA^GV_iC_zT_d$, T_i,T_n,T_v	(of) antigen | the last of a series of injections (which) | (are) intravenous || on the first few days after ← || antibody against human gamma-globulin or ovalbumin | is present in | groups of plasma cells in the red pulp of the spleen, the medullary areas of the lympy nodes,the submucosa of the ileum, and the portal connective tissue of the liver
	58.3.3
$AV_iCT_fT_n$	of antibody | small amounts were occasionally visible in | cells in the lymphoid follicles of the spleen and lymph nodes
$AV_p^{r-}C_y$	, so that ||| antibody | a minor contibution to synthesis of | by lymphocytes ←
M	cannot be excluded

"Studies on Antibody Production II. The Primary and Secondary Responses in the Popliteal Lymph Node of the Rabbit", Elizabeth H. Leduc, Albert H. Coons, and Jeanne M. Connolly, *Journal of Experimental Medicine*, vol. 102 (1955), 61-72.

61.1.1
This paper reports the cellular changes which take place in the popliteal lymph node of the rabbit following one or two injections of antigenic material into the homolateral foot-pad, and correlates them with the presence of antibody in the individual cells as determined by immunohistochemical reactions.

61.1.2
The results indicate that the sharp rises in antibody detectable in the serum within the 1st days after stimulation by antigen reflect the number of cells engaged in antibody synthesis, and that during this period most if not all of the antibody produced is synthesized during the multiplication and differentiation of a cell family the mature member of which is the plasma cell.

Paper 9

	61.1.1
	This paper reports
$GJ^{1,2}B$: $CW_cT_n^B$	of antigenic material | one or two injections | into the homolateral foot-pad, || following || The cellular | changes which take place | in the popliteal lymph node of the rabbit
M	, and correlates them with
AV_iC^1	of antibody | the presence in | the individual cells
GJB: C^1W_a	as determined by ||| (GJB) || (to) (The individual cells') | immunohistochemical reactions
	61.1.2
M	The results indicate that
$GJ:{}^e_tAV_i^{\uparrow} + T_b$	antigen | stimulation by || within the 1st days after ← || (of) antibody | the sharp rises in (contents) detectable in | the serum
C^wW_i	reflect ||| of cells | the numbers (present) ←
AV_p^rC	WH ||| antibody | (are) engaged in synthesis of | (cells) ←
$A^wY + A^w$	and that ||| of the antibody | most if not all is | (antibody)
$GJ:{}^e_tAV_p$	WH ||| (antigen) | (stimulation by) || during this period (within the 1st days after) ← || (antibody) | (is) produced
AV_p	WH ||| (antibody) | (is) synthesized
$C\not{W}_p$	during ||| (of a cell family) | the multiplication ←
$C\not{^w}W_c$	and (during) ||| of a cell family | (the) differentiation of ←
$C\not{Y}_c^tC_z$	of which ||| (cell family) | the mature member is | the plasma cell

61.1.3
These observations confirm, therefore, those of numerous investigations summarized below, and extend them one step further by the demonstration that these cells, as individuals, in fact contain antibody.

62.2.1
The cell type responsible for antibody synthesis, however, has been the subject of a slowly resolving confusion, brought about by the complicated and changing character of the cell population in lymphatic tissue, and the difficulty of making a positive identification of the undifferentiated cells present in such tissue and present in larger numbers after antigenic stimulation.

62.2.2
Students working with animals repeatedly injected with antigenic material have unanimously concluded that the cell type associated with antibody production was the developing plasma cell.

61.1.3

M	These observations confirm, therefore, those of numerous investigators summarized below, and extend them one step further by the demonstration that in fact
AV_iC^{wl}	antibody | contain | the cells, as individuals, ←
$CYC^{\not w}$	WH ||| (cells) | of | a cell family
$C^{\not}Y^t_cC_z$	WH ||| (cell family) | of which the mature member is | the plasma cell

62.2.1

AV^r_pC	however, ||| antibody | responsible for synthesis (of) | the cell type ←
M	has been the subject of a slowly resolving confusion, brought about by
$CW_cT_{\ell'}$	the cell population's | complicated and changing character | in lymphatic tissue
M	, and the difficulty of making a positive identification of
$C^c \sim W_iT_{\ell'}$	the undifferentiated cells | present in | such tissue
$GJ{:}C^c \sim W_i^{>}T_{\ell'}$	and ||| antigen- | -ic stimulation || after ← || (the undifferentiated cells) | present in larger numbers (in) | (such tissue)

62.2.2

M	Students working with
GJ^3B	antigenic material | repeatedly injected with | animals ←
M	have unanimously concluded that
$C^wYC^c_z$	the cell type | was | the developing plasma cell
AV^r_pC	WH ||| antibody | (was) associated with production of | (cell type)←

62.2.3
On the other hand, workers who examined the primary response were at first led to believe that the lymphocyte was responsible because of its very great predominance in antibody-containing suspensions made from once stimulated lymph nodes.

63.3.1
Finally, using an agglutination reaction on the surface of cells as a test for intracellular antibody, Reiss, Ehrich, and Mertens and Moeschlin and Demiral found antibody present in both immature and mature plasma cells.

63.2.2
Hayes and Dougherty, however, carrying out the same reaction on stimulated subcutaneous tissue, found adherence of the organisms to small lymphocytes.

64.2.1
The secondary response is characterized by the formation of colonies of cells in the homolateral lymph node following two injections into the foot-pad.

	62.2.3
M	On the other hand, workers who examined
GJ^1: AV	primary (injection) || (to) || the response ←
M	were at first led to believe that
GJ^1:$AV^r_pC_y$	(GJ^1) || (:) | (antibody) | was responsible (for the production of) | the lymphocyte ←
$C_yW_i^{+\ +}T_n^{wsw}$	because of ||| the lymphocyte's | very great predominance in | suspensions made from lymph nodes
AV_iT^s	WH ||| antibody | (are) containing | (suspensions) ←
GU^1T_n	WH ||| (antigen) | (were) once stimulated (by) | (lymph nodes) ←
	63.3.1
M	Finally, using
GJ:A^GV_aC	an agglutination reaction on the surface | of cells
M	as a test for
AV_iC	antibody | within | cells
M	, Reiss, Ehrich, and Mertens, and Moeschlin and Demiral, found
$AV_iC^{m\sim}_z$,C^m_z	antibody | present in | both immature and mature plasma cells
	63.2.2
M	Hayes and Dougherty, however, found, carrying out
GJ:$A^GV_aT_i$	the same reaction || on || stimulated | subcutaneous tissue |||
GJ:$A^GV^t_uC^{g\sim}_y$	of the organisms | adherence to | small lymphocytes
	64.2.1
GJ^2:CW	secondary (injection) || (to) || the response ←
GJ^2B:$CW_pT^B_n$	is characterized by ||| two injections | into the footpad || following ← || of cells | the formation of colonies | in the homolateral lymph node

64.4.1
Two series of animals were injected in the foot-pad with fluid diphtheria toxoid; one series received a second injection of the same dosage 4 weeks after the first, the other 6 weeks after the first.

64.5.1
On the 2nd day after a secondary stimulus there were regularly present, in sections of the homolateral popliteal lymph node stained for antibody, large cells within a thin rim of fluorescent cytoplasm, quite faint, indicating a low but definite concentration of antibody.

64.7.1
By the 4th day there were clusters of smaller brightly fluorescent antibody-containing cells scattered in profusion throughout the medullary cords and around the medial borders of the follicles, sometimes extending almost to the periphery of the node.

64.4.1

$GJB_{1,2}$	fluid diptheria toxoid | were injected with | in the foot-pad two series of animals ←
GJ^2B_1	; ||| the same dosage | received a second injection of | one series ←
GJ^1B_1	4 weeks after ||| the same dosage | (received) the first injection of | one series ←
GJ^2B_2	, ||| (the same dosage) | (received a second injection of) | the other series ←
GJ^1B_2	6 weeks after ||| (the same dosage) | (received a first injection of) | (the other series) ←

64.5.1

$GJ^2B:_tC^{gw}W_iT_n^{Bw}$	a secondary stimulus || on the 2nd day after ← || large cells | there were regularly present |, in sections of the homolateral popliteal lymph node, ←
$GJ^2B:AV_iT_n^B$	WH ||| antibody | (was) stained for | (sections of the hom. pop. lym. node) ←
$C^gS_c^-W_s^-$	WH ||| (large cells) with a thin rim of cytoplasm (which) | (was) fluorescent, quite faint,
$AV_i^-C^g$	indicating ||| of antibody | a low but definite concentration (in) | (the large cells)

64.7.1

$GJ^2:_tC^wW_i^+T_{u,f,n}$	(a secondary stimulus) || by the 4th day (after) ← || of cells | there were clusters scattered in profusion | throughout the medullary cords and around the medial borders of the follicles, sometimes extending almost to the periphery of the node ←
AV_iC^w	WH ||| antibody | (were) containing | (cells) ←
$C^wW_s^+$	WH ||| (cells) | (were) brightly flourescent
$CW_{g\sim}^>$	WH ||| (cells) | (were) smaller

65.1.1
The fluorescence due to antibody increased in brilliance from the immature to the mature cells.

65.2.1
In the animals sacrificed on the 8th, 14th, or 21st day following the second injection the number of antibody-containing cells had decreased to about 10 per section.

65.2.2
Most of them were mature plasma cells.

65.5.1
After a single injection of antigen into the left hind foot-pad, antibody-containing cells were first detectable on the 4th day.

65.5.2
They were large cells, with a thin rim of faintly to moderately brightly fluorescent cytoplasm, scattered singly in the medullary area near the edges of the follicles or in the medullary cords.

65.1.1

$CW_s^{w\uparrow}$	the (cellular) | fluorescence increased in brilliance
CW_s	WH ||| (cellular | fluorescence)
AV_iC	(is) due to ||| antibody | (content in) | (the cell)
$C^m{\sim}W_s$	from ||| immature (cells) (the degree of brilliance of fluorescence of) ←
$C^mW_s^+$	to ||| mature cells | (the degree of brilliance of fluorescence of) ←

65.2.1

$GJ^2B:_tC^wW_i^{\downarrow}T_n^B$	the second injection | in the animals sacrificed || on the 8th, 14th, or 21st day following ← || of cells | the number (present) had decreased to about 10 per | section
AV_iC	WH ||| antibody | (were) containing | (cells) ←

65.2.2

$CY^{>>}C_z^m$	of them | most were | mature plasma cells

65.5.1

$GJ^1B:_t^eC^wW_i$	of antigen | a single injection | into the left hind foot-pad, || (at a time which was) first on the 4th day after ← || cells | were detectable
AV_iC	WH ||| antibody | (were) containing | (cells) ←

65.5.2

CYC^{gw}	they | were | large cells
$C^gS_c^-W_s^-$	WH ||| (large cells) | (were) with a thin rim of cytoplasm (which) | (was) faintly to moderately brightly fluourescent
$C^{g1}W_iT_{u,u'}$	, WH ||| (large cells) (which) singly | (were) scattered in | the medullary area near the edges of the follicles or the medullary cords

66.4.1
It seems clear from all the evidence that the cells responsible for the synthesis of antibody shortly after the injection of a second antigenic stimulus are members of a family which arise from some undifferentiated precursor as the direct result of the stimulus.

66.4.2
The first cells which demonstrably contain antibody and can therefore be assigned to this family are large cells with a thin rim of basophilic cytoplasm and large nuclei whose appearance is indistinguishable from that of other primitive hematogenous cells.

66.4.3
During the 2 or 3 days after their first appearance they multiply, synthesize antibody specific for the antigen which stimulated their development, and differentiate through immature to mature plasma cells.

66.4.1

M	It seems clear from all the evidence that
$C^{w}YC^{\not w}$	the cells | are | members of a family
$GJ^{2}{:}^{e}AV^{r}_{p}C$	WH ||| antigen | the injection of a second stimulus of || shortly after || antibody | (are) responsible for the synthesis of | (cells) ←
$GJ^{2}{:}C^{\not}Y^{f}_{c}C_{b}$	which ||| the stimulus || as the direct result of || (Members of a family) | arise from | some undifferentiated precursor

66.4.2

$C^{w}YC^{gw}$	the cells | are | large cells
$GJ\ ^{2}{:}^{e}AV^{i}C$	which ||| (antigenic stimulus) | (the second injection of) || first (after) || antibody | demonstrably contain | (cells) ←
$CYC^{\not}$	and therefore (which) ||| (cells) | can be assigned to | this family
$C^{g}S^{-}_{c}W_{s}$	WH ||| (large cells) with a thin rim of cytoplasm (which) | (is) basophilic
$C^{g}S_{n}W_{g}$	WH ||| (large cells with) nuclei (which) | (are) large
$C^{g}YC_{b}$	whose ||| (large cells') | appearance is indistinguishable from that of | other primitive hematogenous cells

66.4.3

$C^{g}W_{p}$	the large cells | multiply
$G^{w}J^{2}{:}A^{G}V_{p}C^{g}$	, ||| (antigen) | (was twice injected) || WH← || antibody specific for the antigen | synthesize | (the large cells) ←
$G{:}C^{g}W_{p}$	which ||| (antigen) || stimulated || the large cells' | development
$C^{g}Y^{ft}_{c}C^{m}_{z}{\sim}C^{m}_{z}$	, and ||| (the large cells') | differentiate | through immature (plasma cells) | to mature plasma cells
$GJ^{2}{:}^{e}C^{g}W_{i}$	during the 2 or 3 days after ||| (antigenic stimulus) | (a second injection of) || (at a time which was) first (after) || The large cells' | appearance

67.1.1
Their descendants form colonies in the medullary areas of the lymph node, and these colonies often merge with others to form larger colonies.

67.2.1
The course of events described above for the secondary response takes place on a very small scale when only one injection of antigen is administered, although the cell-types involved are indistinguishable in form and location under the fluorescence microscope when stained for specific antibody.

67.2.2
This paucity of cells engaged in antibody synthesis during the primary response accounts, in our opinion, for the difficulties encountered by those workers who have tried to distinguish the cell type responsible for this limited response in the complex cell population of the lymph node.

67.1.1

$C^{w}W_{p}T_{u}$	the cells | form colonies | in the medullary areas of the lymph node
$CY_{c}^{f}C^{g}$	WH ||| (cells) | descended | from the large cells
$CW_{p}^{\geq}Tu$	and ||| these colonies often merge with others to form larger colonies | (in the medullary areas of the lymph node)

67.2.1

$GJ^{1}{:}CW_{a}^{w-}$	of antigen | only one injection is administered || when ← || the course of events takes place on a very small scale
$GJ^{2}{:}CW_{a}$	WH ||| secondary (injection) || (to) || (course of events) described above for the response ←
$C^{\not w}YC^{\not w}$	, although ||| the cell types | are indistinguishable in form and location under the fluorescence microscope | (from) (the cell types)
$GJ^{1}{:}AV_{p}^{r}C^{\not}$	WH ||| (of antigen) | (only one injection is administered) || (when) || involved (in the response) | (cell types) ←
$GJ^{2}{:}AV_{p}^{r}C^{\not}$	WH ||| (secondary injection) || (to) || (involved in the response) | (cell types) ←
$GJ{:}A^{G}V_{i}C^{\not}$	when ||| (GJ) || (:) || specific antibody | stained for | (the cell types) ←

67.2.2

$GJ^{1}{:}C^{w}W_{i}^{-}$	primary (injection) || during the response (to) || cells | this paucity of ←
$AV_{p}^{r}C$	WH ||| antibody | (are) engaged in synthesis of | (cells) ←
M	accounts, in our opinion, for the difficulties encountered by those workers who have tried to distinguish
$C^{w}Y_{i}C^{\Delta w}$	the cell type | in | the complex cell population
$GJ^{1}{:}AV_{p}^{-r}C$	WH ||| (primary injection) || (to) || is responsible for this limited response | (cell type) ←
$C^{\Delta}W_{i}T_{n}$	WH ||| (complex cell population) | (is) of | the lymph node

67.3.1
The synthesis of antibody is not the usual outcome of the uptake of antigen by previously unstimulated cells.

67.3.2
Hundreds of cells in a section through the medullary areas contain antigen 24 hours after a single injection, and yet 4 days later only about fifty of them contain demonstrable antibody.

67.3.3
If, however, a second injection is given a month after the first, it then appears that this stimulus acts as a trigger mechanism which detonates a remarkable biological event engaging many cells in the area where the first antigen was deposited.

67.3.4
This event consists in the concurrent inauguration of cell differentiation, cell multiplication, and the synthesis of a new protein.

	67.3.1
$GU_s^{lt}C^w{:}AV_p^{\sim}$	of antigen | the uptake | by cells || (that) is the usual outcome of || antibody | (It is) not the synthesis of ←
$GU_s^{\sim}C$	WH ||| (antigen) | (are) previously unstimulated (by) | (cells) ←
	67.3.2
$GJ^1{:}_tGU_iC^+T_u$	(of antigen) | a single injection || 24 hours after || antigen | contain | hundreds of cells in a section through the medullary areas ←
$GJ^1{:}_t^{e\sim}AV_iC^-T_u,$	and yet ||| (of antigen) | (a single injection) || 4 days later (than 24 hours after) ← || antibody | contain demonstrable | only about 50 of them ←
	67.3.3
GJ^2B	If, however, ||| a second injection is given
GJ^1B	a month after ||| the first (injection)
M	, then it appears that
$GJ^2B{:}C^+W_aB^w$	this stimulus || acts as a trigger mechanism which detonates || many cells | being engaged in a remarkable biological event | in the area
G^wJB	where ||| the antigen | was deposited | (in the area)
GJ^1	WH ||| (antigen) | (was) first (injected)
	67.3.4
M	This event consists of
CW_c^b	cells | the inauguration of differentiation of ←
CW_p^b	, concurrent (with) ||| cell | (the inauguration of) multiplication (of) ←
$A_pV_p^bC$	, and (concurrent with) ||| a new protein | (the inauguration of) synthesis of ←

67.3.5
This raises the question whether the "primary response" exists as such on a cellular level, or whether the synthesis of antibody results only after the uptake of two doses of antigen by the same primitive cell of the proper variety, with some unknown but necessary intracellular event intervening.

67.3.6
In only a few of the cells, perhaps, has this event taken place after one injection before the concentration of antigen has fallen so low as to make a second encounter unlikely.

67.4.1
The implication of the experimental facts concerning antibody production is that the cell type responsible does not exist in the absence of stimulation; that the plasma cell family is a specific response to antigenic stimulation, and is engaged in antibody synthesis whenever encountered, except perhaps as a neoplasm.

	67.3.5
M	This raises the question whether
GJ^{1}:AVC	"primary" (injection) || (to) || The "response" exists as such | on a cellular level
$GU_{s}^{2t}C$:$AV_{p}C$	, or whether ||| antigen | the uptake of two doses of | by the same primitive cell of the proper variety || results only after || antibody | synthesis of | the (cellular) ←
CW_{a}	with intervening ||| the cell | some unknown but necessary event in ←
	67.3.6
GJ^{1}:$C^{-}W_{a}$	perhaps, ||| one injection || after ← || in only a few of the cells | has this event taken place
$GU_{i}^{\downarrow +}$	before ||| of antigen | the concentration has fallen so low
$GU_{s}^{2t}C$	as to make unlikely ||| (antigen's) | second encounter (with) | (the cell)
	67.4.1
M	The implication of the experimental facts concerning
AV_{p}	antibody | production
$GJ^{\sim}$:$C^{w}W_{i}^{\sim}$	is that ||| the absence of stimulation || in || The cell type | does not exist
$AV_{p}^{r}C$	WH ||| (antibody) | (is) responsible (for production of) | (cell type) ←
GJ:$C_{z}^{\swarrow}W_{i}$	; that ||| an antigen | stimulation by || is a specific response to || the plasma cell family | (the appearance of) ←
$AV_{p}^{r}C_{z}^{\swarrow}$	, and ||| antibody | is engaged in synthesis (of) | (the plasma cell family) ←
$C_{z}^{\swarrow}W_{i}$	whenever ||| (the plasma cell family) | (is) encountered
CW_{i}	except perhaps ||| a neoplasm | (encountered) as ←

67.4.2
If this is true, the resulting globulin then must always be a specific antibody, with no "normal" inactive prototype.

67.4.3
The course of cellular events also has an obvious bearing on theories of antibody production.

68.1.1
There is no cellular evidence of a normal synthetic process which could be modified in its final stages by the presence of antigen.

68.1.2
Nor, evidently, does the intracellular presence of antigen result in antibody formation at once, but requires a latent period and a second stimulus.

	67.4.2
M	If this is true, then always
$GJ{:}A_p^wYA^G$	(GJ) || (:) || the globulin | must be | a specific antibody
$A_pV_pC_z^{\prime}$	WH ||| (globulin) | (is) resulting (from) | (the plasma cell family)
$GJ\sim B{:}A_pV_i^{\sim}$	, with ||| "normal" (animals) || (in) ← || of inactive prototype | none present
	67.4.3
CW_a	the cells | the course of events in ←
M	also has an obvious bearing on theories of
AV_p	antibody | production
	68.1.1
M	There is no evidence of
$GJ\sim B{:}A_pV_p^wC$	normal (animals) || (in) || A synthetic process | in cells
$GU_iC{:}A_pV_p^e\sim C$	which ||| of antigen | the presence of | (in the cell) || could be modified by || (Synthetic process) in its final stages | (in cells)
	68.1.2
M	Nor, evidently, does
$GU_iC{:}AV_p$	of antigen | the presence in | the cell || result at once in || antibody | formation
AV_p	, but ||| antibody | formation
$CW_{a\sim}$	requires ||| (in the cell) | a latent period ←
$GU^2C{:}AV_p$	and ||| a second stimulus || (requires) || (Antibody) | (formation)

68.1.3
Knowledge of the nature of this postulated latent change in some primitive cell impressed by the first exposure to antigen is fundamental to an understanding of the mechanism by which an antigen molecule can impose a complementary surface pattern on an antibody molecule.

68.3.5
The antibody detected in and around small lymphocytes may have been due to the occasional synthesis of small amounts by these cells, but the appearance morphologically was not sharply limited to individual cells, as was the case in the medullary areas; it occured over an area of the follicle involving a number of cells in an indistinct way, often with a particulate distribution between the cells as well.

68.3.6
The lymphocyte family of cells obviously can not be excluded from participation in the formation of antibody, although under the conditions of our experiments its contribution was minor if present at all.

68.1.3

M	Knowledge of the nature of
$GU_s^1C{:}CW_c$	antigen | first exposure to | the (cell's) || impressed by || in some primitive cell | this postulated latent change ←
M	is fundamental to an understanding of the mechanism by which
GXA	an antigen molecule | can impose a complementary surface pattern on | an antibody molecule

68.3.5

$AV_iC_y^{g\sim}$	the antibody | detected in | small lymphocytes
$AV_i^yC_y^{g\sim}$	and ||| (the antibody) | (detected) around | (small lymphocytes)
$AV_p^-C_y^{g\sim}$	may have been due to ||| of antibody | the occasional synthesis of small amounts | by these cells
AV_iC^1	, but not ||| the (antibody) | appearance morphologically was sharply limited to | individual cells
$AV_iC^1T_u$	as ||| (the antibody) | (appearance was sharply limited to) | (individual cells) in the medullary areas
$AV_i^yCT_f$	; ||| antibody | occurred | involving in an indistinct way a number of cells over an area of the follicle
AV_i^yC	, often as well with ||| (of) particulate (antibody) | a distribution | between the cells

68.3.6

$AV_p^rC_y^{\not}$	antibody | from participation in the formation of | the lymphocyte family of cells ←
M	obviously can not be excluded, although under the conditions of our experiments
$AV_p^{r-}C_y^{\not}$	(antibody) | contribution was minor if present at all (to the formation of) | the lymphocyte family of cells' ←

"The Antibody Response of Rats Depleted of Lymphocytes by Chronic Drainage from the Thoracic Duct", D.D. McGregor and J.L. Gowans, *Journal of Experimental Medicine*, vol. 117 (1963), no. 2, 303-320.

303.1.1
Experimental procedures which deplete lymphoid tissue of small lymphocytes have provided circumstantial evidence that small lymphocytes play a part in primary immune responses.

303.1.4
The view that the immunological deficiency is due solely to a lack of small lymphocytes would be greatly strengthened if the unresponsiveness could be corrected by injections of small lymphocytes from normal animals.

303.2.1
Adult rats can be depleted of small lymphocytes by the chronic drainage of cells from a thoracic duct fistula, and they will still give a normal secondary antibody response.

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	303.1.1
M	Experimental procedures which cause
$C_y^g{\sim}W_i{\sim}T_{\ell'}$	small lymphocytes | depletion of | lymphoid tissues' ←
M	have provided circumstantial evidence that
$GJ^1{:}AV_p^rC_y^g{\sim}$	primary (injection) || (to) || play a part in immune responses | small lymphocytes ←
	303.1.4
M	The view would be greatly strengthened that
$AV{\sim}$	the immunological deficiency
$C_y^g{\sim}W_i{\sim}$	is due solely to || small lymphocytes | a lack of ←
$GJ^1B{:}AV{\sim}{\sim}$	if ||| (GJ^1B) || (to) || the unresponsiveness could be corrected ←
$C_y^g{\sim}I^{ft}B_d^wB$	by ||| of small lymphocytes | injections | from animals | (into animals)
$C^g{\sim}W^f{\sim}B_d$	WH ||| (are) normal | (animals) ←
	303.2.1
$C_y^g{\sim}W_i{\sim}B$	small lymphocytes | can be depleted of | adult rats ←
$CW^{fn}T_h$	by ||| of cells | the chronic drainage | from a thoracic duct fistula
$GJ^2{:}AVB$	, and still ||| secondary (injection) || (to) || will give a normal antibody response | they ←

303.2.2
In contrast, the present experiments have shown that the primary antibody response is severely depressed in such rats but that it can be restored by injecting small lymphocytes from other rats of the same highly inbred strain.

306.4.1
A single intraperitoneal injection of tetanus toxoid into a normal rat gave no response that could be measured by the tanned red cell hemagglutination technique.

306.4.2
The response to a second intravenous injection of toxoid was therefore taken as evidence of sensitization by the first injection.

306.5.1
Fig. 2 shows the response of 5 inbred rats which received a first injection of tetanus toxoid immediately after closure of the fistula.

	303.2.2
M	In contrast, the present experiments have shown that
GJ^{1}:$AV^{-}B^{w}$	primary (injection) || (to) || The antibody | response is severely depressed | in rats
$C_{y}^{g}{\sim}W_{i}{\sim}B$	WH ||| (small lymphocytes) | (are) (depleted of) | (rats) ←
GJ^{1}:$AV{\sim}{\sim}B^{w}$	but that ||| (primary injection) || (to) || The antibody | response which is severely depressed can be restored | (in rats)
$C_{y}^{g}{\sim}W_{i}{\sim}B$	WH ||| (small lymphocytes) | (depleted of) | (rats) ←
$C_{y}^{g}{\sim}I^{ft}B_{d}B$	by ||| small lymphocytes | being injected | from other rats of the same highly inbred strain | (into rats)
	306.4.1
$GJ^{1}B^{w}$:$AV{\sim}$	of tetanus toxoid | a single injection (which) | (is) intraperitoneal into a rat || gave || no response that could be measured by the tanned red cell hemagglutinin technique
$C_{y}^{g}{\sim}W^{f}{\sim}B$	WH ||| (is) normal | (rat) ←
	306.4.2
$GJ^{2}B$:AV	of toxoid | a second injection (which) | (is) intravenous || to ← || the response ←
GJ^{1}:$GU_{s}C$	was therefore taken as evidence of ||| the first injection || by || (the antigen) | sensitization (to) | (the cells') ←
	306.5.1
M	Fig. 2 shows
$GJ^{1}B$:AVB	tetanus toxoid | received a first injection of | (rats) || which || the response of 5 inbred rats ←
$C_{y}^{g}{\sim}W^{fs}T_{h}$	immediately after ||| (small lymphocyte) | (drainage ended with) closure of | the fistula

306.5.2
When these animals were challenged with tetanus toxoid 3 weeks later, they failed to show an antibody response that could be measured by the tanned red cell hemagglutination technique.

307.2.1
The effect of lymphocyte depletion on the secondary immune response was studied by injecting 2 inbred rats with a second injection of tetanus toxoid immediately after the closure of the thoracic duct fistula, the sensitizing injection having been given 3 weeks earlier.

307.2.2
These animals showed a brisk antibody response.

307.3.1
The hemolysin response to a single intravenous injection of 10^8 sheep erythrocytes became progressively smaller when the interval between cannulation and closure of the fistula was increased.

306.5.2

$GJ^2B:AV^{\sim}B$ three weeks later ||| tetanux toxoid | were challenged with | these animals || when || failed to show an antibody response that could be measured by the tanned red cell hemagglutinin technique | they ←

307.2.1

M The effect of

$C_yW_i^{\sim}$ lymphocyte | depletion

$GJ^2B:AVB$ on ||| secondary (injection) || (to) || the immune response ←

M was studied by

GJ^2B tetanus toxoid | being injected with a second injection of | 2 inbred rats ←

$C_yW^{fs}T_h$ immediately after ||| (lymphocyte) | (drainage ended following) the closure of | the thoracic duct fistula

GJ^1B , 3 weeks earlier ||| the sensitizing injection having been given

307.2.2

$GJ^2B:AV^{+}B$ (tetanux toxoid) | (second injection of) || (to) || antibody | showed a brisk response (of) | these animals ←

307.3.1

$GJ^1B:AV^{\downarrow b}B$ 10^8 sheep erythrocytes | single injection of | an intravenous || to ← || The hemolysin | response became progresively smaller

$C_yW^{fb}T_h$ when the interval was increased between ||| (lymphocyte) | (drainage beginning upon) cannulation (of) | (the fistula)

$C_yW^{fs}T_h$ and ||| (lymphocyte) | (drainage ending upon) closure of | the fistula

308.2.1
The chronic drainage of lymph and cells from the thoracic duct had no significant effect on the hemolysin response once antibody formation was initiated.

310.1.1
It was necessary to determine whether loss of lymphocytes alone was responsible for the immunological unresponsiveness which followed chronic drainage from the thoracic duct or whether other factors such as operative trauma and restraint played a part.

310.1.2
An attempt was therefore made to reverse the unresponsive state by injecting lymphocyte-depleted rats with thoracic duct cells from normal non-immunized rats of the same highly inbred strain.

	308.2.1
$T_{\ell'}CW^{fn}T_h$	of lymph and cells | the chronic drainage | from the thoracic duct
$GJ^1B{:}A^GVB$	had no significant effect on ||| (sheep erythrocytes) | (primary injection) || (to) || The hemolysin | response ←
AV_p^b	once ||| antibody | formation was initiated
	310.1.1
M	It was necessary to determine whether
$C_yW^fT_h$	lymphocytes | loss | (from the fistula)
GJB:AVB~	alone was responsible for ||| (GJB) || (to) || the immunological unresponsiveness ←
$T_{\ell'}CW^{fn}T_h$	which followed ||| (of lymph and cells) | chronic drainage | from the thoracic duct
M	or whether other factors such as operative trauma and restraint played a part
	310.1.2
M	An attempt was therefore made to
GJB:AV~~B	(GJB) || Reverse the unresponsive || state (of the animal)
$C^wI^{ft}B_d^wB^w$	by ||| cells | being injected from | rats of the same highly inbred strain | (into) rats
CW^fT_h	WH ||| (cells) | (drained from) | (the) thoracic duct
$C^g{\sim}W^f{\sim}B_d^w$	WH ||| (were) normal | (rats) ←
$GJ{\sim}B_d$	WH ||| (were) non-immunized | (rats) ←
$C_yW_i{\sim}B$	WH ||| lymphocytes | (were) depleted (of) | rats ←

310.3.1
Fig. 6 shows that the antibody response of lymphocyte-depleted rats was restored by living thoracic duct cells but not by disintegrated cells.

314.3.1
During the 5 days which followed cannulation of the thoracic duct in rats approximately 2.5 x 10^9 cells emerged from the fistula: about 90 per cent were typical small lymphocytes and the remainder were larger lymphocytes.

	310.3.1
M	Fig. 6 shows that
GJB:AV~ ~B^w	(GJB) || The antibody | response was restored | of rats
$C_yW_i^{\sim}B$	WH ||| lymphocyte | (were) depleted (of) | rats ←
C^wI^tB	by ||| living cells | (injected) | (intravenously into these rats)
$CW^fT_hB_d$	WH ||| (living cells) | (were drained from) | (the) thoracic duct (of rats)
GJB:AV~B^w	but ||| (GJB) || (to) || (The antibody response was) not (restored) | (of rats)
$C_yW_i^{\sim}B$	WH ||| (lymphocytes) | (were depleted of) | (rats)
$C^{dw}I^tB$	by ||| disintegrated cells | (injected) | (intravenously into these rats)
$C^dW^fT_hB_d$	WH ||| (disintegrated cells) | (were drained from) | (the thoracic duct of rats)
	314.3.1
CW^fT_h	cells | (in numbers which were) approximately 2.5 x 10^9 emerged | from the fistula
$CW^{fb}T_hB$	during the 5 days which followed ||| (cell) | (drainage beginning upon) cannulation of | the thoracic duct in rats
$CY^{>}{}^{>}C_y^{g\sim}$	: ||| (of these cells) | about 90% were | typical small lymphocytes
$CY^{-}C_y^g$	and ||| (of these cells) | the remainder were | larger lymphocytes

314.3.2
The present investigation showed that the loss of these cells from the fistula severely depressed or abolished the primary immune response of rats to a small dose of either tetanus toxoid or sheep erythrocytes.

314.3.3
The unresponsive state was related to the loss of cells because the inability to respond to sheep erythrocytes could be corrected by an injection of thoracic duct lymphocytes from normal, non-immunized rats.

314.3.4
Since it was corrected equally well by injecting suspensions of thoracic duct cells from which large lymphocytes had been virtually elimated, it is likely that the immunological unresponsiveness was due to a loss of small lymphocytes from the fistula.

	314.3.2
M	The present investigation showed that
$C_yW^fT_h$	these cells | loss | from the fistula
$GJ^1B{:}AV^{\downarrow+}B$	(caused) ||| a small dose of either tetanus toxoid or sheep erythrocytes | the primary (injection) of || to || the severe depression (of) the immune response | of rats ←
$GJ^1B{:}AV{\sim}B$	or (caused) ||| (a small dose of either tetanus toxoid or sheep erythrocytes) | (the primary injection of) || (to) || the abolition (of the immune response) | (of rats) ←
	314.3.3
$GJB{:}AV{\sim}B$	(GJB) || (to) || The unresponsive | state (of the rats)
$C_yW^fT_h$	was related to ||| cells | the loss of | (from the thoracic duct fistula) ←
$GJB{:}AV{\sim}{\sim}B$	because ||| sheep erythrocytes | (injection of) || to || the inability could be corrected to respond ←
$C_y^wI^tB$	by ||| of lymphocytes | an injection | (into the rat)
$C_yW^fT_hB_d^w$	WH ||| (lymphocytes) | (drained) from | (the) thoracic duct (of) rats
$C_yW^{f\sim}B_d^w$	WH ||| (were) normal | (rats) ←
$GJ{\sim}B_d$	WH ||| (were) non-immunized | (rats) ←
	314.3.4
$GJB{:}AV{\sim}{\sim}B$	Since ||| (GJB) || (to) || the unresponsive state was corrected equally well ←
C^wI^tB	by ||| suspensions of cells | being injected | (into rats)
CW^fT_h	WH ||| (suspension of cells) | (drained from) | (the) thoracic duct
$C_y^gY_i{\sim}C$	from which ||| large lymphocytes | had been virtually eliminated | (suspensions of cells) ←
M	, it is likely that
$GJB{:}AV{\sim}B$	(GJB) || (to) || the immunological unresponsiveness ←
$C_y^g{\sim}W^fT_h$	was due to ||| of small lymphocytes | a loss | from the fistula

316.2.4
Rats in which drainage from the thoracic duct was carried out 3 weeks after a first dose of tetanus toxoid and immediately before the second dose gave an antibody response which was, if anything, greater than normal.

316.2.5
The secondary response, unlike the primary response, is mediated by cells which cannot be withdrawn from lymphoid tissue by drainage from a thoracic duct fistula.

316.2.6
This does not mean that in the intact animal circulating lymphocytes play no part in secondary responses.

316.2.4

$GJB{:}AV^{>}B^{w}$	(GJB) || (to) || gave an antibody response which was, if anything, greater than normal | rats ←
$GJ^{1}B{:}_{t}CW^{f}T_{h}B$	in which ||| tetanus toxoid | a first dose of || 3 weeks after || (of cells) | drainage was carried out | from the thoracic duct | (rats) ←
$CW^{f}T_{h}B$	and (in which) ||| (of cells) | (drainage was carried out) | (from the thoracic duct) | (rats) ←
$GJ^{2}B$	immediately before ||| the second dose

316.2.5

$GJ^{2}{:}AV^{r}_{p}C^{w}$	secondary (injection) || (to) || mediate the response | cells ←
$CW^{f}{\sim}T_{\ell'}$	which ||| (cells) | cannot be withdrawn | from lymphoid tissue
$CW^{f}T_{h}$	by ||| (the cells) | being drained | from a thoracic duct fistula
$GJ^{1}{:}AV^{r}_{p}C^{w}$	, unlike ||| primary (injection) || (to) || (mediate) the response | cells ←
$CW^{f}T_{\ell'}$	WH ||| (cells) | (can be withdrawn) | (from lymphoid tissue)
$CW^{f}T_{h}$	(by) ||| (the cells) | (being drained) | (from a thoracic duct fistula)

316.2.6

M	This does not mean (it is not the case) that
$GJ^{2}B{:}AV^{r}_{p}C^{w}_{y}$	secondary (injection) || (to) || play a part in responses | lymphocytes ←
$C_{y}W_{i}T_{b}B^{w}$	WH ||| (lymphocytes) | (are) (present) | circulating in the animal
$C_{y}W^{f}{\sim}B$	WH ||| (is) intact | (animal) ←

316.2.7
Mitchell and Gowans found that a "secondary" response to diphtheria toxoid could be obtained in normal rats after a single dose of antigen if this was preceded by an injection of thoracic duct lymphocytes from primarily immunized donors.

316.2.8
Clearly some of the donors' lymphocytes (either large or small) had become specifically sensitized during primary immunization.

316.5.1
The present experiments have provided no information about the way in which small lymphocytes mediate primary responses.

317.1.1
One difficulty is that antibody is not produced by small lymphocytes but a line of cells which divides and differentiates to form plasma cells.

316.2.7

M	Mitchell and Gowans found that
$GJ^1B{:}A^GV^+B^w$	of antigen | a single dose | (into rats) || after || A "secondary" response to diptheria toxoid could be obtained | in rats
$CW^{f\sim}B$	WH ||| (are) normal | rats ←
GJ^1	if ||| antigen | a single dose of ←
$C_y^wI^tB$	was preceded by ||| of lymphocytes | an injection | (into rats)
$GJ^1B_d{:}C_yW^fT_hB_d$	WH ||| primarily immunized | (donors) || WH || (Lymphocytes) | (were) (drained) from | the thoracic duct of donors

316.2.8

$GJ^1B_d{:}GU_sC^{g,g\sim}B_d$	Clearly ||| primary immunization || during || had become specifically sensitized | some of the lymphocytes (either large or small) of the donor ←

316.5.1

M	The present experiments have provided no information about the way in which
$GJ^1{:}AV_p^rC_y^{g\sim}$	primary (injection) || (to) || mediate responses | small lymphocytes ←

317.1.1

M	One difficulty is that
$AV_p^{\sim}C_y^{g\sim}$	antibody | is not produced by | small lymphocytes
$AV_pC^{\not w}$	but ||| (antibody) | (is produced) | by a line of cells
$C^{\not}W_o$	which ||| (line of cells) | divides
$C^{\not}Y_c^tC_z$	and (which) ||| (line of cells) | differentiates to form | plasma cells

317.1.2
However, it is now clear that the small lymphocyte is not an "end" cell but that it can develop rapidly into a "large pyroninophilic cell" which divides and which resembles morphologically a plasma cell precursor.

317.1.5
Although there are strong grounds for supposing that small lymphocytes may be the ultimate precursors of antibody-forming cells it must be emphasized that this has not yet been unequivocally established.

317.2.1-2
The simplest hypothesis would be as follows. Primary immune responses are initiated by the interaction of small lymphocytes with antigen or possibly with antigen which has been "processed" by reticuloendothelial phagocytes.

317.2.3
The extensive studies of Harris could be interpreted in this way.

317.1.2

M	However, it is now clear that
$C_y^g \sim Y \sim C^w$	the small lymphocyte | is not (a cell)
$CY_c^t \sim C$	WH ||| cell | (is) an "end" | (cell) ←
$C_y^g \sim Y_c^{it} C_h^w$	but that ||| the small lymphocyte | can develop rapidly into | a "large pyroninophilic cell"
$C_h W_o$	which ||| ("large pyroninophilic cell") | divides
$C_h Y C^w$	and which ||| ("large pyroninophilic cell") | resembles morphologically | (a cell)
$C_z Y_c^t C$	WH ||| plasma cells | (is) a precursor | (cell) ←

317.1.5

M	Although there are strong grounds for supposing that
$C^w Y_c^t C_y^g \sim$	cells | may be ultimate precursors of | small lymphocytes ←
$AV_p C$	WH ||| antibody | form | (cells) ←
M	it must be emphasized that this has not yet been unequivocably established

317.2.1-2

M	The simplest hypothesis would be as follows.
$GU_s^t C_y^g \sim$	antigen | interaction with | small lymphocytes' ←
$G^w U_s^t C_y^g \sim$	or possibly ||| antigen | (interaction) with (small lymphocytes) ←
$GU^u C_g$	which ||| (antigen) | has been "processed" | by reticuloendothelial phagocytes
$GJ^1{:}AV^b$	(causes) ||| primary (injection) || (to) || Initiation of immune responses

317.2.3

M	The extensive studies of Harris could be interpreted in this way

317.2.4
After contact with antigen the small lymphocytes become fixed in lymphoid tissue and no longer circulate between blood and lymph; thus, drainage from the thoracic duct immediately after the administration of antigen does not affect the primary response.

317.2.5
In the lymphoid tissue the fixed lymphocytes enlarge and give rise to a dividing cell line which perpetuates itself and produces a small number of plasma cells.

317.2.6
In the secondary response further contact with antigen greatly increases the rate at which the dividing cells produce plasma cells.

317.2.7
The precise location of the dividing cells within the lymph nodes has not been determined.

	317.2.4
$GU_s^tC_y^g{\sim}:C_y^g{\sim}W_iT_{\ell'}$	antigen | contact with | (the small lymphocytes') || after ← || the small lymphocytes | become fixed in | lymphoid tissue
$C_y^g{\sim}W_u^{ft}{\sim}T_{b,}T_\ell$	and ||| (the small lymphocytes) | no longer circulate between | blood and lymph
$GJ{:}^eC_y^g{\sim}W^fT_h$	; thus ||| antigen | the administration of || immediately after || (Small lymphocytes') | drainage from | the thoracic duct
$GJ^1{:}AV$	does not affect ||| primary (injection) || (to) || the response ←
	317.2.5
$C_y^wW_g$	the lymphocytes | enlarge
$C_yW_iT_{\ell'}$	WH ||| (lymphocytes) | (are) fixed | in the lymphoid tissue
$C_yY_c^tC^{w\ell w}$	and ||| (the lymphocytes) | give rise to | a line of cells
CW_o	WH ||| (cells) | (are) dividing
$C'W_p$	which ||| (line of cells) | perpetuates itself
$C'Y_c^tC_z^-$	and (which) ||| (line of cells) | produces | a small number of plasma cells
	317.2.6
$GU_s^{2t}C{:}C^wY_c^{o\uparrow+t}C_z$	with antigen | further contact | (by the cells) ← || (causes) || the cells | to produce at a greatly increased rate | plasma cells
CW_o	WH ||| (cells) | (are) dividing
$GJ^2{:}AV$	in ||| secondary (injection) || (to) || the response ←
	317.2.7
$C^wW_iT_n$	of the cells | the precise location within | the lymph nodes
CW_o	WH ||| (cells) | (are) dividing
M	has not been determined

317.2.8
Aggregates of them may possibly constitute germinal centers which, during secondary responses, either synthesize antibody or generate antibody-forming cells.

317.3.1
These speculations rest on the assumption that small lymphocytes participate in primary responses by generating the cells which eventually synthesize antibody.

317.3.2
If this assumption is false then the only alternative is that small lymphocytes transfer some antigen-conditioned material to other cell types.

317.3.3
There are only the vaguest precedents for such a mechanism.

	317.2.8
$C^{w}W_{p}T_{r}^{w}$	of the cells | aggregates may possibly constitute | germinal centers
CW_{o}	WH ||| (cells) | (are) dividing
$GJ^{2}{:}AV_{p}T_{r}$	which, either ||| secondary (injection,) ||, during the responses to || antibody | synthesize | (germinal centers) ←
$GJ^{2}{:}C^{w}W_{p}T_{r}$	or ||| (secondary injection,) || (, during the responses to) || cells | generate | (germinal centers) ←
$AV_{p}C$	WH ||| antibody | forming | (cells)
	317.3.1
M	These speculations rest on the assumption that
$GJ^{1}{:}AV_{p}^{r}C_{y}^{g}{\sim}$	primary (injection) || (to) || participate in responses | small lymphocytes ←
$C_{y}^{g}{\sim}Y_{c}^{t}C^{w}$	by ||| (small lymphocytes) | generating | the cells
$AV_{p}C$	which ||| antibody | eventually synthesize | (cells)
	317.3.2
M	If this assumption is false then the only alternative is that
$A_{a}^{w}V_{u}^{ft}C_{y}^{g}{\sim}C$	some material | is transferred | (by) small lymphocytes | to other cell types
$G{:}A_{a}$	WH ||| antigen || (is) conditioned (to) || (material)
	317.3.3
M	There are only the vaguest precedents for such a mechanism

"Electron Microscopic Observations on Antibody-Producing Lymph Node Cells" by T.N. Harris, Klaus Hummeler, and Susanna Harris, *The Journal of Experimental Medicine*, vol 123, 1966, 161-172.

161.1.1
The direct demonstration by McMaster and Hudack of the production of antibody in lymph nodes led to a long search for the cell in the lymph node which synthesized antibody.

161.2.1
The culmination, in 1955, of this decade and a half of intensive research was the actual finding of antibody within plasma cells, by Coons and his colleagues, using the indirect fluorescent antibody technique.

161.2.2
These cells were found in antibody-producing lymph nodes; antibody-containing plasma cells were soon also found in other situations, i.e., in sites of deposition of transferred lymph node cells, by Dixon and his colleagues, and in chambers containing antigen-stimulated lymph node cells, by several groups of workers.

Paper 11

	161.1.1
M	The direct demonstration by McMaster and Hudack of
AV_pT_n	antibody | production | in lymph nodes
M	led to a long search for
AV_pC^w	antibody | synthesized | the cell which ←
CW_iT_n	WH ||| (cell) | (is) in | the lymph node
	161.2.1
M	The culmination, in 1955, of this decade and a half of intensive research was the actual finding, by Coons and his colleagues, using the indirect fluorescent antibody technique, of
AV_iC_z	antibody | within | plasma cells
	161.2.2
$C_z^wW_iT_n^w$	these (plasma) cells | were found in | lymph nodes
AV_iC_z	WH ||| antibody | contain | (plasma cells) ←
AV_pT_n	WH ||| antibody | (were) producing | (lymph-nodes) ←
$C_z^wW_iT_{n\sim}$	; soon also ||| plasma cells | were found in | other situations
AV_iC_z	WH ||| antibody | contain | (plasma cells) ←
$C_zW_iT^w$	, i.e., ||| (plasma cells) | (were found) in | sites
$C^wW_u^tT$	WH ||| cells | (were) of deposition of | (sites) ←
$CW_u^fT_n$	WH ||| (cells) | transferred (from) | lymph nodes
M	, by Dixon and his colleagues,
$C_z^wW_iT^w$	and ||| (plasma cells) | (were found) in | chambers
AV_iC_z	WH ||| (antibody) | (contain) | (plasma cells) ←
C^wW_iT	WH ||| cells | containing | (chambers) ←
GU_sC^w	WH ||| antigen | stimulated (by) | (cells) ←
CW_iT_n	WH ||| (cells) | (were) of | lymph nodes
M	, by several groups of workers

161.2.3
Also supporting this association was the observation of Nossal, in single cell preparations from active lymph nodes, that virtually all the cells which were identified as antibody-producing were plasma cells.

161.3.1
More recently, however, a number of reported observations have again given direct evidence of a role of the lymphocyte in antibody formation.

161.3.2
In single cell droplet studies which involved a more sensitive antibody assay than that of Nossal, Attardi, Cohn, Horibata and Lennox found lymphocytes among the antibody-forming cells, the frequency of antibody-producing cells among the lymphocytes found being roughly one-third that found among plasma cells.

	161.2.3
M	Also supporting this association was the observation of Nossal, in
$C^1W_{/}^{f}T_n^a$	single cell | preparations | from active lymph nodes
$C^wY^{>>}C_z$	, that ||| (of) the cells | virtually all were | plasma cells
CYC^w	which ||| (cells) | were identified as | cells
AV_pC	WH ||| antibody | (were) producing | (cells) ←
	161.3.1
M	More recently, however, a number of reported observations have again given direct evidence of
$AV_p^rC_y$	antibody | having a role in formation of | the lymphocyte ←
	161.3.2
M	In single-cell droplet studies which involved a more sensitive antibody assay than that of Nossal, Attardi, Cohen, Horibata, and Lennox found
$C_yY_iC^w$	lymphocytes | among | the cells
AV_pC	WH ||| antibody | (are) forming | (cells) ←
$C^wY_i^{<<}C_y^w$	, ||| of cells | the frequency being roughly one-third among | the lymphocytes
AV_pC	WH ||| antibody | (are) producing | (cells) ←
C_yW_i	WH ||| (lymphocytes) | (were) found
$C^wY_iC_z$	of ||| of cells | the frequency found among | plasma cells
AV_pC	WH ||| antibody | (are) producing | (cells) ←

162.2.1
Since it is difficult to ascertain the amount or concentration of antibody necessary for its detection in a cell by the indirect fluorescent antibody technique, the small number of cells thus identified in active lymph nodes following primary stimulation raised the question of whether only the most active antibody-synthesizing cells were selected by the immunofluorescent technique.

162.2.5
It was, therefore, desirable to examine antibody-producing cells at some stages between the induction of antibody formation by immunocompetent cells and the presence of completed antibody in such cells in an amount necessary for detection by immunofluorescence.

162.2.6
An opportunity for such a study was offered by the recent descriptions by Jerne and Nordein, and by Ingraham and Bussard of a method for detecting single cells which have produced antibody in vitro.

	162.2.1
M	Since it is difficult to ascertain by the indirect fluorescent antibody technique
AV_iC	of antibody | the amount or concentration necessary for its detection in | a cell
$GJ^1{:}C^wW_i^-T_n^a$	, ||| primary stimulation || following ← || of cells | the small number (present) in | active lymph nodes
CYC^w	WH ||| (cells) | identified (as) | (cells)
AV_iC	WH ||| (antibody) | (containing) | (cells) ←
M	raised the question of whether
$AV_p^{>>}C$	antibody | most actively synthesizing | only the cells ←
M	were selected by the immunoflourescent technique
	162.2.5
M	It was, therefore, desirable to examine
AV_pC	antibody | -producing | cells
$AV_p^bC^w$	at some stages between ||| of antibody | the induction of formation | by cells
AV_p^cC	WH ||| (are) immunocompetent | (cells) ←
$A^wV_iC^w$	and ||| of antibody | the presence in an amount necessary for detection by immunofluorescence in | cells
AV_p	WH ||| (antibody) | (is) completed
AV_p^cC	WH ||| (are) immunocompetent | (cells) ←
	162.2.6
M	An opportunity for such a study was offered by the recent descriptions by Jerne and Nordin, and by Ingraham and Bussard of a method for detecting
$AV_p^vC^1$	antibody | have produced *in vitro* | single cells which ←

163.3.1-2
In the eight experiments which yielded cells for electron microscopic study in this experiment, 2 or 3 rabbits were given a single injection of sheep erythrocytes (0.2 ml of a 50% suspension) in each hind foot-pad. After 4 days the popliteal lymph nodes were excised and teased as described above, and the pooled cell suspension was used for plating.

163.3.3
In such pooled suspensions, the yield of cells per lymph node was in the range of 285 to 480 million.

163.3.4
Such cell suspensions were examined for the number of plaque-producing cells by plating 0.6 ml volumes, as described above, at five successive two-fold dilutions, between 200 and 3200.

163.3.5
Plaque-producing cells were found in these experiments in the range of 1 per 4400 cells to 1 per 12,600 cells.

164.3.1
Two classes of cells, with distinct morphological features, were found to produce hemolysis after a single injection of sheep erythrocytes.

164.3.2
The cells were in the category either of lymphocytes or of plasma cells.

163.3.1-2

M
In the eight experiments which yielded cells for electron microscopic study in this experiment,

$GJ^{1}B:_{t}T^{B}_{n}W_{\ell}$
sheep erythrocytes | were given a single injection (0.2 ml of a 50% suspension) of | in each hind foot-pad 2 or 3 rabbits ← || and after 4 days || the popliteal lymph nodes | were excised and teased as described above,

$T^{s}_{n}W_{\ell}$
, and ||| the pooled cell suspension | was used for plating

163.3.3

$CW_{i}T^{s}_{n}$
of cells | the yield was in the range of 285 to 480 million | per lymph node in such pooled suspensions

163.3.4

$C^{w}W_{i}T^{s}_{n}$
cells | were examined for the number (present) of | such cell suspensions ←

$A_{q}V_{p}C$
WH ||| plaques | (were) producing | (cells) ←

M
by plating 0.6 ml volumes, as described above, at five successive two-fold dilutions, between 200 and 3200

163.3.5

M
In these experiments

$C^{w}W_{i}T^{s}_{n}$
cells | were found in the range of 1 per 4400 cells to 1 per 12,600 cells (in) | (the suspensions)

$A_{q}V_{p}C$
WH ||| plaques | (were) producing | (cells) ←

164.3.1

$GJ^{1}:A^{G}V_{p}C'C'$
sheep erythrocytes | a single injection of || after || hemolysis | were found to produce | two classes of cells, with distinct morphological features, ←

164.3.2

$CYC^{\ell}_{y}C^{\ell}_{z}$
the cells | were in | the category of either lymphocytes or (the category) of plasma cells

164.4.3
The lymphocytes contained some morphological features both of the small lymphocyte and the lymphoblast, according to the current terminology.

164.4.4
The eccentric nucleus showed deep indentations, with the chromatin in part condensed.

164.4.5
Most of the cells had a relatively large and honeycombed nucleolus, which is illustrated in Fig. 4.

164.4.6
The cytoplasm was fine and granular, with most organelles confined to the larger pole of the cell.

164.4.7
The number of small mitochrondria varied greatly, the larger lymphocytes containing a greater number of mitochondria than the smaller ones, even in relation to their size.

164.4.8
A Golgi apparatus was usually present but it was small, with few smooth vesicles.

	164.4.3
$C_yYC_y^{g\sim}, C_y^b$	the lymphocytes | contained some morphological features both of | the small lymphocyte and of the lymphoblast,
M	according to the current terminology
	164.4.4
$S_nC_yW_e$	the nucleus (which) | (was) eccentric showed deep indentations
$S_tW_i\bar{S}_nC_y$	, with ||| the chromatin | in part condensed (in) | (the nucleus of these lymphocytes)
	164.4.5
$C_y^{>} > S_uW_g$	most of the cells had a nucleolus (which) | (was) relatively large and honeycombed
M	, which is illustrated in Fig. 4
	164.4.6
$S_cC_yW_n$	the cytoplasm | was fine and granular, with most organelles confined to the larger pole of the cell
	164.4.7
$S_m^{g\sim}W_i^{A+}C_y$	of small mitochrondria | the number varied greatly (in) | (the lymphocytes)
$S_mW_i^{>}C_y^g$	, ||| mitochrondria | containing, even in relation to their size, a greater number of | the larger lymphocytes ←
$S_mW_iC_y^{g\sim}$	than ||| (of mitochrondria) | (the number contained in) | the smaller ones
	164.4.8
$S_gW_iC_y$	usually ||| a Golgi apparatus | was present | (in the lymphocytes)
$S_g^wC_yW_{g\sim}$	but ||| the Golgi apparatus | was small
$S_vW_i\bar{S}_gC_y$	, WH ||| smooth vesicles | (was) with few | (the Golgi apparatus) ←

164.5.1
The most interesting feature in these antibody-producing lymphocytes was the rough endoplasmic reticulum.

164.5.2
In the smaller lymphocytes a small amount of endoplasmic reticulum was found, as has been described in the recent literature.

164.5.3
This was sparse and was consistently widened.

164.5.4
The resulting vaucoles, ringed with ribosomes, were partially filled with a grayish, granular material.

164.5.5
In the larger lymphocytes, however, endoplasmic reticulum of a different form was also found, in relative abundance.

164.5.6
The channels were narrow.

	164.5.1
M	The most interesting feature was
$C_y^w S_r W_r$	in these lymphocytes the endoplasmic reticulum (which) | (was) rough
AV_pC_y	WH ||| antibody | (were) producing | (lymphocytes) ←
	164.5.2
M	As has been described in the recent literature,
$S_rW_i^-C_y^{g\sim}$	of endoplasmic reticulum | a small amount was found in | the smaller lymphocytes
	164.5.3
$S_rC_y^{g\sim}W_w$	this endoplasmic reticulum in the smaller lymphocytes | was sparse, and was consistently widened
	164.5.4
$A_aV_i^-S_v^wS_rC_y^{g\sim}$	a grayish, granular material | were partially filled with | the resulting vacuoles (in the endoplasmic reticulum of the smaller lymphocytes) ←
$S_bW_iS_v^-S_rC_y^{g\sim}$	WH ||| ribosomes | ringed with | (vacuoles in the endoplasmic reticulum of the smaller lymphocytes) ←
	164.5.5
$S_r^wW_i^+C_y^g$	also, however, ||| endoplasmic reticulum | was found, in relative abundance, in | the larger lymphocytes
$S_rC_y^gW_{r\sim,w\sim}$	WH ||| (endoplasmic reticulum) | (was) of a different form
	164.5.6
$S_r^hC_y^gW_{w\sim}$	the channels (of endoplasmic reticulum) | were narrow

165.1.1
Short pieces were observed, cut longitudinally, with apparently random orientation.

165.1.2
No organization into lamellae was apparent.

165.2.1
While the lymphocytes exhibited a certain morphological unity, differing primarily in size and in degree of cytoplasmic organization, the plasma cells showed considerable pleomorphism.

165.2.4
The plasma cells were found in several forms, which may represent various stages of development, especially in view of the appearance of the endoplasmic reticulum in these cells.

165.2.5
All of the cells in this group were characterized by a well developed and flattened endoplasmic reticulum, a distinct Golgi apparatus, and a round nucleus with evenly dispersed chromatin.

165.1.1

$S_r^h C_y^g W_{y\sim}$ of the channels of endoplasmic reticulum | short pieces were observed, cut longitudinally, with apparently random orientation

165.1.2

$S_r^h C_y^g W_{y\sim}$ (of the channels of endoplasmic reticulum) | no organization into lamellae was apparent

165.2.1

$C_y W_c^-$ While ||| the lymphocytes | exhibited a certain morphological unity

$C_y W_g^\Delta$, ||| (the lymphocytes) | differing primarily in size

$S_c C_y W_c^\Delta$ and ||| in their cytoplasm (the lymphocytes) | (differing primarily) in degree of organization

$C_z W_c^+$, ||| the plasma cells | showed considerable pleomorphism

165.2.4

$C_z Y C^{\Delta w}$ the plasma cells | were found in | several forms

$C^\Delta Y C^w$, which ||| (several forms) | may represent | (cells)

$C W_c^\Delta$ WH ||| (cells) | (are in) various stages of development

$S_r C_z W$ especially in view of ||| the endoplasmic reticulum in these cells | the appearance of ←

165.2.5

$C_z' S_r W_c^+$ all of the cells in this group were characterized by an endoplasmic reticulum (which) | (was) well developed

$C' S_r W_{w\sim}$ and ||| (all of the cells in this group were characterized by an endoplasmic reticulum which) | (was) flattened

$C_z' S_g W_m$, ||| (all of the cells in this group were characterized by) a Golgi apparatus (which) | (was) distinct

$C_z' S_n W_{e\sim}$, and ||| (all of the cells of this group were characterized by) a nucleus (which) | (was) round with evenly dispersed chromatin

165.2.6
Their size varied from 6 to 9 M.

165.7.1
The observations reported here indicate that cells which are clearly shown to have produced antibody include both plasma cells and lymphocytes.

165.7.2
That cells of the morphologic classification of plasma cells can synthesize antibody is well accepted in the current literature.

165.7.3
However, in the case of the lymphocyte, also, there has been recorded evidence that these cells can produce antibody.

165.7.4
Evidence that a function of the lymphocyte is the synthesis of antibody was originally presented in the 1940's, in cells of lymph node and spleen, in the mouse and rabbit, and with cellular, bacterial, and viral antigens.

	165.2.6
$C_z^{\checkmark}W_g^{\Delta}$	their | size varied from 6 to 9 M
	165.7.1
M	The observations reported here indicate that
$C^wY_iC_z{\cdot}C_y$	cells | include |both plasma cells and lymphocytes
AV_pC	which ||| antibody | are clearly shown to have produced | (cells)←
	165.7.2
AV_pC^w	that ||| antibody | can synthesize | cells ←
CYC_z	WH ||| (cells) | (are) of the morphological classification of | plasma cells
M	is well accepted in the current literature
	165.7.3
M	However, in the case of the lymphocyte, also, there has been recorded evidence that
AV_pC_y	antibody | can produce | these cells ←
	165.7.4
M	Evidence was originally presented in the 1940's that
$AV_p^rC_y^w$	antibody | a function is the synthesis of | of the lymphocyte←
$C_yY_iC^w$	WH ||| (lymphocytes) | (are) in | cells
$GJB{:}CW_iT_{n's}^B$	WH ||| cellular, bacterial, and viral antigens | (injected into) | (the mouse and rabbit) || and with ← || (Cells) (are) of | lymph node and spleen, in the mouse and rabbit

165.7.5
Subsequently, however, in view of the evidence for the plasma cell as a source of antibody, culminating in the finding of antibody within the plasma cell, the emerging descriptions of these two cell types by electron microscopy gave rise to a generally accepted view that the synthesis of antibody could be expected in the plasma cell, with its well developed endoplasmic reticulum and associated organelles, but not in the lymphocyte, with its paucity of cytoplasmic differentiation.

166.2.1
In the lymphocytes found as single cells in the center of plaques in this study, however, there were definitely more of the structural units generally associated with synthetic functions than have been described thus far for the small lymphocyte; Golgi bodies, nucleoli, and the short channels of endoplasmic reticulum.

	165.7.5
M	Subsequently, however, in view of the evidence for
AV_pC_z	antibody | as a source of | the plasma cell←
M	, culminating in the finding of
AV_iC_z	antibody | within | the plasma cell
M	, the emerging descriptions of these two cell types by electron microscopy gave rise to a generally accepted view that
AV_pC_z	of antibody | the synthesis could be expected | in the plasma cell
$C_zS_rW_c^+$	, with ||| its endoplasmic reticulum (which) | (is) well developed
SW_iC_z	and (with) ||| organelles | associated | (its) ←
$AV_p^{\sim}C_y$	but ||| (antibody) | (synthesis could) not (be expected) | in the lymphocyte
$C_yS_cW_c^-$	, with ||| its cytoplasm | having paucity of differentiation
	166.2.1
$S^wW_i^{>}C_y^w$	in this study, however, ||| of the structural units | there were definitely more in | the lymphocytes
$A_pV_p^rS$	WH ||| (are) generally associated with synthetic functions | (structural units) ←
$A_qV_pC_y^l$	WH ||| plaques | in the center of | (lymphocytes) found as single cells ←
$SW_iC_y^{g\sim}$	than ||| (of the structural units) | (the quantities that) have been described thus far for | the small lymphocytes
$SYS_g{,}S_n{,}S_r^h$	; ||| (the structural units) | (are) | Golgi bodies, nucleoli, and the short channels of endoplasmic reticulum.

166.2.2
The significance of these structures for antibody synthesis in these cells is borne out by the fact that they were not found in the lymphocytes examined which were at the edges of plaques, and which were, therefore, not producing the antibody.

166.4.1
The observations on the antibody-synthesizing lymphocytes are also of interest in relation to the protein-synthetic mechanism of the mammalian cell.

166.4.2
Although many of the ribosomes of the lymphocytes were found lining the scattered channels of apparently developing endoplasmic reticulum, the substantial majority appeared to be free in the cytoplasm.

166.4.3
Thus it may be that this represents an instance in mammalian cells of a secreted protein synthesized by ribosomes not bordering an organized endoplasmic reticulum.

	166.2.2
$AV_p^rS^w$	antibody | the significance for the synthesis of | of these structures ←
$SW_iC_y^g{\sim}$	WH ||| (structures) | (are) (present) in | these cells
M	is borne out by the fact that
$SW_i{\sim}C_y^w$	they | were not found in | the lymphocytes examined
$A_qV_p{\sim}C_y$	which ||| plaques | were at the edges of | (lymphocytes) ←
$AV_p{\sim}C_y$	, and, therefore, which ||| the antibody | were not producing | (lymphocytes) ←
	166.4.1
M	The observations on
AV_pC_y	antibody | synthesizing | the lymphocytes ←
M	are also of interest in relation to
A_pV_pSC	protein | synthesizes | the mechanism of the mammalian cell (which) ←
	166.4.2
$S_bC_yW_i^+S_r^{wh}$	Although ||| of the ribosomes of the lymphocytes | many were found lining | the scattered channels of endoplasmic reticulum
$S_rC_yW_c$	WH ||| (endoplasmic reticulum) | | (was) apparently developing
$S_bC_yW_i{\geq}S_c$	, ||| (of the ribosomes of the lymphocytes) | the substantial majority appeared to be free in | the cytoplasm
	166.4.3
M	Thus it may be that this represents an instance of
$A_p^wV_pS_b^wC$	a protein | synthesized by | ribosomes in mammalian cells
A_pV_s	WH ||| (protein) | (is) secreted
$S_bW_i{\sim}S_r^hC$	WH ||| (ribosomes) | (are) not bordering | an organized endoplasmic reticulum

167.1.1
The effectiveness of these free ribosomes in the synthesis of secreted protein is indicated by the fact that thus far no association has been observed between the size of the plaque and the development of endoplasmic reticulum in the cell.

167.1.3
The fact that single cell plaques selected on a basis of maximum clarity contained a lymphocyte or a plasma cell with roughly equal frequency suggests that the cells of the two cytologic classes do not differ widely in their rate of secretion of antibody to the external medium.

167.1.4
Rather, the plasma cell appears to represent a cell type or a stage of development in which the cell synthesizes antibody at a higher rate but stores some of it within its endopalsmic reticulum until disintegration of the cell releases this additional antibody.

	167.1.1
$A_p^w V_p^r S_b S_c$	protein | the effectiveness in the synthesis of | of these ribosomes (which are) free (in the cytoplasm) ←
$A_p V_s$	WH ||| (protein) | (is) secreted
M	is indicated by the fact that thus far no association has been observed between
$A_q V_p$	the plaque | the size of ←
$S_r C W_c$	and ||| endoplasmic reticulum in the cell | the development of ←
	167.1.3
M	The fact that
$A_q^w V_p C_y$	plaques selected on a basis of maximum clarity | contained | a lymphocyte
$A_q V_p C^1$	WH ||| (plaques) | (were) of | single cells
$A_q V_p C_z$	or with roughly equal frequency ||| (the plaques) | (contained) | a plasma cell
M	suggests that
$AV_s^o C_y'$	of antibody | in their rate of secretion to the external medium | the cells of the lymphocytic class ←
$AV_s^o C_z'$	do not differ widely (from) ||| (of antibody) | (in their rate of secretion to the external medium) | the cells of the plasmacytic class ←
	167.1.4
$C_z Y C', C^c$	Rather, ||| the plasma cell | appears to represent | a cell type or a stage of development
$AV_p^{o>} C$	in which ||| antibody | synthesizes at a higher rate | the cell ←
$AV_t S_r C$	but ||| the antibody | stores some of | within its endoplasmic reticulum (the cell) ←
CW_d	until ||| the cell | disintegration of ←
AV_s	(causes) ||| this additional antibody | release of ←

167.2.1
The evidence for secretion of antibody by active lymphocytes, with morphological evidence of activity of the cell at the end of a period of such secretion, confirms the results of the ingenious double labelling experiments by Helmreich, Kern, and Eisen which led to the conclusion that in active lymph node cells antibody is produced by a continuous secretory process and that the cell may still be active after a period of secretion of antibody.

167.5.1
The finding of these diverse cell types, lymphocytes larger and smaller, with endoplasmic reticulum of apparently different kinds or of different degrees of development, and plasma cells with different amounts of endoplasmic reticulum, raises the question of whether there are, in fact, two different cell lines which produce antibody or whether all of these forms may represent different stages of development of a single cell line.

167.2.1

M	The evidence for
$AV_sC_y^a$	of antibody | secretion by | active lymphocytes
CW_a	, with ||| the cell | morphological evidence of activity of ←
AV_sC	at the end of a period of ||| antibody | secretion | by the cell
M	, confirms the results of the ingenious double labeling experiments by Helmreich, Kern, and Eisen which led to the conclusion that
AV_pC^a	antibody | is produced in | active cells
$C^aW_iT_n$	WH ||| (active cells) | (are) of | lymph nodes
AV_s^n	by ||| a continuous secretory process
CW_a^n	and that ||| the cell | may still be active
AV_s	after a period of ||| antibody | secretion of ←

167.5.1

M	The finding of
$AV_pC_y^g{,}C_y^{g\sim}$	(antibody) | (are producing) | these diverse cell types, lymphocytes larger and smaller, ←
$C_y^g{,}C_y^{g\sim}S_rW_c^{\Delta}$	, WH ||| (lymphocytes, larger and smaller,) | (are) with endoplasmic reticulum | of apparently different kinds or of different degrees of development
$AV_pC_z^w$	, and ||| (antibody) | (are producing) | plasma cells (which) ←
$S_rW_i^{\Delta}C_z$	WH ||| endoplasmic reticulum | (are) with different amounts of | (plasma cells) ←
M	, raises the question of whether, in fact,
$AV_pC^{\mathcal{A}1},C^{\mathcal{A}2}$	antibody | produce | there are two different cell lines which ←
$C^{\mathcal{A}1},C^{\mathcal{A}2}YC^w$	or whether ||| all of these forms | may represent | (cells)
CW_c^{Δ}	WH ||| (cells) | (are in) different stages of development
$CYC^{\mathcal{A}1}$	WH ||| (cells) | (are) of | a single cell line

168.1.3
In the present study a group of cells selected by their activity in the synthesis of this 19S antibody have shown pleomorphism of both kinds of cell, and a progression of development of endoplasmic reticulum through a series of cell forms which includes both lymphocytes and plasma cells.

168.1.4
These observations suggest that such developmental change of the small lymphocyte can, in fact, occur, as this cell, in its remarkable response to a stimulus for rapid synthesis of a special protein, develops a synthetic apparatus before producing the protein itself.

168.1.3

M	In the present study
$C^{w}YC^{\prime}_{y},C^{\prime}_{z}$	a group of cells | have shown pleomorphism of | both kinds of cell
$AV^{+}_{p}C$	WH ||| this 19S antibody | (were) selected by their activity in the synthesis of | (group of cells) ←
$CY^{wy}_{c}C^{\prime w}$	, and ||| (a group of cells) | (have shown) a progression of development through | a series of cell forms
$S_{r}CW_{c}$	WH ||| (is) of (the) endoplasmic reticulum | (progression of development) ←
$C^{\prime}Y_{i}C_{y},C_{z}$	which ||| (series of cell forms) | includes | both lymphocytes and plasma cells

168.1.4

M	These observations suggest that, in fact,
$S_{r}C^{g}_{y}{\sim}W_{c}$	in the endoplasmic reticulum of the small lymphocytes | developmental change can occur ←
$S^{w}W_{c}C^{g}_{y}{\sim}$	as ||| an apparatus | develops | this cell ←
$A_{p}V_{p}S$	WH ||| (protein) | for synthesis (of) | (apparatus) ←
$A_{p}V_{p}C^{g}_{y}{\sim}$	before ||| the protein itself | producing | (this cell) ←
$GJ^{w}{:}AVC^{g}_{y}{\sim}$	, in ||| a stimulus || to || remarkable response | this cell's ←
$GJ{:}A^{G}_{p}V^{i}_{p}$	WH ||| (stimulus) || (is) for || a special protein's | rapid synthesis|

"Ultrastructural Localization of Antibody in Differentiating Plasma Cells", Elizabeth H. Leduc, Stratis Avrameas, and Michel Bouteille, *Journal of Experimental Medicine*, vol. 127 (1968), 109-118.

109.2.3
Horseradish peroxidase was employed as an antigen to hyperimmunize rabbits and to trace the distribution of the antibody to peroxidase in differentiating plasma cells, from the earliest appearance of antibody in hemocytoblasts 2 days after the booster injection of antigen through its accumulation in well-developed plasma cells 3-5 days after injection.

112.3.1
As was described by light microscopy, utilizing a variety of techniques, the most primitive cell to contain antibody is the hemocytoblast, a cell characterized by its large electron-lucent nucleus, extensive and complex nucleolus, and cytoplasm rich in free ribosomes but poor in ergastoplasmic lamellae.

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	109.2.3
$GJ^{3}B$	as an antigen horseradish peroxidase | was employed to hyperimmunize | rabbits
$GJ{:}A^{G}V_{i}C_{z}^{c}$	and ||| (as an antigen horseradish peroxidase) | (was employed) || to trace || of the antibody to peroxidase | the distribution in | differentiating plasma cells
$GJ^{3}{:}_{t}AV_{i}^{e>>}C_{b}$	, from ||| antigen | the booster injection of || 2 days after ← || Of antibody | the earliest appearance in | hemocytoblasts
$GJ^{3}{:}_{t}AV_{i}^{\uparrow}C_{z}^{m}$	through ||| (antigen) | (the booster) injection (of) || 3 to 5 days after ← || Antibody's | accumulation in | well-developed plasma cells
	112.3.1
M	As was described by light microscopy, utilizing a variety of techniques,
$C^{w}YC_{b}$	the cell | is | the hemocytoblast
CYC^{w}	WH ||| (cell) | (is of) | (the cells)
$AV_{i}C$	WH ||| antibody | to contain | (cells) ←
$CW_{m\sim}^{>>}$	WH ||| (cell) | (is) most primitive
$C_{b}S_{n}W_{q\sim,g}$	, ||| a cell characterized by its nucleus | which is electron-lucent, which is large
$C_{b}S_{u}W_{g,c}^{+}$	, ||| (a cell characterized by its) nucleolus | which is extensive and complex
$S_{b}W_{i}^{+}C_{b}S_{c}$	, ||| free ribosomes | rich in (numbers of) | (a cell characterized by its) cytoplasm (which is) ←
$S_{r}^{y}W_{i}^{-}C_{b}S_{c}$	but ||| ergastoplasmic lamellae | poor in (contents of) | (a cell characterized by its cytoplasm which is) ←

112.3.2
The antibody is present primarily in the perinuclear space; this seems to be the initial site of antibody synthesis.

112.3.3
The rare ergastoplasmic cisternae in this cell sometimes also contain antibody, but often do not.

112.3.4
The Golgi apparatus even in these early blast cells, may be filled with the reaction product.

112.4.1
The subsequent differentiation of these cells is characterized primarily by the gradual development of the ergastoplasm or ribosome-associated endoplasmic reticulum.

	112.3.2
$AV_i^{>} S_pC_b$	the antibody | is present primarily in | the perinuclear space
$AV_p^bS_pC_b$	; ||| antibody | (is) initial of synthesis of | this seems to be the site (which) ←
	112.3.3
$AV_iS_r^{sw}$	sometimes also ||| antibody | contain | the ergastoplasmic cisternae ←
$S_r^sW_i^-C_b$	WH ||| (ergastoplasmic cisternae) | (are) rare in | the hemocytoblast
$AV_i^{\sim} S_r^{sw}$	, but often ||| (antibody) | do not (contain) | (the ergastoplasmic cisternae) ←
$S_r^sW_i^-C_b$	WH ||| (ergastoplasmic cisternae) | (are rare in) | (the hemocytoblast)
	112.3.4
$GJ^3B:A^GV_iS_gC_b$	(GJ³B) || (to) || the reaction product | may be filled with | the Golgi apparatus even in these early blast cells, ←
	112.4.1
C_bW_c	of these cells | the subsequent differentiation
$S_rC_bW_c^n$	is characterized primarily by ||| the ergastoplasm | the gradual development of ←
$S_r^wC_bW_c^n$	or ||| the endoplasmic reticulum | (the gradual development of) ←
$S_bW_iS_rC_b$	WH ||| ribosomes | (is) associated (with) | (endopalsmic reticulum) ←

112.4.2
In the earliest of the differentiating cells, which we here distinguish from hemocytoblasts by the term plasmablast, the cisternae of the ergastoplasm remain flattened.

112.4.3
The perinuclear space continues to contain antibody, and all of the developing ergastoplasm appears positive; in fact, the continuity of the endoplasmic reticulum is particularly well illustrated by its content of antibody.

112.5.1
In the next phase of cell differentiation, resulting in the immature plasma cell, the endoplasmic reticulum is more extensive and its cisternae, instead of being flattened, become dilated so that in sections they appear as a collection of ribosome-studded vesicles.

112.4.2

$C^{w}S^{s}_{r}W^{n}_{w\sim}$	in the cells the cisternae of the ergastoplasm | remain flattened
$CY^{e>>f}_{c}C_{b}$	WH ||| (cells) | (are) earliest differentiating from | the hemocytoblast
CYC^{w}	WH ||| (cells) | (are) of | the cells
$CY^{f}_{c}C_{b}$	WH ||| (cells) | (are) (differentiating) (from) | (the hemocytoblast)
$C^{b}_{z}Y\sim C_{b}$	, which ||| (cells) by the term plasmablast | we here distinguish from | hemocytoblasts

112.4.3

$AV^{n}_{i}S_{p}C^{b}_{z}$	antibody | continues to contain | the perinuclear space ←
$AV_{i}S^{c}_{r}C^{b}_{z}$	, and ||| (antibody) | appears positive (for) | all of the developing ergastoplasm ←
$S_{r}C^{b}_{z}W$	; in fact, ||| of the endoplasmic reticulum | the continuity
$AV_{i}S_{r}C^{b}_{z}$	is particularly well-illustrated by ||| antibody | content of | the endoplasmic reticulum's ←

112.5.1

$C^{b}_{z}Y^{t}_{c}C^{m}_{z}\sim$	In ||| of the cell | the next phase of differentiation, resulting in | the immature plasma cell
$S_{r}CW^{>}_{g}$	, ||| the endoplasmic reticulum | is more extensive
$S^{s}_{r}CW_{w}$	and ||| its cisternae | become dilated
$S^{s}_{r}CW_{w\sim}$	, instead of ||| (its cisternae) | being flattened,
$S^{s}_{r}YS^{w}_{v}$	so that ||| its cisternae | appear in sections as | a collection of vesicles
$S_{b}W_{i}S_{v}C$	WH ||| ribosomes | (are) studded (with) | vesicles ←

112.5.2
At this stage antibody is usually but not always present in the perinuclear space; when present, it is sometimes irregularly distributed instead of filling the space entirely.

112.5.3
Similarly, not all of the ergastoplasmic cisternae are positive.

112.5.4
There is usually an intermingling within the cytoplasm of cisternae that are intensely or moderately positive with those which are nonreactive for peroxidase.

112.5.2

$AV_iS_pC_z^m{\sim}$	usually but not always ||| antibody | is present in | the perinuclear space at this stage
AV_i	; when ||| (antibody) | (is) present
$AV_iS_pC_z^m{\sim}$	, ||| antibody | is sometimes irregularly distributed (in) | (the perinuclear space)
$AV_i^+S_pC_z^m{\sim}$	instead of ||| (antibody) | filling entirely | the (perinuclear) space

112.5.3

$AV_iS_r^sC_z^m{\sim}$	Similarly, ||| (antibody) | are positive (for) | (some) of the ergastoplasmic cisternae ←
$S_r^sY{\sim}S_r^s$	(:) ||| (some of the ergastoplasmic cisternae) | (are) not | all (ergastoplasmic cisternae)

112.5.4

$S_r^{sw}S_cY_iS_r^{sw}S_c$	of cisternae within the cytoplasm | there is usually an intermingling with | cisternae within the cytoplasm
$AV_i^+S_r^s$	WH ||| (antibody) | are intensely (positive for) | (cisternae) ←
$AV_iS_r^s$	or WH ||| (antibody) | (are) moderately positive (for) | (cisternae) ←
$GJ^3{:}A^GV_i{\sim}S_r^s$	which ||| (GJ^3) || (:) || are nonreactive for peroxidase | (cisternae) ←

112.5.5
The latter are distended like those containing antibody, and they contain a coarse granular material which is less dense than the reaction product of peroxidase.

112.5.6
In immature plasma cells undergoing mitotic division, antibody-containing vesicles are abundant.

112.5.7
Higher magnification electron micrograph show that antibody is restricted to the space between the membranes of the nuclear envelope and of the endoplasmic reticulum.

112.5.8
Attempts to discern it associated with ribosomes in noncounterstained sections were not successful.

112.6.1
As the plasma cell matures, the ergastoplasmic cisternae become increasingly distended.

112.5.5

$S_r^{sw}C_z^{m\sim}W_w$	the cisternae (in the immature plasma cell) | are distended
$GJ^3{:}A^GV_i^{\sim}S_r^s$	WH ||| (GJ^3) || (:) || are nonreactive for peroxidase | (cisternae) ←
$S_r^{sw}C_z^{m\sim}W_w$	like ||| those (cisternae) (in the cell) | (are distended)
$AV_iS_r^s$	WH ||| antibody | (are) containing | (cisternae) ←
$A_aV_iS_r^s$	, and ||| a coarse granular material | contain | they ←
$GJ^3{:}A^GY{<}A_a$	WH ||| (GJ^3 || (:) || the reaction product of peroxidase | is less dense than | (coarse granular material) ←

112.5.6

$S_v^wW_i^+C_z^{m\sim w}$	vesicles | are abundant in | immature plasma cells
AV_iS_v	WH ||| antibody | contain | (vesicles) ←
$C_z^{m\sim}W_o$	WH ||| (immature plasma cells) | (are) undergoing mitotic division

112.5.7

M	Higher magnification electron micrograph show that
$AV_iS_pC_z^{m\sim}$	antibody | is restricted to | the space between the membranes of the nuclear envelope
$AV_iS_r^hC_z^{m\sim}$	and ||| (antibody) | (is restricted to) | (the space between the membranes) of the endoplasmic reticulum

112.5.8

M	Attempts were not successful to discern
$AV_iS_bC_z^{m\sim}$	antibody | associated with | ribosomes in noncounterstained sections

112.6.1

$S_r^sC_zW_w^{\uparrow}$	the ergastoplasmic cisternae | become increasingly distended
C_zW_m	as ||| the plasma cell | matures

112.6.2
Not all mature plasma cells in a given spleen contain antibody; positive and negative plasma cells occurred side by side.

112.6.3
Two types of antibody distribution were observed in mature plasma cells.

112.6.4
In both cell types, the perinuclear space is free of antibody.

113.1.1
In some cells, antibody remains within the ergastoplasm where it tends to accumulate into spherical masses, often very large (Russell bodies?) and always studded with ribosomes.

112.6.2

$AV_iC_z^mT_s$	antibody | contain | (some) mature plasma cells in a given spleen ←
$C_z^mY \sim C_z^m$	(;) ||| (some mature plasma cells) | (are) not | all (mature plasma cells)
$AV_iC_z^mT_s$	; ||| (antibody) | (are) positive (for) | (plasma cells) (in a given spleen) (which) ←
$AV_i \sim C_z^mT_s$	occurred side by side ||| (antibody) | (are) negative (for) | plasma cells (in a given spleen) (which) ←

112.6.3

$AV_iC_z^m$ M	of antibody | distribution in | mature plasma cells two types were observed

112.6.4

$AV_i \sim S_pC_z^{mI}C_z^{mII}$	antibody | is free of | the perinuclear space in both (mature plasma) cell types ←

113.1.1

$AV_iS_r^wC_z^{mI}$	antibody | remains within | the ergastopalsm in some (mature plasma) cells
$AV_i^{\uparrow}S_i^wS_r$	, where ||| antibody | tends to accumulate into | spherical masses (within the ergastoplasm)
$S_iW_g^{+w}$	, often WH ||| (the spherical masses) | (are) very large
$S_i^{g+}YS_R$	WH ||| (very large spherical masses) | may be | Russell bodies
$S_bW_iS_iS_r$	and (which) always ||| ribosomes | (are) studded with | (the spherical masses) ←

113.1.2
The remainder of the ergastoplasm then contains little or no antibody and is in the form of smaller vesicles or even flattened cisternae; nevertheless, a considerable amount of nonreactive, coarsely granular material persists.

113.1.3
In other cells, the antibody appears to escape the confines of the endoplasmic reticulum and to be present throughout the cytoplasm.

113.1.4
The nuclei are intact and antibody-free, but they are sometimes pushed to one side of the cell and indented by the mass of intensely peroxidase-positive material with which the cytoplasm is engorged.

113.2.1
Throughout plasma cell development, the Golgi apparatus usually contains antibody, but an occasional cell has been found in which the Golgi apparatus appears to be antibody-free.

	113.1.2
$AV_i^-S_rC_z^{mI}$	Then ||| antibody | contains little | the remainder of the ergastoplasm ←
$AV_i^{\sim}S_rC_z^{mI}$	or ||| (antibody) | (contains) no | (the remainder of the ergastoplasm) ←
$S_rYS_v^{g\sim}$	and ||| (the remainder of the ergastoplasm) | is in the form of | smaller vesicles
$S_rYS_r^{sw}$	or even ||| (the remainder of the ergastoplasm) | (is in the form of) | cisternae
$S_r^sW_{w\sim}$	WH ||| (cisternae) | (are) flattened
$GJ^3{:}A^G{\sim}V_i^nS_rC_z^{mI};$	nevertheless, ||| (GJ^3) || (:) || of nonreactive, coarsely granulated material | a considerable amount persists (in) | (the remainder of the ergastoplasm)
	113.1.3
$AV_u^fS_rC_z^{mII}$	the antibody | appears to escape (from) | the confines of the endoplasmic reticulum in other (mature plasma) cells
$AV_i^yS_cC_z^{mII}$	and ||| (the antibody) | (appears) to be present throughout | the cytoplasm
	113.1.4
$S_nC_z^{mII}W_{e\sim}$	the nuclei | are intact
$AV_i^{\sim}S_nC_z^{mII}$	and ||| antibody | (are) free of | (the nuclei) ←
$S_nC_z^{mII}W_e$	, but sometimes ||| nuclei | are pushed to one side and indented
$GJ^3{:}A^GV_i^+S_cC_z^{mII}$	by ||| (GJ^3) || (:) || the mass of intensely peroxidase-positive material with which | is engorged | the cytoplasm
	113.2.1
$AV_iS_gC_z^m$	usually ||| antibody | contains | the Golgi apparatus ←
C_zW_c	throughout ||| plasma cell | development
$C_z^{mw}W_i^-$	but ||| a (plasma) cell | has been occasionally found
$AV_i^{\sim}S_gC_z^m$	in which ||| antibody | appears to be free of | the Golgi apparatus (of) (the cell) ←

113.2.2
When present, it occurs chiefly in the interior of some or all of the large flattened sacs of the lamellar portion and only rarely in the associated small vesicles and large vacuoles.

113.3.1
No antibody could be identified in small lymphocytes in the cortex of lymph nodules or in extracellular spaces.

113.4.1
Antigen could not be found in any of the spleens with the method employed.

113.5.5
We did not attempt to localize the antibody in the primary response, because the cells involved in antibody synthesis are the same as those in the secondary response and they are so few in number that the sampling problem for electron microscopy becomes very great.

	113.2.2
$AV_iS_gC_z^m$	When ||| (antibody) | (is) present (in) | (the Golgi apparatus)
$AV_i^+ S_g^{g,w} \sim S_g^y$	, ||| antibody | occurs chiefly in | the interior of some or all of the large flattened sacs of the lamellar portion (of the Golgi apparatus)
$AV_i^- S_v^g \sim S_v^g, S_g$	and ||| (antibody) | only rarely (occurs) in | the associated small vesicles and large vacuoles (of the Golgi apparatus)
	113.3.1
$AV_i^- \sim C_y^g \sim T_x$	of antibody | none could be identified in | small lymphocytes in the cortex of lymph nodules
$AV_i^- \sim C \sim$	or ||| (of antibody) | (none could be identified) in | extracellular spaces
	113.4.1
$GU_i^- \sim T_s$	antigen | could not be found in | any of the spleens
M	with the method employed
	113.5.5
M	We did not attempt to (establish)
$GJ^1{:}AV_iSC$	primary (injection) || in response (to) || The antibody | location in | the ultrastructure of cells
C^wYC^w	, because ||| the cells | are the same as | those (cells)
AV_p^rC	WH ||| antibody | (are) involved in synthesis of | (cells) ←
$GJ^2{:}AV_p^rC$	WH ||| secondary (injection) || (to) || (are involved) in the response | (cells) ←
$GJ^1{:}CW_i^-$	and ||| (primary injection) || (after) || The cells | are so few in number
M	that the sampling problem for electron microscopy becomes very great

114.2.1
The antibody-containing cells revealed by the peroxidase-antiperoxidase antibody system are the same as those described at the light microscope level by the immunofluorescent technique, namely, those of the plasmacytic series.

	114.2.1
M	revealed by the peroxidase-antiperoxidase antibody system
C^wYC^w	the cells | are the same as | those (cells)
AV_iC	WH ||| antibody | containing | (cells) ←
AV_iC	WH ||| antibody | containing | (cells) ←
M	described at the light microscope level by the immunofluorescent technique
$CYC_z^{\checkmark}$	, namely, ||| (the cells) | (are) | those of the plasmacytic series

"Studies on Antibody-Producing Cells, I. Ultrastructure of 19S and 7S Antibody-Producing Cells," by Fred G. Gudat, T.N. Harris, Susanna Harris, and Klaus Hummeler, *The Journal of Experimental Medicine*, v. 132, 1970, 448-474

448.1.1
Recent developments in the detection of individual antibody-forming cells by hemolytic antibody plaque production or by adherence of antigen-bearing red blood cells to antibody-forming cells have made possible the electron microscopic study of cells involved in antibody production.

448.2.4
In antibody-producing cells detected by rosette formation, which is a substantially more sensitive method than plaque formation, examination of several hundred such cells showed these to be in both the lymphocytic and plasmacytic categories, as we had found in plaque-forming cells of the rabbit lymph node, but with the great majority in the lymphocytic category, and a few cells which showed morphologic indications of a transition between the two groups.

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	448.1.1
M	Recent developments in the detection of
AV_pC^1	antibody |-forming | individual cells
$A_q^GV_p$	by | hemolytic antibody plaque | production
GU^tC^w	or by ||| of antigen-bearing red blood cells | adherence to | cells
AV_pC	WH ||| antibody | (are) forming | (cells) ←
M	have made possible the electron microscopic study of
AV_p^rC	antibody | involved in production of | cells ←
	448.2.4
AV_pC	In ||| antibody | -producing | cells
A_rV_p	detected by ||| rosette | formation
M	, which is a substantially more sensitive method than
A_qV_p	plaque | formation
M	, examination of several hundred such cells showed
C^wYC_y',C_z'	several hundred cells | to be in | both the lymphocytic and the plasmacytic categories
AV_pC	WH ||| antibody | are producing | (cells) ←
$A_qV_pCT_nB$	, as we had found in ||| plaque | -forming | cells of the lymph node of the rabbit
$CY^{>>}C_y'$	, but with ||| of the cells | the great majority in | the lymphocytic category
$C^-Y_c^{ft}C_y'C_z'$	, and ||| a few cells which | showed morphologic indications of a transition | between the two groups

449.1.1
Plaque-producing cells, both direct and facilitated by the use of anti-IgG (19S and 7S, respectively), were again found to be in both categories: in this case with a substantial majority in the plasmacytic group

451.3.1
The classification of cells into the lymphocytic or plasmacytic group was determined by the state of the endoplasmic reticulum (ER) according to the descriptions below.

451.5.1
Cells typical of small, inactive lymphocytes occurred only in rosettes of uninjected animals.

453.1.1
These contained an indented, electron-opaque nucleus, a small Golgi area, and a narrow rim of cytoplasm with few mitochrondria and rare narrow profiles of ER.

449.1.1

$C^{w}YC_{y}^{\prime}C_{z}^{\prime}$	cells | were again found to be in | both categories
$A_{q}V_{p}C$	WH ||| plaque | producing, both direct and facilitated by the use of anti-IgG (19S and 7S, respectively), | (cells) ←
$CY^{>>}C_{z}^{\prime}$	: in this case with ||| (of the cells) | a substantial majority in | the plasmacytic group

451.3.1

$CYC_{y}^{\prime}C_{z}^{\prime}$	of cells | the classification into | the lymphocytic or plasmacytic group
M	was determined according to the descriptions below by
$S_{r}CW$	the endoplasmic reticulum (ER) (in the cell) | the state of ←

451.5.1

$GJ\sim B{:}A_{r}V_{p}C^{w}$	(were) uninjected | animals (which) || of || rosettes | occurred only in | cells ←
$CYC_{y}^{a\sim,g\sim}$	WH ||| (cells) | (were) typical of | small, inactive lymphocytes

453.1.1

$C_{y}^{a\sim,g\sim}S_{n}W_{q,e}$	these (small, inactive lymphocytes) contained a nucleus (which) | (was) electron-opaque, indented
$C_{y}^{a\sim,g\sim}S_{g}W_{g\sim}$	, ||| (these contained) a Golgi area (which) | (was) small
$C_{y}^{a\sim,g\sim}S_{c}^{w}W_{w\sim}$	, ||| (these contained) a rim of cytoplasm (which) | (was) narrow
$S_{m}W_{i}^{-}S_{c}C_{y}^{a\sim,g\sim}$	WH ||| mitochondria | (was) with few | (rim of cytoplasm) ←
$C_{y}^{a\sim,g\sim}S_{c}S_{r}W_{w\sim}$	and (which) ||| (rim of cytoplasm) (was with) profiles of ER (which) | (were) narrow, rare

453.1.2
A few of these background rosette-forming lymphocytes, and those of SRBC-injected animals, were larger, with a higher degree of cytoplasmic differentiation of the type shown in Fig. 1.

453.1.4
Nucleoli were prominent in many of these cells.

453.1.5
The cytoplasm was moderately broadened, and the ribosomes appeared less densely packed.

453.1.8
Most of these cells had single narrow channels of rough ER as well as partly distinct perinuclear spaces.

453.2.1
Rosette-forming cells of this group had the same cytoplasmic components, differing only in quantitative aspects.

	453.1.2
$C_y^{w\text{-}}W_g^{>}$	a few of these lymphocytes | were larger,
$GJ\sim B{:}A_rV_pC_y$	WH ||| background || (:) || rosettes | (are) forming | (lymphocytes) ←
$C_y^{w}W_g^{>}$	, and ||| those (lymphocytes) | (were larger)
$GJB{:}A_rV_pC_y^{B}$	WH ||| SRBC | (were) injected (with) | (animals) || WH ← || rosettes | forming | (lymphocytes) of animals ←
$C_yS_cW_c^{>}$	, WH ||| (lymphocytes) with in their cytoplasm | a higher degree of differentiation of the type shown in Fig. 1
	453.1.4
$C_y^{+}\,S_uW_w$	in many of these cells nucleoli | were prominent
	453.1.5
$C_y^{+}\,S_cW_w$	(in many of these cells) the cytoplasm | was moderately broadened
$S_bW_i^{<\,<}S_cC_y^{+}$	, and ||| the ribosomes | appeared less densely packed (in) | (the cytoplasm in many of these cells)
	453.1.8
$C_y^{>\,>}S_rW_r$	Most of these cells had ER (which) | (was) rough having single narrow channels
$C_y^{>\,>}S_pW_m^{-}$	as well as ||| (most of these cells had) perinuclear spaces (which) | (were) partly distinct
	453.2.1
$SW_iS_cC_y^{gw}$	the same componenets | had | in their cytoplasm cells of the large lymphocytes group ←
$A_rV_pC_y^{g}$	WH ||| rosettes | (are) forming | (cells of the large lymphocytes group) ←
$SW_iS_cC_y^{g\sim},C^{g\text{-}w}$	,differing only in quantitative aspects, (as) ||| (components) | (had) | (cells of the small to medium lymphocytes group) ←
$A_rV_pC_y^{g},C^{g\text{-}}$	WH ||| (rosettes) | (form) | (cells of the small to medium lymphocytes group) ←

453.2.6
The ample cytoplasm was studded with free ribosomes which either appeared to be randomly distributed or were clustered in polyribosomes.

453.3.1
Some ER was demonstrable in almost every cell, in one of the following variations.

453.3.2
In medium and large lymphocytes, there were channels with a constant, narrow distance between the rows of ribosome-bearing membrane, and no evidence of protein storage.

456.2.1
In some of the large lymphocytes, a difference in the ER was noted in that the channels were slightly and variably distended, and appeared to have deposits of protein-like material.

456.2.2
In addition, a more nearly parallel orientation of the channels became apparent.

453.2.6

$S_bW_i^+ S_c^+ C_y^g$ free ribosomes | was studded with | the ample cytoplasm (of the large lymphocytes) ←

$S_bW_{b'}S_c^+ C_y^g$ which either ||| (free ribosomes) | appeared to be randomly distributed | (in the ample cytoplasm of the large lymphocytes)

$S_bW_{b''}S_c^+ C_y^g$ or (which) ||| (free ribosomes) | were clustered in polyribosomes | (in the ample cytoplasm of the large lymphocytes)

453.3.1

$S_rW_iC_y^{g++}$ M some ER | was demonstrable in | almost every cell , in one of the following variations

453.3.2

$C_y^{g-,g}S_r^hW_{w\sim}$ In medium and large lymphocytes, there were channels (of ER) | with a constant, narrow distance between the rows of ribosome-bearing membrane

$A_pV_t^{\sim}S_r^hC_y^g$ and ||| protein | (were with) no evidence of storage of | (the channels of ER in these lymphocytes) ←

456.2.1

$S_rC_y^gW_c$ in the ER in some of the large lymphocytes, | a difference was noted

$S_r^hC_y^gW_w^{\Delta,-}$ in that ||| the channels | were slightly and variably distended

$A_pV_tS_r^hC_y^g$ and ||| protein-like material | appeared to have deposits of | (the channels) ←

456.2.2

$S_r^hC_y^gW_y^{>}$ In addition, ||| of the channels | a more nearly parallel orientation became apparent

456.2.3
These cells, which still had a predominantly ribosomal cytoplasm, were regarded as transitional forms between the lymphocytes described in the previous paragraphs and the early plasmablasts.

456.5.1
These cells were characterized by further increase in number, length, and width of the channels of ER, with evidence of the deposition of more protein within them.

456.5.2
With increasing volume of the ER there was a corresponding reduction in the volume occupied by free ribosomes, which were either in random distribution or in clusters.

456.6.1
Cells with regular circular lamellae of ER channels, and relatively few free ribosomes between them, were considered mature plasma cells.

463.4.1
Plaque-producing cells were classified according to the nomenclature used above for rosette-forming cells.

456.2.3

$C_y^{gw}Y_c^{ft}C_y^{g,g\sim}$,C_z^b these cells were regarded as forms \ transitional between | the lymphocytes described in the previous paragraphs and the early plasmablasts

$S_bW_i^+ S_cC_y^g$, which ||| ribosomal | predominately | (cells) still had a cytoplasm ←

456.5.1

$C_z^bS_r^hW_c^>$ these plasmablast cells | were characterized by the channels of ER | having further increase in number, length, and width

$A_pC_t^> S_r^hC_z^b$, with ||| protein | evidence of the deposition of more | within the channels of ER ←

456.5.2

$S_rW_i^{\uparrow}C_z^b$ corresponding with ||| the ER's | increasing volume (in) | (the plasmablast)

$S_bW_i^{\downarrow}C_z^b$ free ribosomes | there was a reduction in the volume occupied by | (in the plasmablasts) ←

$S_bW_{b'}S_cC_z^b$, which either ||| (free ribosomes) | were in random distribution (in the cytoplasm of the plasmablasts)

$S_bW_{b''}S_cC_z^b$ or (which) ||| (free ribosomes) | (were) in clusters | (in the cytoplasm of the plasmablasts)

456.6.1

$C^wYC_z^m$ cells | were considered | mature plasma cells

$CS_r^hW_y$ WH ||| (cells) (are) with ER channels | having regular circular lamellae

$S_bW_i^-S_r^hC$, and ||| free ribosomes | relatively few | between the ER channels (cells with) ←

463.4.1

A_qV_pC plaque | -producing | cells

M were classified according to the nomenclature used above for

A_rV_pC rosette | -forming | cells

463.4.2
They were called lymphocytic when free ribosomes were the main constituent of the cytoplasm, with only a few solitary, unoriented channels of endoplasmic reticulum, very narrow and of constant width throughout the typically short pieces seen.

464.2.1
In the plasmacytic series, cells were classified as plasmablasts if the ER was oriented in more or less parallel lamellae and showed definite indications of protein deposition in widened channels, but occupied less of the cytoplasm than did the area of free ribosomes.

464.2.2
Within the group of mature plasma cells, the ER occupied the greater part of the cytoplasm, being distributed either as parallel channels of uniform medium width or as irregularly distended vesicles.

464.2.3
A transition from lamellar to vesicular ER is shown in Fig. 13.

463.4.2

$C^{w}YC_{y}$	cells | were called | lymphocytic
$A_{q}V_{p}C$	WH ||| plaques | produce | (cells) ←
$S_{b}W_{i}^{+\ +}S_{c}^{w}C$	when ||| free ribosomes | were the main constituent of | the cytoplasm
$S_{r}^{h,y\sim w}W_{i}^{-}S_{c}C$	, WH ||| unoriented channels of endopolasmic reticulum | (was) with only a few solitary, | (cytoplasm) ←
$S_{r}^{h,y\sim}W_{w}^{+}{}_{\sim}$	, WH ||| (unoriented channels of endoplasmic reticulum) throughout the typically short pieces seen | (were) very narrow and of constant width

464.2.1

$C_{z}^{\checkmark}YC_{z}^{b}$	in the palsmacytic series, cells | were classified as | plasmablasts
$S_{r}CW_{y}$	if ||| the ER | was oriented in more or less parallel lamellae
$A_{p}V_{t}S_{r}^{hw}C$	and (if) ||| protein | showed definite indications of deposition (of) | in channels (the ER) ←
$S_{r}^{h}W_{w}$	WH ||| (ER channels) | (were) widened
$S_{r}W_{i}^{<\ <}S_{c}C$	but ||| (the ER) | occupied less of | the cytoplasm
$S_{b}W_{i}S_{c}C$	than ||| the area of free ribosomes | (occupied) | (the cytoplasm)

464.2.2

$S_{r}W_{i}^{>}S_{c}C_{z}^{m}$	the ER | occupied the greater part of | the cytoplasm, within the group of mature plasma cells
$S_{r}YS_{r}^{hy}$	, either ||| (the ER) | being distributed as | parallel channels of uniform medium width
$S_{r}YS_{v}^{w}$	or ||| (the ER) | (being distributed) as | vesicles
$S_{v}W_{w}$	WH ||| (vesicles) | (are) irregularly distended

464.2.3

$S_{r}^{y}Y_{c}^{t}S_{r}^{v}$	from lamellar (ER) | a transition | to vesicular ER
M	is shown in Fig. 13

469.3.1
It is generally assumed that RFC are antibody-producing cells.

469.3.2
The most direct evidence for the involvement of antibody in rosette formation comes from the observation that this can be suppressed by specific antiglobulin.

469.4.1
In the case of the macrophage, on the other hand, it was shown by Storb and Weiser that antibody adsorbed to the surface of this cell could cause rosette formation.

469.4.5
In contrast, it has been shown that lymphoid cells cannot be coated passively with antibody to the point of rosette formation.

469.5.1
The fact that even small and medium lymphocytes were found to produce rosettes would indicate that antibody production starts before the development of large lymphocytes or blast forms.

	469.3.1
M	It is generally assumed that
A_rV_pC	rosette | -forming | cells
AV_pC	are ||| antibody | -producing | cells
	469.3.2
M	The most direct evidence for
A_rY_pA	rosettes | the involvement in formation of | of antibody ←
M	comes from the observation that
$A_rV_p^s$	rosette | formation can be suppressed
GXA	by ||| antiglobulin (which) || (is) specific (to) || (antibody)
	469.4.1
M	In the case of the macrophage, on the other hand, it was shown by Storb and Weiser that
$AV_u^tC_m$	antibody | adsorbed to | the surface of the macrophage cell
A_rV_p	could cause ||| rosette | formation
	469.4.5
M	In contrast, it has been shown that
$AV_u^t{\sim}C^{\not}$	antibody | cannot be coated passively with | lymphoid cells ←
A_rV_p	to the point of ||| rosette | formation
	469.5.1
$A_rV_pC_y^{g\sim},C_y^{g-}$	The fact that ||| rosettes | were found to produce | even small and medium lymphocytes ←
AV_p^b	would indicate that ||| antibody | production starts
C_y^g,C_bW_c	before ||| large lymphocytes or blast forms | the development of ←

469.5.2
However, it would appear that to reach the full rate of antibody secretion, cells would generally require morphologic adaptations from the inactive stage.

469.5.3
Varying degrees of this adaptation or differentiation could account for the heterogeneity of the rosette-forming population.

470.2.1
The interpretation that the plasma cells could constitute a subpopulation of lymph node cells with the greatest rate of synthesis of antibody was supported by the finding of antibody-forming cells which were considered the most differentiated cells of the lymphocytic category – the transitional cells found among RFC and PFC – which had some points of similarity to the plasmablasts.

469.5.2

M	However, it would appear that
$CY_c^fC^a\sim$	cells | would generally require morphologic adaptations from | the inactive stage
$AV_s^{o+}C$	(for) ||| antibody | to reach the full rate of secretion of | (cells) ←

469.5.3

$CY_c^{\Delta f}C^a\sim$	cells | having varying degrees of adaption or differentiation from | the inactive stage
$A_rV_pC^{\prime\Delta}$	could account for ||| rosettes | forming | the heterogeneity of the (cell) population ←

470.2.1

M	The interpretation that
$C_zYC^{\prime w}$	the plasma cells | could constitute | a subpopulation of cells
$C^{\prime}W_iT_n$	WH ||| (subpopulation of cells) | (are) of | the lymph node
$AV_p^{o>>}C^{\prime}$	WH ||| antibody | (are) with the greatest rate of synthesis of | (subpopulation of cells) ←
M	was supported by the finding of
AV_pC^w	antibody | -forming | cells
CYC_z^b	which ||| (cells) | had some points of similarity to | the plasmablasts
$C_y^{\prime w}YC$	which ||| the cells of the lymphocytic category | were considered | (cells) ←
$C_y^{\prime}W_c^{>>}$	WH ||| (cells of the lymphocytic category) | (are) most differentiated
$C^cY_iC^w$	– the transitional cells | found among | cells
A_rV_pC	WH ||| rosettes | form | (cells) ←
$C^cY_iC^w$	and ||| (the transitional cells) | (found among) | cells
A_qV_pC	WH ||| plaques | form | (cells) ←

470.3.1
The observation that lymphocytic cells produce antibody, especially among the RFC, is consistent with our earlier findings that lymph node lymphocytes equipped with prominent nucleoli, Golgi bodies, and mitochondria, but lacking a substantial amount of ER, could produce antibody plaques, and were therefore judged to be continuously secreting antibody.

470.3.2
On the other hand, in recent studies of antibody-forming cells based on the detection of antibodies within cells, even by the sensitive methods of electron microscopy, antiferritin and antiperoxidase have been demonstrated in the ER only of plasma cells, plasmablasts, and immature blast cells.

	470.3.1
M	The observation that
AV_pC_y	antibody | produce | lymphocytic cells ←
$AV_pC_y^w$	, especially ||| (antibody) | (produce) | (lymphocytic cells) ←
$C_yY_iC^w$	WH ||| (lymphocytic cells) | (are) among | cells
A_rV_pC	WH ||| rosettes | form | (cells) ←
M	, is consistent with our earlier findings that
$A_qV_pC_y^wT_n$	antibody plaques | could produce | lymphocytes of the lymph node ←
$C_yS_uW_g$	WH ||| (lymphocytes) (are) equipped with nucleoli | which are prominent
$C_yS_gW_g$	, WH ||| (lymphocytes) (are) (equipped with) mitochondria | which are prominent
$S_rW_i^-C_y$	, but WH ||| ER | (are) lacking a substantial amount of | (lymphocytes) ←
$AV_s^nC_yT_n$	and therefore it was judged that ||| antibody | were continuously secreting | (the lymphocytes of the lymph node) ←
	470.3.2
M	On the other hand, in recent studies of
AV_pC	antibody | -forming | cells
M	based on the detection, even by the sensitive methods of electron microscopy, of
AV_iC	antibodies | within | cells
$GJB{:}A^GV_iS_r^w$	, ||| (GJB) || (:) || antiferritin and antiperoxidase | have been demonstrated in | the ER
$S_rW_iC_z,C_z^b,C_b^{m\sim}$	WH ||| (ER) | (is) only of | plasma cells, plasmablasts, and immature blast cells

470.3.3
It was considered, in those studies, that the plasma cells were derived from these blast cells and that antibody production starts at this stage, since no evidence of antibody was found in small lymphocytes which had very scanty ER.

470.3.4
The disagreement between these studies and ours, with respect to antibody formation by the lymphocytic cells, might be explained in part by quantitative differences in antibody production and in the sensitivity of the methods involved.

470.3.5
Another difference between studies involving detection of antibody within cells, referred to above, and those like the rosette and plaque studies, is that the former detect only the cells which contain antibody in sufficient concentration to be detectable by the technique employed, (each method, of course, having its own threshold of detection).

	470.3.3
M	It was considered, in those studies, that
$C_zY_c^fC_z^b,C_b^{m\sim}$	the plasma cells | were derived from | plasmablasts and immature plasma blast cells
$AV_p^bC_z^b,C_b^{m\sim}$	and that ||| antibody | production starts | at this (blast) stage
$AV_i^{\sim}C_y^{g\sim w}$	, since ||| of antibody | no evidence was found in | small lymphocytes
$S_rW_i^{-}C_y^{g\sim}$	, which ||| ER | had very scanty (amounts of) | small lymphocytes) ←
	470.3.4
M	The disagreement between these studies and ours, with respect to
AV_pC_y	antibody | formation | by the lymphocytic cells
M	, might be explained in part by
AV_p^{Δ}	antibody | quantitative differences in production of ←
M	and (quantitative differences) in the sensitivity of the methods involved
	470.3.5
M	Another difference between studies, referred to above, involving detection of
AV_iC	antibody | within | cells
M	and those like the rosette and plaque studies, is that the former detect
AV_iC	antibody | contain in sufficient concentration | only the cells which ←
AV_i	(for) ||| (antibody) | to detectable by the technique employed (each method, of course, having its own threshold of detection)

471.1.1
The rosette and plaque tests, however, detect antibody-producing cells which can be secreting most of the antibody which they are synthesizing.

471.1.2
Thus a cell could be producing and secreting enough antibody to produce a rosette or plaque without containing, at a given time, enough completed antibody to be detectable even by the sensitive electron microscopic anti-ferritin method.

471.1.1

M	The rosette and plaque tests, however, detect
AV_pC^w	antibody | -producing | cells
A^wV_sC	which ||| antibody | can be secreting | (cells) ←
$AY^{>>}A^w$	WH ||| (antibody) | (is) most of | the antibody
AV_pC	which ||| (antibody) | is synthesized by | them

471.1.2

AV_pC^1	Thus ||| (antibody) | could be producing | a cell ←
$A^wV_sC^1$	and ||| antibody | (could be) secreting | (a cell) ←
AV_i	WH ||| (antibody) | (is) (present) (in an amount) enough
$A_{r'q}V_pC^1$	(for) ||| a rosette or plaque | to produce | (the cell) ←
$A^wV_i^{\sim}C^1$	with ||| antibody | not containing, at a given time, enough | (the cell) ←
AV_p	WH ||| (antibody) | (is) completed
AV_iC^1	(for) ||| (antibody) | to be detectable even by the sensitive electron microscopic antiferritin method (in) | (the cell)

Lymphatics, Lymph and the Lymphomyeloid Complex, by J.M. Yoffey and F.C. Courtice. 3rd edition. New York, Academic Press, 1970, 573-588

573.3.2
McMaster and Hudack, reinvestigating the problem, demonstrated that aggultinin formation could take place in nodes, though their experiments threw no light on the actual cells concerned in the process.

574.2.1
Soon after McMaster and Hudack had begun their experiments in 1935, evidence began to accumulate from other workers that the plasma cell plays an essential part in antibody formation.

574.2.2
Fagraeus, studying mainly the spleen, concluded that the administration of antigens not only gives rise to the production of antibody, but is also a powerful stimulus to the formation of immature plasma cells from reticulum cells, especially in the splenic pulp.

577.1.3
Wesslen, also working with rabbits, obtained thoracic duct lymph three days after the subcutaneous injection of living typhoid bacilli.

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	573.3.2
M	McMaster amd Hudack, reinvestigating the problem, demonstrated that
AV_pT_n	agglutinin | formation could take place | in nodes
M	, though their experiments threw no light on
AV_p^rC	agglutinin | concerned in the process of formation of | the actual cells ←
	574.2.1
M	Soon after McMaster and Hudack had begun their experiments in 1935, evidence began to accumulate from other workers that
$AV_p^rC_z$	antibody | plays an essential part in formation of | the plasma cell ←
	574.2.2
M	Fagraeus, studying mainly the spleen, concluded that not only
$GJB{:}AV_pT_s$	antigen | administration || gives rise to || antibody | production | (in the spleen)
$GJB{:}C_z^m{\sim}Y_c^fC_rT_s$	, but also ||| (antigens) | (administration) || is a powerful stimulus to || immature plasma cells | being formed | from reticulum cells, especially in the splenic pulp
	577.1.3
M	Wesslen, also working with rabbits, obtained
$GJB{:}_tT\not{W}^fT_h$	living typhoid bacilli | injection of | the subcutaneous || three days after || Lymph | (drained from) | the thoracic duct

577.1.4
The lymphocytes were centrifuged, washed in saline, and then divided into two portions, of which one was at once lysed in distilled water, the other suspended in normal rabbit serum and cultured in a roller tube for 48 hr.

577.1.5
The lysed lymphocytes did not contain specific agglutinin, whereas the cultured lymphocytes did.

577.1.6
Wesslen, therefore, concluded that while the cells in thoracic duct lymph do not contain antibody they are capable of forming it.

579.2.1
Hall *et al.* further noted that when the efferent lymph was collected externally, and prevented from reaching the blood stream, no general immunity developed even though the popliteal node contained large numbers of plasma cells and was the seat of a vigorous immune response.

	577.1.4
$C_yT_\ell W_\ell$	The lymphocytes (of the thoracic duct lymph) | were centrifuged, washed in saline, and then divided into two portions
C_yW_ℓ	, ||| one portion of the lymphocytes | was at once lysed in distilled water
C_yW_ℓ	, ||| one portion (of the lymphocytes) | (was) suspended in normal rabbit serum and cultured in a roller tube for 48 hr.
	577.1.5
$GJ{:}A^GV_i{\sim}C_y^w$	(antigen) | (was injected) || WH || agglutinin specific (to antigen) | did not contain | the lymphocytes ←
C_yW_ℓ	WH ||| (the lymphocytes) | (were) lysed
$GJ{:}A^GV_i^vC_y$	, whereas ||| (antigen) | (was injected) || WH ← || (agglutinin specific to antigen) | which were cultured did (contain) | the lymphocytes ←
	577.1.6
M	Wesslen, therefore, concluded that
$AV_i{\sim}C_yT_\ell$	while ||| antibody | do not contain | the cells in thoracic duct lymph ←
$AV_p^cC_yT_\ell$	antibody | are capable of forming | the cells in thoracic duct lymph ←
	579.2.1
M	Hall et al. further noticed that
$AV{\sim}B$	of immunity | none developed | generally
$T_\ell^fW_\ell$	when ||| the efferent lymph | was collected externally
$T_\ell^fW_u^t{\sim}T_b$	, and ||| (the efferent lymph) | (was) prevented from reaching | the blood stream
$C_zW_i^+T_n$	even though ||| plasma cells | contained large numbers of | the popliteal node ←
$AV_p^+T_n$	and ||| a vigorous immune response | (the popliteal node) was the seat of ←

579.2.2
This observation would seem to imply that any gamma globulin which was formed in the node was not directly absorbed into the blood stream, unless the amount absorbed was so small that its blood concentration was too low for detection.

579.2.3
The observations of Hall *et al.* raise once again the question of the ultimate fate of these immature plasma cells, which in the intact animal would either be held up in any further lymph nodes which they entered, or would pass through them and so enter the blood stream.

579.2.4
If they settle in another lymph node, they can apparently continue their development into mature plasma cells.

579.2.2

M	This observation would seem to imply that
$A_g^w V_u^t \sim T_b$	any gamma globulin | was not directly absorbed into | the blood stream
$A_g V_p T_n$	which ||| (gamma globulin) | was formed | in the node
$A_g V_u^{-t} T_b$	unless ||| gamma globulin | amount absorbed was so small (into) | (the blood stream)
$A_g V_i^- T_b$	that ||| gamma globulins | concentration was too low for detection in | blood

579.2.3

M	The observations of Hall *et al.* raise once again the question of
$C^m \sim {}^w W$	these immature plasma cells | the ultimate fate of ←
$C_z^m \sim W_u^f \sim T_n^w B$	, which either ||| (these immature plasma cells) | would be held up in any | further lymph nodes in the intact animal
$C_z^m \sim W_u^t T_n$	which ||| these immature plasma cells | entered | (lymph nodes)
$C_z^m \sim W_u^y T_n$	, or (which) ||| (these immature plasma cells) | would pass through | the lymph nodes
$C_z^m \sim W_u^t T_b$	and so ||| (these immature plasma cells) | (would) enter | the blood stream

579.2.4

$C_z^m \sim W_u^t T_n$	If ||| the immature plasma cells | settle in another | lymph node
$C_z^m \sim Y_c^{nt} C_z^m$	, ||| the immature plasma cells | can apparently continue their development into | mature plasma cells

579.2.5
This was shown by Birbeck and Hall, who labelled (with thymidine) lymphocytes from the efferent lymph in an antigenically-stimulated node and introduced them in the afferent vessel of another node, in which they then gave rise to mature plasma cells which could be identified on electron microscopic radioautography.

583.3.1
There are considerable differences of opinion concerning the changes which occur in the primary and secondary response to an antigen reaching the node.

583.3.2
On the whole, it seems to be generally accepted that during the primary response there is a moderate increase in cellular proliferation which subsides after a few days, and appears to culminate in the formation of an increased number of small lymphocytes.

579.2.5

M	This was shown by Birbeck and Hall, who
$C_yT^f_\ell T^w_n W_\ell$	lymphocytes from the efferent lymph in a node | labelled (with thymidine) ←
GUT_n	WH ||| antigenically | (was) stimulated | (node) ←
$C_yI^tT^f_\ell T^w_n$	and ||| lymphocytes | were introduced | in the afferent vessel of another node
$GU^{\sim}T_n$	(WH) ||| (antigenically) | (was not stimulated) | (node) ←
$C_yT_nY^t_cC^{mw}_z$	, which ||| lymphocytes in (the node) | then gave rise to | mature plasma cells
$C^m_zW_\ell$	which ||| (mature plasma cells) | could be identified on electron microscopic radioautography

583.3.1

M	There are considerable differences of opinion concerning
$GU^{1t}T_n$:CW_c	an antigen | primarily reaching | the node || to ← || The changes which occur in the response
$GU^{2t}T_n$:CW_c	and ||| (an antigen) | secondarily (reaching) | (the node) || (to) ← || (the changes which occur in the response)

583.3.2

M	On the whole, it seems to be generally accepted that
$GU^{1t}T_n$:CW	during ||| (an antigen) | primarily (reaching) | (the node) || (to) ← || The response ←
$CW^{w\uparrow}_p$	cells | there is a moderate increase in proliferation of ←
$CW^{\downarrow}_p$	which after a few days ||| (cellular) | (proliferation)
$C^g_y{\sim}W^{\uparrow}_p$	subsides, and appears to culminate in ||| small lymphocytes | the formation of an increased number of ←

583.3.4
These small lymphocytes, now "conditioned" (also sometimes termed "committed" or "primed") to respond to their secondary stimulus, may persist for many years, either in their original site, or migrating throughout the lymphomyeloid complex, until a further stimulus starts them off on their secondary response, which would presumably be chiefly the production of plasma cells in the case of humoral antibody.

584.2.2
One of the major points at issue, then as now, was whether the plasma cell was derived from lymphocytes, or not.

584.2.5
Subsequently, on the basis of ultrastructural studies, Thiery states: "We shall end by underlining the independence of the plasmacytic and lymphocytic series; we have not been able to discover a single cell which would bridge the gap, with any certainty, between the two series."

583.3.4

$C_y^g{\sim}W_i^nT_n$	either ||| these small lymphocytes | may persist for many years in | their original site
$C_y^g{\sim}W_u^yT_{\ell'}$	or ||| (these small lymphocytes) | (may persist for many years) migrating | throughout the lympho-myeloid complex
$GU^2C_y^g{\sim}:C_y^g{\sim}W^c$	, WH ||| secondary stimulus | their || to ← || (small lymphocytes) | (are) now "conditioned" (also sometimes termed "committed" or "primed") to respond
$GU^2C_y^g{\sim}:C_y^g{\sim}W^{wb}$	, until ||| a further stimulus || (causes) || these small lymphocytes | to start off on a response
$GU^2C_y^g{\sim}:C_y^g{\sim}W$	WH ||| secondary (stimulus) | their || (to) ← || (response) is ←
$C_y^g{\sim}Y_c^tC_z$	, which would presumably be chiefly ||| (the small lymphocytes) | production of | plasma cells
AV_iT_b	in the case of ||| antibody | humoral ←

584.2.2

M	One of the major points at issue, then as now, was
$C_zY_c^fC_y$	whether ||| the plasma cell | was derived from | lymphocytes
$C_zY_c^f{\sim}C_y$	, or ||| (the plasma cell) | (was) not (derived from) | (lymphocytes)

584.2.5

M	Subsequently, on the basis of ultrastructural studies, Thiery states: we shall end by underlining
$C_z'Y{\sim}C_y'$	the plasmacytic (series') | independence of | (the) lymphocytic series
M	; we have not been able to discover
$CY_c^{ft}C_y'C_z'$	a single cell which | would bridge the gap, with any certainty, | between the lymphocytic series | and the plasmacytic series

584.2.6
As against this Zucker-Franklin comments, "Exactly how much rough-surfaced endoplasmic reticulum a lymphocyte should display... to be considered a full-fledged plasma cell, becomes a matter of semantics."

585.3.1
Zlotnick, following up the earlier work of Zlotnick *et al.*, has carefuly studied the changes undergone by sensitized lymphocytes in the cheek pouch of irradiated hamsters.

585.3.3
Thymidine labelling showed the major change to be in the small lymphocyte population, which started to enlarge and label after 24 hr.

585.3.4
From a careful study of the sequential changes in these labelled cells, it is difficult not to accept the view that plasma cells are derived from small lymphocytes.

587.5.1
Part of the cellular response to an antigen consists in the increased production of small lymphocytes which are capable of responding to a secondary stimulus.

584.2.6

M	As against this Zucker-Franklin comments that it becomes a matter of semantics
$S_r^rW_iC_y$	of rough-surfaced, endoplasmic reticulum | exactly how much should be displayed by | a lymphocyte
$C_yYC_z^m$	(in order for) ||| (a lymphocyte) | to be considered | a full-fledged plasma cell

585.3.1

M	Zlotnick, following up the earlier work of Zlotnick *et. al.*, has carefully studied
$GU_sC_y{:}C_yW_cB$	(were) sensitized | (lymphocytes) || WH || lymphocytes | the changes undergone by | in the cheek pouch of irradiated hamsters ←

585.3.3

M	Thymidine labelling showed
$C_y^{g\sim w}W_c$	the small lymphocyte population | the major change to be in ←
$GU_sC_y^{g\sim}{:}_tC_y^{g\sim}W_i^{\uparrow b}$	, which ||| (sensitization) || 24 hr. after ← || (small lymphocyte population) | started to enlarge
$GU_sC_y^{g\sim}{:}_tC_y^{g\sim}W_\ell^{\flat}$	and (which) ||| sensitization) || (24 hr. after) || (small lymphocyte population) | (started to) label

585.3.4

M	From a careful study of
$C_y^{g\sim w}W_c^{\Delta}$	the small lymphocytes | the sequential changes in ←
$C_y^{g\sim}W_\ell$	WH ||| (small lymphocytes) | (are) labelled
M	, it is difficult not to accept the view that
$C_zY_c^fC_y^{g\sim}$	plasma cells | are derived from | small lymphocytes

587.5.1

G:CW	an antigen || to ← || The cellular | response
$C_y^{g\sim w}W_p^{\uparrow}$	consists in part of ||| small lymphocytes | the increased production of ←
$GU^2C_y^{g\sim}{:}AV_p^cC_y^{g\sim}$	which ||| a secondary stimulus || to || (Small lymphocytes) | are capable of responding

587.5.2
But a number of these cells, with the characteristic small lymphocyte morphology, are also antibody producers.

587.5.3
Jerne and Nordin and Ingraham and Bussard elaborated a method for isolating single cells producing antibody *in vitro*.

588.1.1-2
Harris *et al.* studied such cells by electron microscopy. They found small but quite definite numbers of antibody-producing cells which were typically lymphocytic in structure, in regional lymph nodes four days after a single injection of sheep red blood cells.

588.1.3
The cells in the centre of haemolytic plaques were presumably producing 19S anti-sheep-erythocyte haemolysin.

588.1.4
Plasma cells too were found.

587.5.2

$AV_pC_y^{g\sim}$ But ||| antibody | a number are also producers of | of these cells, with the characteristic small lymphocytes morphology, ←

587.5.3

M Jerne and Nordin and Ingraham and Brussard elaborated a method for

$AV_p^vC^1$ antibody | producing *in vitro* | isolating single cells ←

588.1.1-2

M Harris *et. al.* studied such cells by electron microscopy. They found

GJ^1B: $C^wW_i^-T_n^B$ sheep red blood cells | a single injection of || four days after || cells | (appeared) small but quite definite numbers of | in regional lymph nodes ←

AV_pC WH ||| antibody | (were) producing | (cells) ←

CYC_y which ||| (cells) | were typically | lymphocytic in structure

588.1.3

GJ^1B:$A^GV_pC^w$ Presumably ||| 19 S anti-sheep-erythrocyte haemolysin | were producing | the cells ←

A_qV_pC WH ||| haemolytic plaques | (were) in the center of | (cells) ←

588.1.4

GJ^1B:$C_zW_iT_n^B$ Too ||| (sheep red blood cells) | (a single injection of) || (after) ← || Plasma cells | were found (in) | (regional lymph nodes)

588.1.5
They also found antibody-producing cells in lymph and blood, and in these two instances the cells were typically pachychromatic small lymphocytes with varying amounts of endoplasmic reticulum in the cytoplasm.

588.1.5

M	They also found
$AV_pCT_{\ell'},T_b$	antibody- | producing | cells in lymph and blood
$C_y^{g\sim w}YCT_{\ell'},T_b$	, and ||| pachychromatic small lymphocytes | were typically | the cells in these two instances ←
$S_rW_i^AS_cC_y^{g\sim}$	WH ||| endoplasmic reticulum | (are) with varying amounts of | in the cytoplasm (pachychromatic, small lymphocytes) ←

APPENDIX 2

TABLES OF IMMUNOLOGY REPORTS: FRENCH

I. ELEMENTARY CATEGORIES.

A *anticorps, antitoxine*
A_g *agglutinine, hémolysine, globulinémie, α-globulinémie, β-globulinémie, γ-globulinémie*
A_q *plage d'hémolyse*
A_p *protéine, protéique, protéide*
D_r *ARN, acide ribonucléique*

G *antigène, infection, immunisation, anatoxine tétanique, salmonella-typhi, mode (d'administration), antigène radio-actif, virus de la mosaïque du tabac.*
G_f *un myélome*
B *animal, organes d'animaux, animaux, animal sacrifié, lieu (d'administration), lapin, ailleurs*
B_1 *un animal* (used as a donor)
B_2 *un autre animal* (used as a receiver)

C *cellules, lieu, localisation (# de la synthèse des anticorps), systèmes cellulaires, ailleurs*
C_r *histiocytes du système réticulo-endothélial, éléments réticulo-endothéliaux, cellules réticulaires*
$C_{r'}$ *cellules reticulaires stimulées de Gullino*
C_y *lymphocytes, cellule lymphocytaire, éléments lymphocitaires*
C_z *plasmocytes, (production #) plasmocytaire, plasmatocytes, cellule plasmocytaire*

C_z^s *myélocyte*
C_z^b *plasmoblaste*
C_y^b *lymphoblastes*
$C^{m\sim}$ *cellule intermédiaire, cellule immature, cellule à ce stade de maturité incomplète, cellule jeune*
C^m *cellule mûre, cellule développée*
CT_v *cellule hépatique*

C^a *cellule activée, stimulée*
CT^s *suspensions cellulaires*
CT_r *cellules du système réticulo-endothélial, cellules appartenant au SRE, cellules appartenant au systéme réticulo-endothélial.*
S (ultrastructure: inside the cell)
S_n *noyau*
S_r *réticulum endoplasmique*
S_c *protoplasme,cytoplasme, cytoplasmique*
S_b *polribosomes (groupés en rosette)*

T *tissu*
T_x *extrait de tissu*
T_r *système réticulo-endothelial*
T_b *circulation sanguine, sang, sérum globulimémie*
$T_{b'}$ *la moëlle*
T_k *tissu adipeux rénal*
T_d *la pulpe rouge de la rate*
T_p *la lymphe, tissue lymphoïde*
$T_{\ell'}$ *extraits de tissus lymphoïdes*
T_F *lymphosarcome*
T_s *rate*
T_n *le ganglion*
T_u *la portion médulaire, le tissu médulaire*
T_x *la région corticale*

II. 1-ORDER CATEGORIES.

J *←injection, ←on injecte...→dans..., ←introduction de...→dans, ←introduction de...→par voie...,...a été injecté, recu de différentes facons, ←incorporation dans ←rappel de*

I^t *greffé à*

V_p *produire in vitro*
V_t *←stockage, ←mise en réserve, ←lieu de dépôt*
V_u^r *participe au transfert, participe à la mise en circulation*
V_i *le titre en, en, dans, apparaissent dans, existent dans, se trouvent dans*

V_p *former, produire→ être produit dans, être produit par, synthétiser→élaborer, ←mécanisme de synthèse, (←siège) principal de la formation, actif, ←production, ←genèse-dans, ←métabolisme, ←processus de synthèse, ←activité de synthèse, ←formation, ←origine...dans, producteur ←...*
V_p^r *responsable de→, sont le siège de →, jouent le rôle principal→*
V_p^k *←capacité de produire*
$V_i^\uparrow$ *←augmentation du taux (d'agglutines)*
V_i^+ *riche en (# acide ribonucléique), hyperglobulémie*
V_s *←secréter*

U *se déplacer, contaminer*
U_i *←fixation, ←incorporation, incorporer, se fixer*
U_i^r *servent à la fixation, servent à la digestion*
U_d *←digestion*

Y *←il est difficile de distinguer, ne diffère pas, sont appelés, sont* (ex: A Y Ag represents *les anticorps sont des globulines*)
Y_c^t *totipotence, évoluer en, évoluer dans le sens de, se développe en*
Y_c^f *dérive de*

W *←modifications morphologiques*
W_c^+ *considérablement altéré*
W_i *pourvue d', comporte*
W_i^+ *hyperplasie, possède...,très developpé, riche en→*
$W_g^\uparrow$ *←augmentation de volume*
$W_i^\uparrow$ *←augmentation dans*
W_i^- *ont trés peu, faible taille dans*
W_p^+ *←prolifération, ←signes de prolifération, (C#) ←developpement dans (#T_d)*

W_m *←maturation*
W_h *←basophilie, ←apparition d'une basophilie*
W_h^+ *←affinité marquée pour les colorants, par l'incorporation massive de la glycine radioactive*
$W_h^\uparrow$ *←accroisement de la basophilie*
W_s *sont pourvues de →*

III. Superscripts. They can be attached to categories in the following conditions:

$\sim$ indicates a negation and can be attached to a predicative category, to an elementary one or even to another superscript.

m on a category of the C family, represents a mature cell.
This *m* can combine with $\sim$ and then represents an immature cell $C^{m\sim}$

cellules intermédiaires, cellules immatures, cellules plus ou moins mûres, cellules à un stade de maturité incomplète, cellules jeunes.
In the same way, $C_y^{m\sim}$ represents *éléments lymphocytaires plus ou moins mûrs, lymphocytes immatures.*

- on W_i, V_i especially, but also on other W or V.

faible, possible, ne...pas en général, peu, très peu, ne...pas...prédominant.

+ on W, W_p, W_h, W_p, W_i.

un certain degré, en grande quantité, élevé, intense, maxima, massif, de nombreuses, très developpé, à un taux appréciable, hyper-, augmentation, beaucoup plus, riche, beaucoup plus, si (# actif) particulièrement, considérablement, évidente (# basophilie), (affinité #) marquée, prolifération, en quantité supérieure à la normale.

e on U_i or V_i. *précoce, préalable.*

e$\sim$ *plutôt tardif*

$>$ on 1-order categories. It represents *plus...que, beaucoup*

e$>$ represents

avant (*les anticorps existent dans les cellules avant d'apparaître dans la circulation sanguine*)

r on V_r and U_i. It represents
a un rôle de, responsable de, se caractérise par.
r~ *ne sont pas capables de (#synthétiser)*

i on V_s *rapidement*

k on V_p *la capacité*

v on V_p *in vitro*

n on V, W *une persistance, continuent*

↑ on W, V_p *accroissement, augmentation*

↓ on W_i, V_p *toujours plus faible*

↑+ *augmentation particulièrement frappante*

IV. Category on units ":"

: *produit, est suivi de, à la suite de, transmet*

$:_t$ *débute peu de temps après, après huit et douze jours, après cinq jours, une fois, après, plutôt tardive.*

G: A *(anticorps qui réagit) spécifiquement à (l'antigène, (l'anticorps) spécifique à l'antigène), l'antigène homologue à l'anticorps.*

"Etude Autoradiographique de L'incorporation de la Glycine – I – C, lors de la Synthèse des Anticorps," F. Gavosto et A. Ficq, *Ann. Inst. Pasteur*, v. 86 (1954), 425-437.

425

1.1 L'étude du lieu où s'effectue la synthèse des anticorps a pris, au cours de ces dernières années, un essor remarquable, en raison surtout des liens qui unissent ce problème à celui, plus général, de la localisation et du mécanisme de la synthèse protéines.

3.2 Mais les cellules qui incorporent les antigènes ne sont pas nécessairement celles qui sont responsables de l'élaboration des anticorps.

3.3 En effet, il n'est pas possible de préciser si ces cellules servent seulement à la fixation et à la digestion préalable de l'antigène, ou si elles réalisent la synthèse définitive de l'anticorps.

425

1.1	M	L'étude du
	AV_pC	anticorps→| s'effectue la synthèse des |← lieu où
	M	a pris au cours de ces dernières années, un essor remarquable, en raison surtout des liens qui unissent ce problème à celui plus général de
	A_pV_pC	(protéines→| la synthèse des) |←la localisation (de)
	$A_pV_p^m$	et ||| protéines→| le mécanisme de la synthèse des
3.2	GU_iC	Mais ||| les antigènes→| incorporent |←les cellues qui
	AV_p^rC	ne sont pas nécessairement ||| anticorps→| sont responsables de l'élaboration des |←celles qui (les cellules).
3.3	M	En effet, il n'est pas possible de préciser si seulement
	GU_i^rC	l'antigène→| servent à la fixation de |←ces cellules
	$GU_d^{er}C$	et ||| l'antigène→| (servent) à la digestion préalable de |← (ces cellules)
	AV_pC	ou si ||| l'anticorps→| réalisent la synthèse définitive de | ←elles (ces cellules).

4.1 Le premier moyen d'investigation qui ait été utilisé pour attaquer la question a été l'observation des modifications morphologiques que subissent des organes variés à la suite de l'introduction de l'antigène; on a notament, suivi les relations existant entre l'hyperplasie de certains systèmes cellulaires et le titre en anticorps du plasma, de la lymphe, ou méme de suspensions cellulaires.

426

3.1 Deux théories principales s'affrontent: celle, d'une part, qui voit dans le *cellule lymphocytaire* le siège principal de la formation des anticorps, et celle qui attribue cette fonction aux *cellules du système réticulo-endothélial.*

4.1 Ces deux conceptions se basent principalement sur des observations décrivant une hyperplasie soit réticulo-endothéliale, soit lymphocytaire, dans les organes d'animaux qui ont reçu de différentes façons des antigènes.

4.1	M	le premier moyen d'investigation qui ait été utilisé pour attaquer la question a été l'observation
	GJ:TW	(1) l'antigène→| l'introduction de ||←à la suite de || des organes variés→|←des modifications morphologiques;
	M	On a notamment suivi
	CW_i^+	les relations existant entre ||| de certains systèmes cellulaires |←l'hyperplasie
	AV_iT_b	et ||| anticorps |←le titre en | du plasma
	AV_iT_l	, ||| (anticorps |←le titre en) | de la lymphe
	AV_iCT^s	ou même ||| (anticorps |←le titre en) | de suspensions cellulaires
426		
3.1	M	Deux théories principales s'affrontent: celle, d'une part, qui voit dans
	AV_pC_y	des anticorps→| le siège principal de la formation |← le lymphocyte
	M	et celle qui attribue... aux
	AV_pTC_r	(des anticorps)→|cette fonction (d'être le siège principal de formation) |←cellules du système réticulo-endothélial.
4.1	M	Ces deux conceptions se basent principalement sur des observations décrivant
	$GJB:TC_rW_i^+T^B$	soit ||| des antigènes |reçus de différentes façons | dans des organes d'animaux (|| produisant ||) une hyperplasie | (des cellules du système) réticulo-endothéliale(s) | (dans les organes d'animaux injectés)
	$GJB:C_yW_i^+T^B$	soit ||| (des antigènes | reçus de différentes façons | dans des organes d'animaux || produisant ||) une hyperplasie | (des cellules) lymphocytaires(s) | (dans les organes d'animaux injectés)

6.1 White, par exemple, admet que les lymphocytes pourraient ne représenter qu'un lieu de dépôt des anticorps, qui pourraient être synthétisés ailleurs: récemment, Ringertz et al. ont admis que les plasmatocytes pourraient décriver de lymphoblastes qui, une fois stimulés par l'antigène, évolueraient en plasmatocytes producteurs d'anticorps, plutôt qu'en lymphocytes.

8.1 En recueillant le matériel issu du canal lymphatique efférent du ganglion et en le centrifugeant, Harris et ses collaborateurs ont, notamment, pu démontrer l'existence d'un titre beaucoup plus élevé en anticorps dans les lymphocytes isolés que dans la lymphe elle-même.

9.1 D'autre part, Fagraeus a observé, *in vitro*, que la capacité de la pulpe rouge de la rate à former des anticorps est nettement supérieure à celle des follicules lymphocytaires; or les fragments de pulpe rouge qui se montrent si actifs sont aussi particulièrement riches en plasmatocytes.

6.1	M	White par exemple admet que... pourraient ne représenter que...
	$A^{w}V_{t}C_{y}$	des anticorps$^{\rightarrow}$| un lieu de dépôt |$^{\leftarrow}$les lymphocytes
	$AV_{p}C_{y\sim}$	WH- ||| qui (les anticorps) | pourraient être synthétisés | ailleurs (dans d'autres cellules)
	M	récemment, Ringertz et al. ont admis que
	$C_{z}Y_{c}^{f}C_{y}^{bw}$	les plasmocytes | pourraient dériver de | lymphoblastes
	$GJ{:}C_{y}^{b}Y^{f}C_{z}^{w}$	WH- ||| l'antigène $^{\rightarrow}$ | stimulés par || une fois ||$^{\leftarrow}$ qui | évolueraient en | plasmocytes
	$AV_{p}C_{z}$	WH- ||| anticorps$^{\rightarrow}$| (sont) producteurs d' |$^{\leftarrow}$(plasmocytes).
	$C_{y}^{b}Y_{c}^{t}C_{y}$	plutôt qu' ||| (les lymphoblastes | évolueraient) en | lymphcytes.
8.1	M	En recueillant le matériel issu du canal lymphatique efférent du ganglion et en le centrifugeant, Harris et ses collaborateurs ont notamment pu démontrer l'existence d'
	$AV_{i}^{>}C_{y}^{1}$	(2) anticorps |←un titre beaucoup plus élevé en | dans les lymphocytes isolés
	$AV_{i}T_{1}$	que ||| (anticorps) |←(un titre est élevé en) | dans la lymphe elle-même.
9.1	M	D'autre part, Fabraeus a observé que
	$AV_{p}^{vk}T_{d}$	(3) est nettement supérieure→||| des anticorps |←la capacité à former in vitro | de la pulpe rouge de la rate
	$AV_{p}^{vk}C_{y}T_{f}$	à ||| (des anticorps) |←celle (la capacité à former in vitro) | des follicules lymphocytaires
	$C_{z}W_{i}T_{d}^{xw}$	Or ||| plasmocytes →| sont aussi particulièrement riches en |← les fragments de pulpe rouge
	$AV_{p}^{r}T_{d}^{x}$	WH-||| (des anticorps)→| se montrent si actifs (à produire) |←qui (les fragments de pulpe rouge)

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2.1 Les ganglions poplités satellites des animaux injectés d'antigène manifestent une augmentation de volume (environs 1,5 par rapport aux ganglions des témoins): cette augmentation était particulièrement frappante dans le cas de l'animal sacrifié après huit jours.

2.2 La structure microscopique des ganglions satellites est considérablement altérée. Chez l'animal sacrifié après cinq jours, on note d'intereses phénomènes de prolifération tant dans le tissu médullaire que dans la région corticale.

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2.1	GJB:$T_n^B W_9^{\updownarrow}$	(4) d'antigenes→| injectés |←(chez) des animaux || (:) || les ganglions poplités satellites | manifestent une augmentation de volume d'environ 1,5 par rapport aux ganglions des témoins;
	GJB:$_t T_n^B W_g^+$	dans le cas de ||| (antigènes→| injecté d' |) |←l'animal || sacrifié après huit jours || (les ganglions poplités satellites)→|←cette augmentation était particulièrement frappante (dans).
2.2	$T_n W_c^+$	Des ganglions satellites |←la structure microscopique est considérablement altérée.
	M	On note
	GJB:$_t T_u W_p^+$	tant ||| (antigènes | injecté d' |) |←chez l'animal || sacrifié après cinq jours || le tissu médulaire→| intenses phénomènes de prolifération dans
	GJB:$_t T_x W_p^+$	que ||| (antigènes→| injecté d' |←chez l'animal || sacrifié après jours ||) dans la région corticale |←(intenses phénomènes de prolifération dans).

3.1 Dans la portion médullaire, on reconnait, à côte d'éléments lymphocytaires plus ou moins mûrs, de nombreuses cellules réticulaires jeunes, pourvues d'un grand noyau ovoide ou réniforme. Certaines de ces cellules ne possèdent qu'un cytoplasma ténu, non colorable à la pyronine; mais la majorité d'entre elles présentent une évidente basophilie (*cellules réticulaires stimulées* de Gullino).

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5.1 Après l'administration de l'antigène, on observe une prolifération précoce des éléments réticulo-endothéliaux du ganglion.

5.2 Les cellules réticulaires stimulées montrent une affinité marquée pour les colorants basiques (pyronine).

6.1 L'apparition d'une telle basophilie peut être interprétée comme l'expression d'un accroissement de la synthèse protéique: on connait, en effet, les rapports existant entre la présence d'acide ribonucléique en grande quantité et la synthèse des protéines (Brachet, Caspersson).

3.1	M	On reconnait
	$C_r^m \sim W_i^+ T_u$	des cellules réticulaires jeunes | nombreuses dans | la portion médullaire
	$C_y^m \sim W_i T_u$	à côté d' ||| éléments lymphocytaires plus ou moins mûrs | (dans | la portion médullaire)
	$C_r^m \sim S_n W_{g,e}$	(de nombreuses cellules réticulaires jeunes) | (sont) pourvues d'un grand noyau ovoïde ou réniforme.
	$C_r^m \sim S_c W_{h\sim}$	certaines de ||| ces cellules (réticulaires jeunes) | un cytoplasme→| ne possèdent que ténu, non colorable à la pyronine
	$C_r^m \sim W_h$	mais la majorité d'entre ||| elles (cellules réticulaires jeunes) | présentent une évidente basophilie
	$C_r^m \sim YC_r^a$	(ces cellules réticulaires jeunes | sont appellées | [cellules réticulaires stimulées de Gullino].
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5.1	M	On observe[5]
	$GJ{:}C_r W_p^{+e} T_n$	l'antigène→| l'administration de ||← après || des éléments rétioculo-endothéliaux |←une prolifération précoce | du ganglion.
5.2	$C_r^a W_h^+$	les cellules réticulaires stimulées | montrent une affinité marquée pour les colorants basiques [pyronine].
6.1	$C_r^a W_h^+$	(des cellules réticulaires stimulées) |←l'apparition d'une telle basophilie
	M	peut être interprétée comme l'expression d'
	$A_p V_p^{\uparrow} C_r^a$	protéique |←un accroissement de la synthèse | des cellules réticulaires stimulées:
	M	on connaït, en effet, [Brachet, Casperson]
	$D_r V_i^+$	les rapports existants entre ||| acide ribonucléique→ | la présence en grande quantité d'
	$A_p V_p$	et ||| protéines→ | la synthèse des.

11.1 De nombreuses cellules réticulaires stimulées évoluent dans le sens plasmatocytaire:

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1.1 Durant la maturation des plasmatocytes, on observe également un accroissement de la basophilie cytoplasmique: il s'agit sans doute là d'une persistance, sinon d'une augmentation, des processus de synthèse protéique.

2.1 Dans nos préparations, les plasmatocytes présentent, eux aussi, une activité élevée.

2.2 Mais ni leur augmentation numérique ni leur activité ne sont assez importantes pour faire penser que les anticorps soient élaborés exclusivement dans les éléments de ce type.

5.1 La production de l'anticorps débute peu de temps après l'introduction de l'antigène.

11.1	$C_r^a Y_c^t C_z$	de nombreuses ||| cellules réticulaires stimulées | évoluent dans le sens plasmatocytaire
434		
1.1	M	On observe également
	$C_z W_m$	durant ||| des plasmatocytes→| la maturation
	$S_c W_h^{\uparrow}$	cytoplasmique→| un accroissement de la basophilie;
	M	il s'agit sans doute là d'
	$A_p V_p^n$	protéique→| une persistance des processus de la synthèse
	$A_p V_p^{\uparrow}$	sinon d' ||| (protéique)→| une augmentation (des processus del la synthèse)
2.1	M	Dans nos préparations
	$AV_p^+ C_z$	présentent eux aussi une activité élevée→| les plasmatocytes
2.2	$C_z W_p^{\uparrow}$	Mais ni ||| leur (plasmatocytes) | augmentation numérique
	$AV_p C_z$	ni ||| activité |←(plasmatocytes) leur
	M	ne sont assez importantes pour faire penser que, exclusivement
	$AV_p C_z$	les anticorps | soient élaborés dans | des cellules de ce type (plasmatocytaire)
5.1	$GJ:_t AV_p^b$	(6) l'antigène→| l'introduction de ||←peu de temps après || l'anticorps→| débute la production de

5.2 On a pu démontrer avec certitude, au moyen d'antigènes marqués, que ces derniers sont incorporés principalement dans les cellules appartenant au S.R.E.: l'incorporation préférentielle dans les divers organes dépend, on s'en souvient, du mode et du lieu de l'administration.

6.1 Gavosto et Ficq, notamment, ont constaté, par la technique autoradiographique, qu'un antigène radioactif, le virus del la mosaïque du tabac, se fixe en majeure partie dans les cellules réticulo-endothéliales et dans les cellules hépatiques.

8.1 De son côté, Fagraeus a démontré que les cellules réticulaires de la rate, en particulier les plasmatocytes, produisent des anticorps, même *in vitro*.

9.1 Ces exemples, ainsi que de nombreux autres, plaident en faveur de l'hypothèse suivant laquelle les cellules réticulo-endothéliales seraient responsables de plus qu'une simple incorporation de l'antigène.

5.2	M	On a pu démontrer avec certitude, au moyen d'antigènes marqués que
	GU_iCT_r	principalement ||| ces derniers (antigènes marqués) | sont incorporés dans | les cellules appartenant au SRE:
	GU_iT	de l'antigène→| l'incorporation préférentielle dans | les divers organes
	GJB:	dépend de ||| (de l'antigène)→| le lieu et le mode d'administration
	M	on s'en souvient
6.1	M	Gavosto et Ficq, notamment, ont constaté, par la technique autoradiographique, qu'en majeure partie
	GU_iC_r	un antigène radioactif, le virus de la mosaïque du tabac, | se fixe dans | les cellules réticulo-endothéliales
	GU_iCT_v	et ||| (l'antigène radioactif, le virus de la mosaïque du tabac | se fixe dans) | les cellules hépatiques.
8.1	M	De son côté, Fagraeus a démontré que
	$AV_p^vC_rT_s$	des anticorps | produisent in vitro | les cellules réticulaires de la rate.
	$AV_p^vC_z$	en particulier, ||| 1 (des anticorps→| produisent même in vitro |) ← les plasmatocytes
9.1	M	Ces examples ainsi que de nombreux autres, plaident en faveur de l'hypothèse selon laquelle, c'est de plus que d'une simple
	$GU_i^rC_r$	l'antigène |←(que) seraient responsables incorporation de | les cellules réticulaires endothéliales

9.2 Le présent travail établit précisément que ces cellules sont le siège d'un intense métabolisme protéique: l'hypothèse que l'élaboration des anticorps se ferait dans les cellules réticulo-endothéliales, principalement sinon exclusivement se voit donc renforcée.

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1.1 Une activité qui est toujours plus faible, a été trouvée, dans nos préparations, au niveau des cellules du type lymphocytaire *sensu strictiori.*

2.1 Dans leur cas, on note que l'activité maxima semble bien se manifester dans les lymphocytes jeunes (lymphoblastes) des centres folliculaires; il est d'ailleurs difficile de distinguer, dans nos préparations, ces cellules des éléments réticulaires jeunes.

3.1 D'autre part, spécialement dans le cas des animaux sacrifiés après huit et douze jours, il apparaît des signes de prolifération lymphocytaire.

3.2 Le fait qu'un certain degré d'hyperplasie succède à l'intense réaction réticulo-endothéliale nous fait croire à une participation plutôt tardive de la lignée lymphocytaire.

9.2	M $A_pV_p^+C_r$	Le présent travail établit précisément que protéique→| sont le siège d'un intense métabolisme |←ces cellules (réticulo-endothéliales).
	M $AV_p^rC_r$	L'hypothèse se voit donc renforcée que principalement, sinon exclusivement des anticorps→|←l'élaboration se ferait | dans des cellules réticulo-endothéliales.
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1.1	M $AV_p^{\downarrow}C_y$	Dans nos préparations, a été trouvée une activité qui est toujours plus faible | au niveau des cellules du type lymphocitaire sensu strictiori.
2.1	M $C_y^m \sim T_fW_a^+$	Dans leur cas (nos préparations), on note que les lymphocytes jeunes→| des centres folliculaires |←l'activité maxima semble bien se manifester dans
	$C_y^m \sim YC_b$	(WH- ||| les (lymphocytes jeunes | sont | des) lymphoblastes;
	M $C_y^m \sim YC_r^m$	il est d'ailleurs difficile, dans nos préparations ces cellules (les lymphoblastes) |←de distinguer | des éléments réticulaires jeunes.
3.1	$GJB:_tC_yW_p$	D'autre part, ||| spécialement dans le cas de ||| (l'antigène |←l'injection de | à) des animaux || sacrifiés après huit et douze jours || lymphocytaire |←il apparait des signes de prolifération
3.2	$C_yW_i^+$	(des cellules lymphocytaires)→| un certain degré d'hyperplasie
	$C_rW_a^+$	succède à ||| réticulo-endothéliale→ | l'intense réaction
	M $C_y^{\not}W_a^{e\sim}$	ce fait nous fait croire à la lignée lymphocytaire→| une participation plutôt tardive de

4.1 Il se pourrait donc fort bien que celle-ci ne joue pas de rôle prédominant dans l'élaboration de l'anticorps, mais qu'elle participe plutôt aux phénomènes qui président au transfert et à la mise en circulation de celui-ce.

5.1 En effet, les lymphocytes du canal efférent du ganglion sont très riches en anticorps (Harris) qu'ils peuvent libérent rapidement sous l'action de diverses stimulations endogènes ou exogènes (White et Dougherty):

6.1 De toutes ces observations, il résulte qu'une conception nettement dualiste de la genèse des anticorps dans les plasmatocytes ou dans les lymphocytes apparait comme dépassée: en effet, l'élément cytologique dominant dans le tissu ganglionnaire en train de réagir à la stimulation antigénique est une cellule réticulaire jeune.

4.1	M	Il se pourrait donc fort bien que
	$AV_p^r \sim C_y^{\not}$	l'anticorps | ne joue pas le rôle prédominant dans l'élaboration de | celle-ci (la ligneée lymphocytaire)
	$AV_u^r C_y^{\not}$	[7]mais plutôt qu' ||| celui-ci (l'anticorps)$^{\rightarrow}$| participe aux phénomènes qui président au transfert de |$^{\leftarrow}$ elle (la lignée lymphocytaire)
	$AV_u^r C_y^{\not}$	et ||| celui-ci (l'anticorps$^{\rightarrow}$| participe aux phénomènes qui président) à la mise en circulation de |$^{\leftarrow}$ (la lignée lymphocytaire)
5.1	M	en effet, Harris et White et Dougherty (ont montré respectivement que)
	$AV_i^+ C_y T_p^f T_n^w$	anticorps$^{\leftarrow}$| sont très riches en |$^{\leftarrow}$ les lymphocytes de canal efférent de ganglion
	$AV_s^i C_y T_p^f T_n$	WH- ||| qu' (anticorps) | peuvent libérer rapidement sous l'action de deverses stimulations endogènes ou exogènes$^{\rightarrow}$| ils (les lymphocytes du canal efférent du ganglion).
6.1	M	De toutes ces observations, il résulte qu'apparaît comme dépassée une conception nettement dualiste de
	$AV_p C_z$	des anticorps |$\leftarrow$la genèse | dans les lymphocytes:
	$AV_p C_y$	ou ||| (des anticorps |$^{\leftarrow}$la genèse) | dans les lymphocytes:
	$GJ{:}C_r^m \sim W_a^+ T_n$	[8] en effet, ||| la stimulation antigénique$^{\rightarrow}$||$^{\leftarrow}$ à || une cellule réticulaire jeune | est l'élément cytologique dominant en train de réagir | dans le tissus ganglionnaire.

6.2 Celle-ci ne diffère de la cellule réticulaire au repos que par sa forte basophilie cytoplasmique, expression d'un intense métabolisme protéique; c'est pourquoi ce type de cellule a été appelé par certains auteurs italiens (Mottura, Gullino): cellule réticulaire activée.

7.1 Si l'on accept le concept de la totipotence de la cellule réticulaire primitive, on doit admettre que le lymphocyte, tout comme le plasmatocyte, en dérivent.

6.2	$C_r^{m\sim a}YC_r^{m\sim a\sim}$	Celle-ci (la cellule réticulaire jeune soumise à la stimulation antigénique) | ne diffère de | la cellule réticulaire (jeune) au repos
	$S_cW_h^+C_r^{m\sim a}$	que par ||| cytoplasmique$^{\rightarrow}$| forte basophilie |$^{\leftarrow}$sa (la cellule réticulaire jeune soumise à la stimulation antigénique)
	$A_pV_p^+$	expression d'||| protéique$^{\rightarrow}$| un intense métabolisme
	$C_r^{m\sim a}YC_r^a$	c'est pourquoi ||| ce type de cellule (réticulaire jeune soumise à la stimulation antigénique) | a été appelée par ceratins auteurs italiens [Mottura, Gullino]: | cellule réticulaire activée.
7.1	M	Si l'on accepte le concept de
	$C_r^{m\sim}Y_c^tC$	la cellule réticulaire primitive$^{\rightarrow}$| la totipotence
	M	On doit admettre que
	$C_yY_fC_r^{m\sim}$	le lymphocyte | dérive$^{\rightarrow}$| en (la cellule réticulaire primitive)
	$C_zY_c^fC_r^{m\sim}$	tout comme ||| le plasmatocyte | (dérive | de la cellule réticulaire primitive)

7.2 Il se peut que les processus de synthèse des anticorps continuent dans ce dernier, même pendant sa maturation: il se caractérise, en effet, par la persistance d'une forte basophilie et l'incorporation massive de la glycine radioactive; le lymphocyte ne ferait que conserver les anticorps déjà formés et il interviendrait dans leur transport et leur mise in réserve.

NOTES

(1) The linearization produces the sentence:... *la question a été l'observation, à la suite de l'introduction de l'antigène, des modifications morphologiques des organes variés*, instead of: ... *la question a été l'observation des modifications morphologiques que subissent des organes variés à la suite de l'introduction de l'antigène.*

(2) $AV_i > C_y$, AV_iT_1, are linearized:
...Un titre beaucoup plus élevé en enticorps dans la lymphocytes isolés que le titre est élevé dans la lymphe elle-même. This can be reduced: ... *Un titre beaucoup plus élevé en anticorps dans les lymphocytes isolés que dans le lymphe elle-même.*

(3) The higher verb-phrase *est nettement supérieure à* cannot be linearized within the lower verb-phrase *capacité à former.* This is why it is represented here as a conjunction though its informational content is represented by the superscript ">" inside the unit.

(4) In this paragraph, our representation shows several stylistic permutations. The linearization of the first unit is: *chez des animaux injectés d'antigènes, les ganglions poplités satellites manifestent une augmentaton de volume d'environ 1,5 par rapport aux ganglions des témoins.*

(5) The linearization of this unti and the preceding M is: *On observe après l'administration de l'antigène une prolifération précoce des éléments réticulo-endothéliaux des ganglions.*

(6) The linearization is: ... *Peu de temps après l'introduction de l'antigen débute la production de l'anticorps.*

(7) The linearization is: ... *mais plutôt qu'elle (la lignée lymphocytaire) participe aux phénomènes qui président au transfert et à la mise en circulation de celui-ci (l'anticorps).*

(8) The linearization is: *en effet, à la stimulation antgénique, une cellule réticulaire jeune est l'elément cytologique dominant en train de réagir dans le tissu ganlionnaire.*

(9) Ad hoc additional rules for the linearization of sentences containing pronouns must be added. For example, 1a and 2a have to be transformed into 1b and 2b
1a * et il interviendrat dans le transport leur
1b et il interviendrat dans leur transport
2a * et la mise en réserve leur
2b et leur mise en réserve

27.2	M	Il se peut que
	$AV_p^nC_z$	des anticorps$^{\rightarrow}$| les processus de synthèse continuent | dans ce dernier (le plasmatocyte)
	C_zW_m	même pendant ||| sa (du plasmatocyte) | maturation
	$C_zW_h^{+m}$	: en effet ||| il (le plasmatocyte) | se caractérise par la persistance d'une forte basophilie
	$C_zW_h^+$	et ||| il (le plasmatocyte | se caractérise) par l'incorporation massive de la glycine radioactive
	$A^wV_tC_y$	les anticorps$^{\rightarrow}$| ne ferait que conservar |$^{\leftarrow}$le lymphocyte
	AV_p	WH- ||| (les anticorps) | déjà formés
	$AV_u^rC_y$	(9) et ||| leur (des anticorps)$^{\rightarrow}$| interviendrait dans le transport |$^{\leftarrow}$ il (le lymphocyte)
	AV_tC_y	et ||| leur (des anticorps)$^{\rightarrow}$| (interviendrait dans la) mise en réserve |$^{\leftarrow}$(le lymphocyte)

La Synthese des anticorps *in Vitro*", Alain Bussard, *Mem. Acad. Med. Belg.*, (1972) 406-7

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2.1 Un exemple des résultats de l'observation des cellules productrices d'hémolysine peut se voir dans les figures 3 et 4.

2.2 La figure 3 montre un lymphocyte producteur d'anticorps alors que la figure 4 montre un plasmatocyte.

2.3 Ces deux photos ont été prises au microscope au contraste de phase avec un grandissement final de 8 à 900. Dans ces conditions on peut déjà affirmer que deux types de cellules lymphoïdes participent à la synthèse des anticorps *le plasmacyte* dont on avait déjà démontré l'activité par d'autres expériences et *le lymphocyte* qui se trouve être un candidat plus inattendu à cette activité, étant donné la faible taille de son cytoplasme et les lieux de stockage possibles d'anticorps.

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2.1	M	Un exemple des résultats de l'observation
	AV_pC	hémolysine$^{\rightarrow}$| productrices d' |$^{\leftarrow}$des cellules
	M	peut se voir dans les figures 3 et 4.
2.2	M	La figure 3 montre
	AV_pC_y	anticorps$^{\rightarrow}$| producteur d' |$^{\leftarrow}$un lymphocyte
	M	alors que la figure 4 montre
	AV_pC_z	(anticorps$^{\rightarrow}$| producteur d') |$^{\leftarrow}$un plasmocyte.
2.3	M	Ces deux photos ont été prises au microscope au contraste de phase avec un grandissement final de 8 à 900.
	M	Dans ces conditions, on peut déjà affirmer que
	$AV_p^rC_{\gamma}^{1,2}$	anticorps$^{\rightarrow}$| participent à la synthèse des |$^{\leftarrow}$deux types de cellules lymphoïdes:
	$AV_p^rC_z^w$	(anticorps$^{\rightarrow}$| participe à la synthèse des) |$^{\leftarrow}$le plasmocyte
	$AV_p^rC_z$	WH- ||| (anticorps)$^{\rightarrow}$| l'activité (de synthèse des) |$^{\leftarrow}$dont
	M	(1) avait déjà été démontré par d'autres expériences,
	$AV_p^rC_y^w$	et ||| (des anticorps$^{\rightarrow}$| participe à la synthèse) |$^{\leftarrow}$le lymphocyte
	$AV_p^rC_y$	WH- ||| (des anticorps)$^{\rightarrow}$| se trouve être un candidat plus inattendu à cette activité (de synthèse) |$^{\leftarrow}$qui,
	$S_cW_i^-C_y$	(2) étant donné ||| cytoplasme$^{\rightarrow}$|$^{\leftarrow}$la faible taille de | son (le lymphocyte)
	$AV_t^rSC_y$	et ||| des anticorps$^{\rightarrow}$| de stockage possibles |$^{\leftarrow}$les lieux | (des cellules).

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1.1 Depuis quelque années la microscopie électonique (Bussard et Binet, 1965) et (Harris et Hummler, 1966) a pu être appliquée aux cellules productrice des plages d'hémolyse et a égalment démontré que deux types de cellules lymphoïdes: lymphocytes et plasmocytes, participaient à la synthèse des anticorps.

1.2 Le premier type ne comporte pas en général de réticulum endoplasmique organisé, mais au plus des polyribosomes groupés en rosettes.

1.3 Le second type cellulaires, par contre, possède un réticulum endoplasmique très développé et des lieux de stockage des anticorps formés.

NOTES

(1) Instead of applying a passive transformation on this méta-sentence (... *avait déjà été démontré*... instead of ... *on avait déjà démontré*...) we could insert the actual active sentence using an additional symbol of linearization to "read" it after the *dont* and before *l'activité (de synthèse des anticorps).* As this M is not a proper informational unit, the choice is not very important.

(2) The linearization of the unit $C_yW^-S_c$ is given here for its reduced form. The unreduced form would be: *étant donné que le plasmatocyte a une faible taille de cytoplasme*

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1.1	M	Depuis quelques années la microscopic électronique [Bussard et Binet, 1965] et [Harris et Hummeler, 1966] a pu être appliquée aux
	A_qV_pC	plages d'hémolyse→| productices de |←cellules
	M	et (la microscopie élecyronique) a également démontré que
	$AV_p^rC_\ell^{1,2}$	des anticorps→ | particpaient à la synthèse |←deux types de cellules lymphoides:
	$AV_p^rC_y$	(anticorps→| participaient è la synthèse des) |←(les) lymphocytes
	$AV_p^rC_z$	et ||| anticorps→| (participaient à la synthèse des) |←(les) plasmocytes.
1.2	$S_rW_i^-C_y$	réticulum endoplasmique organisé→| ne comporte pas en général de |← le premier type (les lymphocytes)
	$S_bW_i^+C_y$	mais ||| des polyribosomes groupés en rosettes→| (comportent) en plus |← (les lymphocytes)
1.3	$S_rW_m^+C_z$	par contre ||| un réticulum endoplasmique→| possède, très développé |←le second type cellulaire (les plasmocytes)
	$A^wV_tSC_z$	et ||| des anticorps→| de stockage |←(le plasmocyte possède) des lieux
	AV_p	WH- | (les anticorps qui | sont) formés.

"Origine et Role des Anticorps et des Globulines du Serum," Pierre Grabar, *Ann. Inst. Pasteur*, v.79 (1950), 641-53.

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2.1 D'après la définition classique, les anticorps sont des substances, des globulines, qui apparaissent dans la circulation à la suite de l'introduction parentérale d'un antigène et qui réagissent spécifiquement avec cet antigène.

2.2 La définition de l'antigène: substance qui, introduite par voie parentérale à l'animal, provoque la formation d'anticorps, n'ajoute pas beaucoup de renseignements précis.

2.3 Les deux faits les plus importants que nous retiendrons de ces définitions sont: les anticorps sont des *globulines* et ils *réagissent spécifiquement* avec les antigènes homologues.

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2.7 De nombreaux expérimentateurs ont, en effet, démontré que les anticorps avant leur apparition dans la circulation sanguine existent dans des cellules.

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2.1	M	D'après la définition classique,
	$A^{w}YA_{g}$	les anticorps | sont | des substances, des globulines
	$GJ:AV_{i}T_{b}$	(1) WH- ||| un antigène→| l'introduction parentérale d' ||←à la suite de ||←qui (les anticorps) | apparaissent dans | la circulation
	G:A	et WH- ||| cet antigène→|| réagissent spécifiquement avec ||←qui (les anticorps)
2.2	M	La définition de l'antigene n'ajoute pas beaucoup de renseignements précis:
	$GJB:AV_{p}$	(l'antigène est une) substance qui, | introduite | par voie parentérale à l'animal, || provoque || anticorps |←la formation d'
2.3	M	Les deux faits les plus importants que nous retiendrons de ces définitions sont:
	AYA_{g}	les anticorps | sont | des globulines
	G:A	et ||| les antigènes →|| réagissent specifiquement avec ||← ils (les anticorps)
	G:A	(les antigènes) || (sont) homologues (aux) || (anticorps)
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2.7	M	De nombreux expérimentateurs ont, en effet, démontré que
	$AV^{e>}C$	(2) les anticorps | existent avant dans | des cellules
	$AV_{i}T_{b}$	leur (des anticorps) | apparition dans | la circulation sanguine

2.8 De plus, dans certains cas, n'arrive même pas à trouver des anticorps dans le sang, tandis qu'on peut les mettre en évidence à un taux appréciable dans des extraits des tissus infectés; il en est ainsi, par exemple, dans le cas de l'infection expérimentale de la Souris par le virus de la lymphogranulomatose inguinale.

3.1 Quelles sont les cellules capables de synthétiser les anticorps?

3.2 On disait, il y a quelque temps encore, que c'est le système réticulo-endothélial ou bien les histiocytes de ce système qui jouent le rôle principal.

3.3 Mais depuis quelques années, un très grand nombre de travaux ont été consacrés à cette question et deux tendances se sont opposées: la théorie lymphocytaire et la théorie plasmocytaire.

2.8	$AV_i^{\sim}T_b$	De plus, dans certain cas ||| des anticorps→|←on n'arrive même pas à trouver dans	le sang,
	$AV_i^{+}T^{xw}$	tandis qu' ||| les (anticorps) |←on peut mettre en évidence à un taux appréciable	dans des extraits de tissus
	GU_iT_x	WH-			infectés	(←tissus);
	M	il en est ainsi, par exemple, dans le cas de
	$GJB{:}AV_i^{\sim}T_b$		par le virus de la lymphogranulomatose inguinale→|←l'infection expérimentale	de la souris || : || (des anticorps→)|←on n'arrive même pas à trouver	dans le sang,
	$AV_i^{+}T^{xw}$	tandis qu' ||| les (anticorps) |←on peut mettre en évidence à un taux appréciable	dans des extraits de tissus
	GU_iT^x	WH-			infectés	(tissus)).
3.1	M	Quelles sont...?
	AV_p^rC	les anticorps→| capables de synthésiser |←les cellules.
3.2	M	On disait, il y a quelques temps encore, que
	$AV_p^rT_r$	(des anticorps)→	joue le rôle principal (dans la synthèse)	← le système réticulo-endothélial
	$AV_p^rC_rT_r$	ou bien ||| (les anticorps)	jouent le rôle principal (dans la synthèse des) |←les histiocytes de ce système (réticulo-endothélial).
3.3	M	Mais depuis quelques années, un trés grand nombre de travaus ont été consacrés à cette question et deux tendances se sont opposées:
	AV_pC_y	la théorie (des anticorps | produits par | les cellules) lymphocytaire(s)
	AV_pC_z	et ||| la théorie (des anticorps | produits par | les cellules) plasmocytaire(s).

3.4 Nous nous limiterons ici à un aperçu schématique de la question et ne citerons que les principaux arguments invoqués par les défenseurs des deux tendances.

4.1 Ce sont surtout des auteurs scandinaves qui ont développé des arguments en faveur de la formation des anticorps et, en général, des globulines par les plasmocytes.

4.2 Ils constatent, en effet, que dans tous les cas pathologiques d'hyperglobulinémie il y a augmentation des plasmocytes.

4.3 De plus, de par leurs propriétés tinctoriales, les plasmocytes seraient riches en acide ribonucléique, que l'ont croit être responsable de la synthèse des protéides (Casperson, Brachet), tandis que les lymphocytes ont très peu de protoplasme.

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1.2 Il serait donc plus facile d'admettre que ce sont les plasmocytes et non les lymphocytes qui pourraient sécréter des protéides.

1.3 On peut objecter, à cette maniere de voit, que les arguments invoqués sont indirects.

3.4	M	Nous nous limiterons ici à un aperçu schématique de la question et ne citerons que les principaux arguments invoqués par les défenseurs des deux tendances.
4.1	M	Ce sont surtout des auteurs scandinaves qui ont développé des arguments en faveur de
	AV_pC_z	des antticorps |←la formation | (par les plasmocytes)
	$A_gV_pC_z$	et, en général ||| des globulines (|←la formation)| par les plasmocytes.
4.2	M	Ils constatent, en effet, que
	$A_gV_i^+$	dans tous les cas d' ||| hyper-globulinémie pathologique
	$C_zW_i^+$	il y a ||| des plasmocytes |←augmentation.
4.3	C_zW_l	De plus, de par ||| leur (les plasmocytes) | propriétés tinctoriales,
	$D_r^wV_i^+C_z$	acide ribonucléique→| seraient riches en |←les plasmocytes
	M	on croit (Casperson, Brachet)
	$A_pV_p^rD_r$	WH- ||| protéides→| est responsable de la synthèse des |←qu il, (l'acide ribonucléique)
	$S_cW_i^-C_y$	tandis que ||| protoplasme→| ont très peu de |←les lymphocytes.
642		
1.2	M	Il serait donc plus facile d'admettre que
	$A_pV_sC_z$	les protéides→| pourraient secréter |←ce sont les plasmocytes qui
	$A_pV_s^{\sim}C_y$	et ||| |(les protéides→| non(pourraient secréter)|←les lymphocytes
1.3	M	On peut objecter à cette manière de voir que les arguments invoqués sont indirects.

1.4 Cependant, Björneboe, Gormsen et Lundquist ont mis aussi en évidence, chez des lapins, des anticorps dans du tissu adipeux rénal particulièrement riche en en plasmocytes.

2.1 Nous avons essayé récemment, avec MM. Layani, Aschkénasy, Bussard et Lemétayer, de nous rendre compte si, dans les cas d'hyperglobulinémie pathologique, les malades produiraient à la suite d'une immunisation des quantités d'anticorps supérieures à la normale.

2.2 Deux cas été étudiés: un myélome à plasmocytes, avec β-globulinémie et un cas de plasmocytose de la moelle avec γ-globulinémie.

2.3 L'immunisation avec l'anatoxine tétanique n'a fait apparaître qu'un faible taux d'antitoxine, plutôt inférieur à la moyenne normale.

2.4 Ces deux cas sont certes insuffisants pour invalider la théorie plasmocytaire, mais ils semblent indiquer que dans ces cas, les myélocytes ne sont pas capables de synthétiser des anticorps.

1.4	M	Cependant, Björneboe, Gormsen et Lundquist ont mis aussi en évidence, chez des lapins,
	$AV_i T_k^w$	des anticorps | dans | du tissu adipeux rénal
	$C_z W_i^+ T_k$	WH- ||| plasmocytes→| particulièrement riche en |←(tissu adipeux rénal).
2.1	M	Nous avons essayé récement, avec MM. Layani, Aschkénazy, Bussard et Lemétayer de nous rendre compte si
	$A_g V_i^+$	dans les cas d' ||| hyperglobulinémie | pathologique,
	$GJB{:}AV_p^+$	(3) une immunisation, ||←à la suite d' || anticorps→| produiraient des quantités supérieures à la normale d' |←les malades.
2.2	M	Deux cas ont été étudiés:
	$A_g VC_z T_b$	avec β-globulinémie→| un myélome à plasmocytes
	$A_g VC_z T_b$	et un cas de ||| avec γ-globulinémie→| plasmocytose de la moëlle.
2.3	$GJ{:}AV_i C_z$	l'anotoxine tétanique |←l'immunisation avec || n'a fait apparaître que, || d'antitoxine, |←à un faible taux, plutôt inférieur à la moyenne normale | (dans les plasmocytes) |
2.4	M	Ces deux cas sont certes insuffisants pour invalider
	$AV_p C_z$	la théorie (des anticorps | produits par | les cellules) plasmocytaire(s),
	M	mais ils semblent indiquer que, dans ces cas,
	$AV_p^r \sim C_z^s$	des anticorps→| ne sont pas capables de synthétiser |←les myélocytes

3.1 Un point de vue assez proche de la théorie plasmocytaire est celui qu'émet Mlle Fagraeus. Chez des lapins immunisés ayant reçu une injection de rappel de *Samonella typhi*, elle prélève des petits fragments de rate, les maintient dans un milieu convenable et procède à des examens cytologiques, d'une part, et à des dosages d'agglutinines, d'autre part.

3.2 Elle admet qu'il y a parallélisme entre l'augmentation du taux d'agglutinines et le développement dans la pulpe rouge de la rate de plasmoblastes qu'elle appelle "cellules intérmediares".

3.3 C'est à ce stade de maturité incomplète que ces cellules, riche en acide ribonucléique secrèteraient les anticorps.

4.1 La théorie qui cherche l'origine des anticorps dans les *lymphocytes* a été récemment surtout développée en Amérique, bien que le tissu lymphoïde ait été envisagé déjà depuis longtemps.

3.1	M	Un point de vue qu'émet Melle Fagraeus est assez proche de
	AV_pC_z	la théorie (des anticorps | produits par | les cellules) plasmocytaire(s).
	$GJ^2B{:}T^x_sW_1$	Salmonella typhi→| immunisés, ayant reçus une injection de rappel de ||←chez des lapins
	$T^x_sW_1$	|| des petits fragments de rate→| elle prélève, d'une part |||les (petits fragments de rate) | maintient dans un milieu convenable et procède à des examens cytologiques
	$A_gV_iT^x_s$	et, d'autre part ||| agglutinines |←(elle procède) à des dosages d' (|dans les petits fragments de rate)
3.2	M	Elle admet qu'
	$AV^{\uparrow}_i$	il y a parallélisme entre ||| agglutinines→| l'augmentation du taux d'
	$C^{bw}_zW_pT_d$	et ||| de plasmoblastes←| le développement | dans la pulpe rouge de la rate
	$C^b_zYC^{m\sim}$	WH- ||| qu' (les plasmoblastes) | elle appelle | "cellules intermédiaires".
3.3	$AV_sC^{m\sim w}$	(4) les anticorps | secrèteraient | ces cellules (intermédiares)
	$D_rV^+_iC^{m\sim}$	WH- ||| acide ribonucléique→| (sont) riches en |←(ces cellules) à ce stade de maturité incomplète
4.1	M	La théorie qui cherche
	AV_pC_y	anticorps |←l'origine des | dans les lymphocytes
	M	a été récemment surtout développée en Amérique, bien que
	AV_pT_p	(des anticorps | comme origine) |←le tissu lymphoïde
	M	ait été envisagée déjà depuis longtemps.

4.2 Les expériences de White et Dougherty, de Harris et d'Ehrich et de leurs collaborateurs ont montré, en effet, que des extriats de tissus lymphoïdes ou de lymphocytes sont plus riches en anticorps que le sérum ou la lymphe.

4.3 De plus, un lymphosarcome d'un animal immunisé, greffé à d'autres animaux, transmet la capacité de produire des anticorps.

4.4 Si pour certains, commes Harris, ce sont des lymphocytes qui synthétisent les anticorps, d'autres, comme White, se limitent à dire que les lymphocytes les continnent.

4.5 Tandis que Ehrich, dans ces dernières publications, semble attacher une plus grand importance aux cellules plasmocytoïdes.

4.2	M	Les expériences de White et Dougherty, de Harris et d'Ehrich et de leurs collaborateurs ont montré, en effet, que
	$AV_i^{>} T_i^x$	(5) anticorps→| sont plus riches en | les extraits de tissus lymphoïdes
	$AV_i^{>} C_y T^x$	ou ||| (anticorps | sont plus riches en | les extraits) de lymphocytes
	$AV_i T_b$	que ||| (anticorps→| n'est riche en |)←le sérum
	$AV_i T_p$	ou (que) ||| (anticorps→| n'est riche en |)← la lymphe
4.3	$GJB_1{:}T_F^w W_i^{B_1}$	(6) De plus ||| immunisé→|| (qui est) ||←un lymphosarcome d'un animal
	$T_F I^t B_2{:}AV_p^k B_2$	WH-||| (lymphosarcome | est) greffé à | d'autres animaux, || transmet || des anticorps |←la capacité de produire | (aux autres animaux)
4.4	M	Si pour certains, comme Harris, ce sont
	$AV_p C_y$	les anticorps→|synthétisent |←les lymphocytes qui
	M	d'autres, comme White se limitent à dire que
	$AV_i C_y$	les (les anticorps) | contiennent |←les lymphocytes
4.5	M	Tandis qu' Ehrich dans ses dernières publications sembe attacher une plus grande importance aux
	$AV_p C_z$	(des anticorps→| producteurs) |←cellules plasmacytoïdes

NOTES

(1) GJ:AV_iT_b. As the linearization of this formula is quite long, I develop it here; the WH-sequence has to be read first: *qui apparaissent dans la circulation.* Then we read the conjunction word: *à la suite de.* At last we read *l'introduction parentérale d'un antigène.*

(2) $AV^{e>}C$. The word *avant* represented by the superscript *e* is permuted in the linearization of the unit e.g. *les anticorps existent dans des cellules avant...*

(3) GJB:AV_p^+ is linearized: *à la suite d'une immunisation, les malades produiraient des quantités supérieures à la normale d'anticorps*

(4) The linearization of 3.3 is: *Ces cellules, riches en acide ribonucléique, secréteraient les anticorps, à ce stade de maturité incomplète.* Its informational content is the same as the actual sentence where *à ce stade de maturité incomplète* is permuted in front position and is focused.

(5) In the sentence represented by 4.2, the word *plus* is a conjunction whose "scope" extends to the four units, as a concessive *ne...que* bearing on the two last units. The "source" is: *les extraits de tissus lymphoïdes sont plus riches en anticorps ou les extraits de lymphocytes (sont plus riches en anticorps) que le sérum (n'est riche en anticorps) ou (que) la lymphe (n'est riche en anticorps)*

(6) The reconstructed source of the actual sentence represented by the information units in 4.3 is: *De plus, un lymphosarcome d'un animal qui est immunisé – (ce lymphosarcome est) greffé à d'autres animaux – (Ce lymphosarcome transmet (aux autres animaux) la capacité de produire des anticorps.* This source reduced as indicated by the parentheses becomes: *De plus, un lymphosarcome d'un animal immunisé, greffé à d'autres animaux, transmet la capacité de produire des anticorps.*

APPENDIX 3

NOTES TO THE TABLES OF THE ENGLISH ARTICLES

NOTES TO THE TABLES OF APPENDIX 1

The notes provide for each text-sentence analyzed in the tables a listing of the sublanguage transformations applied. These transformations are indicated by the designations given below in the Summary of Sublanguage Trnasformations; others, not discussed in chapter 5, are presented in the notes. The order in which the transformations are listed corresponds to the successive transformations as applied to the text-sentence as read – on occasion, the row of the projected sentence is cited as a reference point. The parenthesized expressions given after many of the cited transformations note the "argument" of the transformation, i.e. the particular word-sequence moved or otherwise transformed in the text-sentence. Where a pronoun or other pro-form has been replaced by its antecedent, the abbreviation "Repl" (for 'replacement') is often used. Further details regarding the text-sentence and its formula(s) are provided where necessary.

SUMMARY OF SUBLANGUAGE TRANSFORMATIONS

The following is a listing of the principal transformations applied in recasting the text-sentences under the heading of the (sub)sections in which they are discussed. Each transformation is designated by an abbreviation used in citing the application of the transformation in the notes to Appendix 1. The transformations marked "*" are either specific to the sublanguage or require specification of domain. (Other, rarely applied, transformations are presented in the notes.)

– from chapter 1, section 3.3 (8)
  Mp: N_1 *is of* $N_2 \leftrightarrow$ N_2 *has* N_1
– from chapter 5, section 2 – Relinearization
  Lin I: i) $N\ V\ PN \leftrightarrow PN\ N\ V$
  ii) $Vn\ PN_1\ PN_2 \rightarrow \quad PN_2\ PN_1\ Vn$

Lin II:	$S_1\ K\ S_2 \leftrightarrow K\ S_2, S_1$
* Lin III:	positioning a local modifier adjacent to its host
* Lin IVa:	$Vn\ PN_1\ PN_2 \rightarrow\ PN_1\ Vn\ PN_2$
* Lin IVb:	i) $An\ PN_1\ P\ Vn\ PN_2 \rightarrow PN_1\ An\ P\ Vn\ PN_2$
	ii) $N_2\ PN_1$ *to* $V\ N_3 \rightarrow PN_1\ N_2$ *to* N_3
* Lin IVc:	$N_Q\ PN_1\ V \rightarrow PN_1\ N_Q\ V$
* Lin M:	extraction of meta-science and conjunctional material from a science-language sentence

– from Chapter 5, section 3 – Reconstruction of Repetitional Zeroing

Rep I:	Parallel Zeroing
Rep II:	End-zeroing
Rep III:	Subject Zeroing $\Sigma_1 V_1$ *to* $V_2 \rightarrow \Sigma_1 V_1$ *for* Σ_1 *to* V_2 (as in 5, 205.1.1): *...the mean titers begin to decline...only to increase again → the mean titers begin to decline only for the mean titers to increase again*

– from Chapter 5, section 4 – Reconstruction of Low-information Zeroing

Br S:	Broad Selection Zeroing (e.g., *amount*, *time*, *degree*, *number*)
ST S:	Strong Selection Zeroing (members of W_1 or V_1, e.g., *present*, *contain*)
Con I:	*wh-*, *-s*
Con II:	*than*, *as* (comparative forms)
* Sub Ap I:	reconstruction of GJB: under time modifiers such as *early*, *on the 4th day*, etc.
* Sub Ap II:	reconstruction of GJB: under sublanguage classifiers *response*, *reaction*
* Sub Ap IIIa:	reconstruction of $\mathbf{W_i}$, $\mathbf{V_i}$ under modifiers expressing quantity such as *numbers of*, *amount*
* Sub Ap IIIb:	reconstruction of AV_p under "r" operator
* Sub Ap IV:	reconstruction of ":" in environment G—A

– from Chapter 5, section 5 – Relative Clause

Rel I:	Reconstruction of Secondary Sentence[+]
* Rel II:	Inversion of Primary and Secondary Sentence – S_1; $S_2 \rightarrow S_2$; S_1
Rel IIIa:	$S(AN) \leftrightarrow S(N$ *which is* $A)$[+ +]
Rel IIIb:	S (N *Vn*/N) $\leftrightarrow$ S (*Vn*/N *Pap* N(pl))

– from Chapter 5, section 6 – Larger Transformations[+ + +]

NOM I:	Σ's *VN t A/PN* → Σ *V A-ly/PN* (from 1,,, 783.1.2): *Flow of peripheral lymph is rapid* → *Peripheral lymph flows rapidly*
NOM II:	*Vn of* N_1 *t A* → N_1 *t Ved A-ly* (from 1, 801.2.1): *Absorption of antigen is vascular* → *Antigen is absorbed vascularly*
NOM IIIa:	*An of* Σ *in N t* A_i → Σ *t* A_i*-ly A in N Vn*
NOM IIIb:	*the Van in/between* Σ *and* Σ' *t A* → Σ *and* Σ' *t* A_i*-ly A*
Passive I:	N_1 *V* $N_2 \leftrightarrow N_2$ *t Ven/ed by* N_1
* Passive II:	N_1 *V* $N_2 \leftrightarrow N_2$ *t Ven P* N_1 (from 2, 297.3.5): *Salivary glands...showed no extractable agglutinins* → *No extractable agglutinins were shown in salivary glands....*
* Causative:	Σ *V N* → Σ *causes N*'s *Vn* (or *Vn of N*) (from 1, 792.1.1): *An antigen forms agglutinin* → *an antigen causes agglutinin formation*

– from Chapter 5, section 8 – Quantifiers and the Negative

Neg:	*No N V* → *of N, none V* (from 14, 579.2.1): *No general immunity developed* → *Of general immunity, none developed*

[+] The operations involved are the same as in Rel III, but Rel I is restricted to reconstruction of a sublanguage sentence-type.

[+ +] This operation includes Con I of section 4.

[+ + +] These operations often follow one or all of Con I, Rel I, or Rel III.

INTERPRETATION OF SYMBOLS

N	– noun	A_i	– adjective
N_Q	– quantity noun, quantifier	*An*	– nominalized adjective
		A-ly	– adverb
V	– verb	*K*	– conjunction
Vn	– nominalized verb	Σ	– subject
PN	– prepositional phrase	*S*(*AN*)	– sentence containing *AN*
Pap	– "appropriate" preposition	pl	– plural morpheme
		t	– tense

Paper 1 – Notes

783.1.1. Lin (*in human skin*): *PN* movable and can relate its information to preceding *N*; *lymphatic capillaries* as argument of $\mathbf{W_i}$ is recovered from row 2; comparative-related *so rich that.* causative: $N_1\ V\ N_2 \rightarrow N_1$ *cause* N_2 *to* *V*

783.1.2. NOM I (*peripheral lymph flow is far more rapid*): see section 5.6.1; the second component of the comparative *than is generally supposed* is left unexpanded in the science sentence, with *is generally supposed* taken as *a moderate degree* (cf. ch 2 section 1): the comparison 'more than a moderate degree' is indicated here as 'is high (great)' (+). Rel I (*dye substances injected intradermally*); Lin III (*in a few minutes, even in a resting limb*); on representation of *dye substances* (cf. chapter 2 section 3)

783.1.3. no transformations applied.

783.1.4. Lin M (*therefore*); Lin II; Lin I (*of the skin*); *infection* is $\mathbf{G_f}$ (cf. chapter 2 section 2)

783.1.5. *the paths which is of infection* → *the path which infection has*; Rel II (*along the path which infection has*: *infection has a path*; *along which* (*path*)....); *between... and* is equivalent to *from ... to.* Rep I (under *or*); Lin (*with* or *without*); *without* is broken into its components *with-* and *-out*, with *-out* taken as a variant of some negative expression, thus $\mathbf{T}_{\ell'}\mathbf{W}_{\mathbf{f}}^{\sim}$

783.1.6. Rep. I (under *as*); on representation of diseases, cf. ch. 2 section 6 (A); *plague*, etc. are treated as reductions form a nominalized *plague occurs* as ':' is an O_{oo}, chapter 2 section 6.

783.1.7. Rel I; through *which this stream passes* is changed to *which this stream passes through*; *travels no further* = 'doesn't move'

783.2.1. Rel I

787.3.1. Lin III (*intradermally in both ears*); *on two successive days* incorporates material (from Table I caption, 787) – thus **J** has superscript **2** (see *last injection* on 787.2); *ears* in this, and succeeding sentences is assigned to the class **B** in the context **GJ–**. (cf. 801.2.6).

787.3.2-3. Sentence 787.3.2 contains material represented by the formula $\mathbf{GJ^2B}$, (**B** is included in formula from 787.3.1), the other material in this sentence contained *non-recurrent* procedural terms; it is then combined by a special sublanguage transformation with 787.3.3. ($\mathbf{T_nW_f}$, $\mathbf{W_g^+}$ abbreviated to $\mathbf{T_n}$,$\mathbf{W_{f,g}^+}$) by repetitionally zeroing *they* under *and*, as well as the referential *the nodes* and moving 787.3.3 into the sentence; Rel I (*enlarged nodes*); Lin M (*in every instance*)

788.2.1. Rep I (under *both ... and*), $\mathbf{GJ^2B:}$ is given in formulas on the basis of *these experiments* referring to those described in sentences 787.3.1-3 (amongst others)

788.2.2. the proforms (*they*, *the former*) are replaced by their antecedents in 789.2.1 (with $\mathbf{GJ^2B:}$, accordingly, reconstructed in the formulas); Con II along with Rep I (under comparative) of second component (from 789.2.1). *were much stronger* = 'were present ($\mathbf{V_i}$) in as amount which is much stronger', *amount* is not explicitly indicated in these cases.

789.1.1. Lin III (*intradermally in the right ear only*)

789.1.2-3. a special sublanguage transformation combines 789.1.2 with its **GJ²B:** along with procedural terms (non-recurrent); *removed* requires *in/from* and so *random groups*... is reconstructed with its previous occurrence repititionally zeroed, *nodes* are *cervical lymph nodes* mentioned, and are zeroable as a repitition; *those* = *the nodes*; $\mathbf{GJ^2B:_t}$ is reconstructed in 3rd formula under the conjunction *while* from the 1st row. *uninjected* is represented by **B**∼: not referential with **B** in **GJ²B**; *normal* is contrastative with *enlarged, hemmorrhagic* and is thus represented by $\mathbf{W_{g\sim}}$,$\mathbf{W_{f\sim}}$ (abbreviated as $\mathbf{W_{g\sim,f\sim}}$)

789.2.1. Neg (*no antibody*)

789.2.2. *It* replaced by antecedent *antibody* of 789.2.1; $\mathbf{GJ^2B:_t}$ is reconstructed in the 1st, 2nd, and 5th formulas from time-referential *then* (GEMP p. 71) to 789.2.1; *N V D*-comparative (*equally, simultaneously*) N_1 *and* $N_2 \rightarrow N\ V\ N_1$ and D-comparative $N\ V\ N_2$; Rep I; Rel I; in 4th and 5th rows, Rep I (under *but*), Con II, with Rep I (under *than*) of second comparative component (from row 2)

789.2.3. **GJ²B:** is indicated in formula from *the lymph nodes of the uninjected side* and 789.2.1.

789.2.4. Sub A_p I of **GJ²B:** (*progressed*); Rep I under *and* (*and* has scope over **GJ²B**); Rep I under *with* ('together with'); referential use of *more*; Con II and Rep I construction of second comparative component (from 2nd row)

789.2.5. Sub Ap I of **GJ²:** (*on the 10th day*), (*until the 12th day*); in 3rd row, tense before subject (*they* = *agglutinins*) is inverted (GEMP 3.15)

789.2.6. Lin M (*too*); Sub Ap I of **GJ²B** (*at the time*); Rep I (*they*) by antecedent *agglutinins* (789.2.5)

789.2.7. *They* replaced by antecedent *agglutinins* in 789.2.5, from which **GJ²B:** reconstructed in formulas; *nor* = *and not*; Rep. I.

789.4.1. Lin IVa *early* moved onto *after*: Lin III: (chapter 5.4.4.1). Rep I (under *and*); *Its* replaced by *agglutinins*, Sub Ap I (*later*) **e**∼ moved onto *after*: Lin III; Rep I (under *and*)

789.4.2. *It* replaced by *this experiment* (789.4.1); *the site* is here a classifier of various tissues; Rel IIIb

789.4.3. *The lymph nodes on the right side* is referential to 789.1.1, i.e. the injected side: Rel I (whence **GB²B:** in the formulas), similarly *left side* is *the uninjected side* from 789.1.1.; Rel I: the concessive sense of *only* (GEMP 9.66), together with a tacit sentence would permit an expansion of 789.1.1.... *and* **G** *was not injected into the left ear – (in the right ear only)*; Rep I *(side); appeared normal* in 3rd row is contrastive with $\mathbf{W_f}$ in 1st formula and receives the index $\mathbf{W_{f\sim}}$

789.4.4. *the former* is replaced by *the lymph nodes on the right side* (see note to 4.3 for treatment of *the left/right side*), Rep I under comparative; in 3rd row, Sub Ap I (*until the 12th day*) of **GJ²B:** (789.1.1) Neg.; *the left side = the uninjected side.* In 4th row: Passive I, Rel IIIb (*blood antibody → antibody from the blood*, The 4th row projection is not truly a passive, *nodes* here is not an agent, but, as indicated by the formula a complement to *was taken up.* The formula here more accurately represents the information than the corresponding English. Rel I (2x) for rows 5 and 6, *elsewhere*, meaning 'not inflamed nodes' is represented by $\mathbf{T_{n\sim}}$; *do so* is replaced by *take up blood antibody which had been formed elsewhere* with Passive I; Rel I (*normal lymph nodes*) with *normal* ($\mathbf{W_{f\sim}}$) contrastive with *inflamed*; Rel I

791.2.1. no transformations applied

791.3.1. Rel IIIb (*the injection of paratyphoid bacterin*); Rep I under *and*; DePassive I (*was induced by*). in **M**, the referend of *first* isn't reconstructed because the internal structure of **M** is disregarded here. The **GJB** and **GJB:TW** formulas here could be expanded to **GJB:TW** and **GJB:TW**. But the existing **T** of *both sides* is ambiguous: it could come from **T** *of one side... and...* **T** *of both sides.* Rather than give 2 alternative reconstructions (which might be done in some cases) the ambiguity is left by not expanding the *and*

792.1.1. Rel I; *-out* in *without* is indicated in **J** segment and represented by ~; Causative I: in the few **GA** sentences, the **:** is *specific* to, whereas *form* is $\mathbf{V_p}$ in e.g. $\mathbf{GJ{:}AV_pT}$; the causative transforms transitive *form* (*antigen forms agglutinin*) to *causes agglutinin formation.* The row is represented as $\mathbf{G{:}AV_p}$, though it may be grouped with $\mathbf{GJ{:}AV_p}$. This is a case of transforming "upward" rather than to a "source" sentence

792.1.2. **GJ²B:** in 2nd-4th formulas from *in these experiments* which involve **J²**; Rep I under *but*: reconstruct $\mathbf{S_1}$ in S_1 *and/but*.... The second component of comparative-like sentence (*same*...) with constant *as* reconstructed; *both sides = one side and the other side*; Con II along with second component of comparative reconstructed (from 791.3.1.)

792.2.1. Lin III (*on 2 successive days*)

792.2.2. Lin III (*at the same time*); **2** on **J** is from table IV (p. 793) which notes *2 intradermal injections*

792.3.1. Rel I. the information contained in the formula is maximized by not expanding after *that is to say*. **2** is indicated in **J** in this and succeeding sentences from 792.2.1.

792.3.2. **GJ²B:** is reconstructed from 792.3.1., *agglutinin. Agglutination* might be decomposed into a case of **G:A** 'the product of the agglutinin floculating with antigen' (cf. chapter 2.3.1.). $\mathbf{T_n}$ might be reconstructed from 792.3.1., contrasted with $\mathbf{T_b}$ in 792.3.3.

792.3.3. *much less*, as subordinate predicate on *agglutinin* (GEMP 3.20) can be combined with main predicate on *agglutinin*, namely *was present*. Lin III (*tests being positive* ...): as a subordinate clause on the sentence is equivalently on its operator (*present*)

792.3.4. Neg (*no agglutinins were demonstrable*...); Rel I

792.3.5. *this side* replaced by *the side injected with diptheria toxin*, Rel I; *the opposite side* replaced by *the side injected with paratyphoid bacterin* (791.3.1.); Rel I; *but*... is left in first row to avoid repetetion of $\mathbf{TW_f}$ sentence; Rep I under comparative

792.4.1. Lin M (*in the earlier experiments*); Rel I (*agglutinins found elsewhere*...): *elsewhere* = 'not nodes of the body' ($\mathbf{T_n^B}\sim$); Rel I (*inflamed nodes, injected side*); Rep I under *or*; **GJ²B:** in formulas is from the 2nd row; Rep III: *for agglutinins* reconstructed; *the lymph nodes* refers to 'nodes on the injected side'; *there* pronouns *in the lymph nodes on the injected side*; Lin M (*in the present experiment*); *some* is a referential use of a quanitifier: *some of the agglutinins*; Lin IVc *of the agglutinins*); previous row's indicate *should*

have been found on that side is from ... *found in the nodes on that side*; *should* is not represented, as unanalyzed **M**

794.5.1 no transformations applied

794.5.2. row 1, if expanded, would be: antigens | were employed ($\mathbf{G^{W}J}$) WH ||| one antigen | is of a similar nature to | a different antigen (**GYG**); the last row would be expanded as: one of various organisms || induces || in the injected ears and in the regional lymph nodes | the same degree of inflammation ($\mathbf{GJB{:}T^{B}_{n}W_{f}}$). Rep II (*were employed*); in the 4th formula, *injected ears* is represented as $\mathbf{T^{B}_{e}}$ as *ears* occurs in the environment of a **W**-operator: *ears on the injected side*; in 3rd and 4th formulas, **JB** is reconstructed from *regional* and *injected*; Lin I (*in the injected ears and in the regional lymph nodes*)

796.2.2. the material enclosed in brackets is from 796.2.1 In 796.2.2.: Lin I (*in the right ears*); *on successive days* modifies *injections* in 796.2.1. and is moved into 796.2.2. as a modifier of *was injected*; *three intradermal* modifying *injections* is moved into 796.2.2.; as a modifier of *was injected*, *intradermal* is transformed (NOM I) into adverbial form (*intradermally*), *three* referring to the number of times of the bacterin were injected appear on *was injected* as *three times*: 'thrice'. As 796.2.2 specifies the bacteria classified by *the two bacterins* in 796.2.1., the referential is zeroable. Rep II (of *ear* under *and*); *the same amount*, as a referential classifier is replaced by its antecedent *0.002 cc...;* an appropriate proposition (*of*) connects *the right ears* to *forty-five micc* Rep II under *and* of *was injected*...

796.4.1. Lin IVc (*of B enteritidis*), Lin III (*two to four times as much*); Rel I with *that antigen* replaced by referend *B. enteritidis*; Rep. I under quantified-comparative

796.4.2. Lin M (*in turn*); **GJB** is reconstructed in 1st row from mention of *the other side* (796.2.2.): *the side injected with B. prodigiosus*, and *in turn*, which establishes a reference to 796.4.1.; Rep I under comparative; *the other side* is represented as $\mathbf{B}\sim$ as it is not referential to the **B** in **GJB**

796.4.3. *the nodes* refers to *the nodes on one side and the nodes on (from) the other side* (in 796.4.1-2). The reciprocal status of *equally*, itself a reduction of *to an equal extent*, permits us to transform: *X and Y were equally inflamed*

→ *Xs were inflamed equally as Ys were inflamed* (cf. ch. 1 section 3.1, **GEMP** 6.71); **GJB** is reconstructed in rows 1 and 2 from mention of 796.4.2.: this and of sides injected, *the other side* is represented as **B**~ (see 796.4.2. note); *size, appearance* are classifiers of **W**-operators.

796.4.4. Rel I in 1st row; *much less, least* are referential quantifiers which zero their referend here (chapter 5.8) of and so *B. prodigiosus agglutinin* is reconstructed; Rep I (*contained* under *with* in 2nd row, under *and* in 3rd row); Rel I in 3rd row; *least* is represented by $<<$; **G**~ indicates **G** not referential to that in **GJB**

796.5.3. *had N V* ↔ *if N had V*: the latter form keeps the verb-phrase continuous and so is used here. *elsewhere than* in *the nodes* = *not in the nodes* and is represented by $\mathbf{T}_{\mathbf{n}}^{\sim}$. *this distribution* classifies the formulas in 4.4 above and the index is given as ~796.4.4., pending further work on the classifiers

798.3.4. *There* in *thereafter* pronouns the sentence *antigen was injected only once or twice*; rather than repeat the sentence, it is zeroed (repititionally) along with *and*; Rel IIIb (*the concentration of antibody*) *sought* (**M**) is left in sublanguage sentence and disregarded here (cf. ch. 2 section 1); Lin III (*in serum and lymph node extract*); *the latter* = *lymph node extract*; *the former* = *serum*, Rep I under comparative

798.3.5. Lin III (*were made*); Lin IVa (*of antigen*); the discontiguous operator *between... and* requires that the 'colon' segment be read up to the left-directed arrow, with the *and* read after the secondary (**GJ**$^{\mathbf{1}}$) sentence; Lin III (*was delayed, for example for 12-21 days*); in row 2, the argument of the procedural term *examination* (indexed $\mathbf{W}_{\ell}$) is recovered from row 3 – *lymph node extract and serum*; Lin IVc (*of antibody*); Lin III (*both in lymph node extract and serum*); in the 5th row, *than* with the second component of the comparative (from row 3) is reconstructed: Con II, Rep I; Rep I (*of agglutinins, the concentration*); *in the serum* is reconstructed in 5th row; *that* pronouns *agglutinin concentration*; *exceed* is a "comparative word" and might be factored into *is greater than*, Lin M (*in one instance*)

801.2.1. Rows 1, 2: the metascientific operator *is of course a truism* (V_M) is extracted by: *That* $S_t V_M \rightarrow$ *it is* V_M *that S*; Rel IIIa (*local injections*); *remote reactions* can be fitted into the structures as *remote tissues*, as indicated in

the formula; *speedy* and *remote* are unordered; in row 3 *vascular* is $\mathbf{T_b}$, *absorb* is **U** – thus *antigen* is appropriately reconstructed in this context. The secondary sentence – *absorption of antigen is vascular* – is reconstructed, which by NOM II is transformed to *antigen is absorbed vascularly*; under *by*, the *is* receives the *-ing* argument-indicator, in row 4, *the action* here receives index $\mathbf{TW_a}$, as is evident from its relation to the second row; in 4th row, Lin III (*rapid*)

801.2.5. *These authors* replaced by antecedent *Oshikawa* (801.2.2.) *and Reitler* (801.2.4). *of N* has *N's* as variant. *antigen* is reconstructed as appropriate argument of **U** operator with $\mathbf{T_b}$ second-argument

801.2.6. Lin M (*in such experiments*); Lin III (*directly*); in row: *lymphatics* as a word is $\mathbf{T_{\ell'}}$, but appears in **GJ**—environment: as the adverb *directly* indicates, *lymphatics*, is created here as a body-part, hence **B**; Rep I in row 3 (*antigen*) under *and*; in rows 3 and 4, **GJB:** is reconstructed by *regional* = of the site of injection; *where* pronouns *in the regional lymph nodes* (chapter 5.5.1) hence **GJB:** in 4th row

801.4.1. Rel I; *various organs* is a classifier **T** (see 801.4.2.)

801.4.2. *They* refers to **M**-subject of 801.4.1. and *the spleen*, etc. are the *various organs*, so that *of rabbits intravenously injected with killed cholera spirilla* is reconstructed repetitionally in 801.4.2; Rel I

801.4.3. Rep I under comparative; Lin M (*in two or three instances*), Rep I of *bacteriolysin* under *and*; *first in the spleen* can be extended to: *before* || **GJB** || : || *bacteriolysin* | *appeared in* | *the blood*; in the 3rd row, the formula indicates the zeroed arguments under the nominalized operator *injection*. **GJB:** is indicated in the 1st and 2nd formulas from *injection* in 3rd row

802.2.5. Rel IIIb (*the injection of typhoid vaccine*); $\mathbf{M_p}$ (a *concentration of agglutinins*) → *agglutinins have a concentration*; under *result in*, *have* receives the *-ing* argument indicator

802.4.1. Lin M (*though highly suggestive*); **GJB:** is reconstructed in the formulas from *the evidence*, referential to 801.4 – 802.3, which note **GJB:**; Repl (*their*); Lin IVa (*of antibody*); Repl (*its*); *therein* = *in that organ.*

802.6.1. extraction of M- segment *have long been known* ($\mathbf{V_M}$): N_1 *t* V_M *to* $V_1 \rightarrow$ *It t* V_M *that* N_1 V_1; Rep I (*lymph nodes*) under *and*; Repl (*them*)

802.6.2. *In* in : position takes a sentential argument – thus, *occurrence of* is reconstructed, see chapter 2 section 6; Lin III (*occurred*), *edema* is 'inflamed' ($\mathbf{W_f}$)

803.2.1. *of N* has *N's* as variant.

803.4.1. *the process of immunization* classifies *the production of antibody*; *immunization* may be further decomposed as suggested in chapter 5.9

803.4.2. No transformations applied.

803.4.3. Lin II (*during* S_2); *the process of immunization*, cf. 4.1 above; **GJB:** is reconstructed in second row, given first.

803.4.7. No transformations applied.

803.4.8. Lin I (*of the cortex of the lymph glands*); Rel IIIa; constant *which were* is zeroed; Lin IVc (*of lymphocytes*); *circulating* = 'in serum'

Paper 2 – Notes

295.1.2 Rep I under *and*; Rel IIIb (*antibody production*); *site* is here a classifier of *reticulo-endothelial cells* and *lymphoid tissue*; in fourth row, Lin IVb (*of antibody*).

296.1.1 no transformations applied. *as a storehouse* = 'contains' ($\mathbf{V_i}$).

296.2.1 *mice received intraperitoneal injections* $\rightarrow$ *mice received injections intraperitoneally*: the body-part adverb (*intraperitoneally*) on verb is placed with body-part *PN* on verb, e.g. *injected intradermally* like *injected into skin*, fronting of *intraperitoneally*; Lin III (*on alternative days for 5 weeks*).

297.3.2 Rel I (*immunized mice*), *hemolysin* is $\mathbf{A^G}$.

297.3.3 Lin II: (*were approximately eight-fold higher on the basis of nitrogen contents*). *The* is taken as a noun, a variant of *that* (GEMP 5.36), referential

to the preceding *agglutinin and hemolysin* (*titers*). Rel I (*immunized mice*); Rep I under comparative.

297.3.4 *titer* requires *antibody*; Rel IIIb (*the absence of titer*). *the final washings of the lymphoid cells* in row 1 refers to fluid between the spherical cells after the cells are washed and is accordingly indexed $\mathbf{T}_{\ell''}$. (cf. 5, 205.2.3) This sentence could be analyzed with *was derived from* indexed $\mathbf{V}^{\mathbf{f}}_{\mathbf{u}}$ and *antibody in the extracts* reconstructed as a secondary sentence. However, *was derived from* does not here refer to movement of the antibody as indicated by the measurement term *titer*; *was derived from* is thus analyzed as conjunctional (a 'derivation' of measurements) with *antibody in* in rows 3 and 5 and reconstructed by Rep I; Rep I under *and*.

297.3.5 Passive II; Neg; Rel I(*immunized mice*).

297.3.6 Rep I under *and*, Rel I (*non-immunized mice*). *when tested for...* is not expanded as *when lymphoid cell extracts were tested for antibodies...*, since expansion would incorrectly indicate the degree of assertion.

297.6.6 no transformations applied.

297.6.7 Lin IVa (*of antibody*)

Paper 3 – Notes

121.1.1 Rel IIIb (*antibody producers*)

121.1.2 *immunized* is **GJ** here; *this* is referential to the preceding row. *hyperglobulonemia* is, by its component morphemes $\mathbf{A_g V_i^+ T_b}$. *globulin* is marked $\mathbf{A_g}$, and does not represent antibody, but globulin in general.

121.1.3 Lin I (*in practically all organs*); Rel IIIb(2x). **T** may be reconstructed in third row, given first.

121.1.4 Lin I (*in the highly immunized animals*); Rel IIIb (*plasma cell proliferation*) with Lin IVa; Rel I (*highly immunized animals*).

121.7.1 Lin IVc *regional* = 'at (of) that injection site, draining that site.'

121.7.2 Passive I with zeroing subject (given in 7.1) (2x); *their* = *regional lymph nodes'*; Rep I under *and*; *regional lymph nodes' weight, histological features were examined* → *regional lymph nodes were examined for weight, histological features* (similarly with *output of lymphocytes*); **GJB** is reconstructed form *regional* (7.1) and preceding row.

122.1.1 Passive I: S_1 *accompanying* S_2 *is* S_3 → S_2 *was accompanied by* S_1 *which is* S_3. *the tissue reaction is chiefly a lymphocyte reaction* is two sentences, not **Y**, on the basis of arguments, *tissues* and *lymphocytes*. Rel I (*which*); in last row – Rel IIIb (*antibody production*).

122.2.1 Rel IIIb (*the antibody production*) in last row; *the pituitary-via the adrenal cortex* is indexed **T**.

122.4.1 *of N* has *N's* as variant (chapter 1, section 3.3); Rel IIIb (*antibody production, antibody determination*); Rel I (2x); *were rich in* = 'contained many.'

122.4.2 Lin III (*in some instances*); Rel IIIb (*plasma cell infiltration*); Rel II (see chapter 5.5.2(B) where this sentence is discussed).

122.4.3 in row 1: Rel IIIb (*plasma cell infiltration*), Lin IVa (*of plasma cells*); Lin I (*in rabbits ...*); Rel I in row 2: Lin I (*in the retroperitoneal...*); Rel IIIb (*plasma cell infiltration*); Lin IVa; *and that* would repeat formula; *that* (along with *and*) is zeroed as repitional with *extrememly seldom* left as a non-current modifier in the second row; Rep I under conjunctional *whereas*.

122.4.4 *the kinds of adipose tissue mentioned* is $\mathbf{T_k}$ and $\mathbf{T_p}$ of preceding sentence.

125.5.1 reconstruct argument-indicator *that* of *reveal*; Neg; referential use of quantifier (chapter 5.5.8) – *very few*; StS (*present*); movement of *-scattered interstitially* (section 3.3 of chapter 1).

125.8.1 in row 1: Lin I (*in the retroperitoneal fat*) with permutation of *PN* phrases in segment; quantifier *a few* is moved onto the verb; Lin IVc; in row 2: Rel IIIb (*plasma cell proliferation*), Lin IVa; in row 3: Neg (*no plasma cells*), Rep I under *and*. Cardinals on *animals* can be taken as the sets of those animals and so are subscripted.

126.1.1 Lin M (*as is evident...*); Lin I (*in the pelvic fat*) with permutation of *PN* phrases; Rel IIIb (*plasma cell proliferation*); Lin IVa; Lin M (*even*); Rep I (*plasma cells, in the pelvic fat*).

126.2.1 *in the pelvic fat* reconstructed from preceding sentence (1.1) and parenthesized expression (shown here as third row; parentheses here do not indicate reconstruction); Rep II; *percent* (as *ratio*) will be covered in later work; *rabbits* refers to those in 122.4.3, thus **GJ^{3}B**;

126.3.1 no transformation applied. *source* is $\mathbf{V_p}$ (cf. paper 5).

128.3.1 Rel IIIb (*antibody producers*).

128.3.2 Rel IIIb (*the presence of plasma cells*). *the experimental objects* is a classifier (**T**), cf. 3.3 below. Rep I under *except* (GEMP 9.66).

128.3.3 *was free from* = 'did not contain' ($\mathbf{V_i^{\sim}}$); Repl (*these cells*) by antecedent *plasma cells*; on concessive *except*, see GEMP 9.66.

128.3.4 Lin II; referential use of *a small number* (*of plasma cells*) extraction of metascientific ($\mathbf{V_M}$) *supposed*: N_1 *is* V_M*ed to be* N_2 → *It is* V_M*ed that* N_1 *is* N_2; *cell type* is a classifier of *plasma cells*; Rel IIIa (*highly active cell type*).

128.4.1 Depassive I with reconstruction of indefinite subject *one*; *single* cannot be moved onto the J-segment and is indicated by superscript **1** on **G**.

128.4.2 Lin M (*However*); Rel IIIb (*the concentration of antibody*); Lin III (*simultaneously, becomes much higher*); Rep I under *and*; Lin III (*becomes more intensive*); *several* is indicated by **+** on **G**, cf. 5.1; the comparatives are not expanded (chapter 5, section 7)

128.4.3 Lin III (*as intensively*); *not as intensively* is indicated by **3** > ∼: 'not as great intensity...as'; Rep II under comparative; *more than one* in last row is indexed by **+** on **G**, cf. 128.4.2 with *several.*

128.4.4 extraction of metascientific *should have appeared...* ($\mathbf{V_M}$): $N\ V_n\ t\ V_M$ → *there* $V_M\ N\ V_n$; Rel IIIb (*plasma proliferation*).

128.5.1 Lin M (*is just as good*); Rep II, see GEMP 3.4.2 on *do*.

128.6.1 *no larger amount ... than* = *'the same amount ... as'* and doesn't receive the index >; Rel I (2x), Rep I under comparative (*from our highly immunized animals*); transposition of tense (*did*) before subject (GEMP 3.1.5) is inverted with Rep II under comparative.

128.7.1 Rel IIIb (*the thymus lymphocytes*); *other lymphocytes* is expanded to *lymphocytes in other tissues*, since it contrasts with the preceding row; Rel IIIa (*the most important lymphocytopoietic organ*) – *most important* is then *most importantly*; *organ* classifies *thymus*; if *lymphocytopoietic* is segmentable as *producing lymphocytes*, we could obtain: *lymphocytes* | *appears to be the most important organ in the production of* | *the thymus* ←.

128.8.1 Rel IIIb (*antibody producers*).

128.8.2 Rel I; Lin III (*ca. 10 percent*). Sub Ap IIIa (*present*) Rel IIIb, Lin IVa. In row 5: *responsible for* selects $\mathbf{V_p}$; Rel I. In row 6: Rel IIIa (*the predominant cell type*) with zeroing of the constant *which is*; Rel I; Rel IIIa (*the high antibody protein concentration*); *the extract of this tissue* is reconstructed as an appropriate argument (from Row 3).

128.9.1 Rep I (*both... and*); in 5th Row for reciprocal verbs: N_1 *and* N_2V ↔ N_1 *and* N_2V *to each other* ↔ N_1V (*to*) N_2; *seems* in text (sic); Lin M (*at least*); Rep I (*plasma cells*); Rel I.

129.1.1 Lin III (*in the rabbit*), *in the rabbits* is treated like *in vivo* – as a modifier on *produce*.

Paper 4 – Notes

1.2.1 *the response of the antibody-forming mechanism* is represented as $\mathbf{AV_p}$ 'antibody produced' since *respnse* and *mechanism* are classifiers of sentences not further specified; *that* is referential to *the response of the antibody-forming mechanism*; *the first contact* is represented $\mathbf{GJ^1}$ 'the first injection of antigen'; *with an antigen*is reconstructed as an appropriate zeroing, *with an antigen* is reconstructed in the environment N_1's *contact* —— N_2

1.2.2 *so-called secondary response*: here the classifier is not expanded via Sub Ap II, since it occurs under the metalinguistic *so-called*; *after repeated injection of the antigen* is reconstructed from 1.2.1 and *after the first injection of teh antigen* of this sentence; Rep I under comparative

1.2.3 *of cells* is appropriately zeroed by *reaction*, by the title of the present paper and by row 4; **GJB:** is not reconstructed under *reaction* since *reaction* is conjoined to an **GJB** containing sentence; Sub Ap II (*secondary response*); DeN II (*after intravenous injections of horse serum into rabbits*) Rel I (*sensitized*), which is represented as $\mathbf{J_1}$, cf. *the sensitizing injection* in paper 10, 307.2.1

1.3.4 Lin M (*it was possible to observe*); Lin I (*in the reaction centers...*); St S (*at a time*), a reconstruction which aids the analysis of the relative pronoun operating upon :, see discussion in chapter 5.4.2; Lin Iva (*the reoccurrence of cellsof characteristic appearance*); Sub Ap I reconstructs $\mathbf{GJ_2}$ under the modifier *on the 2nd or 3rd day*; Rel I (*before the antibody content had begun to increase,*), with *before* represented as **e**, 'early': further work on the conjunctions will have to expand *before* as a comparative

1.3.5 Rep I (*the cells*)

1.3.6 *of the cells* is reconstructed from the referential *the* in *the nucleus*; Rep I (*the nucleus of the cells*); *light with nucleoli* is treated as *'contains nucleoli'*

1.3.7 Rel I (*which obviously originated from reticulum cells*) Sub Ap I (*some days later*) where *later* is with respect to *2 ro 3 days after* of 1.3.4; Rel I (*which were usually somewhat smaller*); Rep I (*which cells*); Rel IIIa (*redder cytoplasm*); Rep I (*which cells had*); Rel I (*(immature plasma cells)*) which is represented $\mathbf{CYC_z^m}$ 'cells are called immature plasma cells'

1.3.8 Sub Ap I (*simultaneously*) which can be treated as referential to 1.3.7.; Lin IVc (*a considerable increase in the amount of circulating antibodies*); Lin III (*was found*); Rel IIIa (*circulating antibodies*) where *circulating* is factored as $\mathbf{T_b}$ 'in the blood'; Con I (*wh*, *-s* → ø)

1.3.9 *at the peak of the serum titer curve* is reconstructed as *at a time which is from 5 to 8 days after when the antibody titer curve reached a peak in the serum*, where *time* is a strong selection word used used in the reconstruc-

tion of the relative *when* (chapter 5.4.2); *titer* requires *antibody*; Rel IIIb (*the serum antibody titer curve*); *reached* is reconstructed as an appropriate aspectual modifier of *peak*, with *reached a peak* represented $\mathbf{AV_i^{>}}^{>b}$ 'antibody content began its maximum amount'; Rel I (*with the typical red cytoplasm*); Rel IIIa (*typical red cytoplasm*) where *typical*, returned to its free standing position, has adverbial (*-ly*) form, cf. chapter 1, section 3.3; Rep I (*which mature plasma cells with*); Rel IIIa (*eccentrically situated*)

2.3.1-2 These sentences are combined to form an elementary sentence; *the mixture* in 3.2 is referential to 3.1

2.4.1 $\mathbf{J^2}$ is the representation of *administered* given 2.3.1-2 and *14-25 days later*

3.4.2 Lin II (*differentiation was sometimes difficult*), where *differentiation* is clearly a meta-science word, under *difficult*; *the transitions* is taken as referential to *the transitions of the cells*, or: *the cells' transitions*; Lin III (*were numerous*); *the different stages of development* is referential to 3.4.1

3.4.3 *All cells* → *all of the cells*, cf. chapter 5.8; Lin IVc (*all of the cells*) Rel IIIa (*low nucleus plasma relation*), represented as 'small nucleus'; Rep I (*cells with*); *eccentricity of the nucleus* is de-nominalized, see chapter 5.6.1

3.4.4 Lin M (*however*); Rel I (*thus classified*) which is expanded, 3.4.3, *thus classified as mature plasma cells*; Repl (*its*); Rel IIIb (*chromatin and nucleoli contents*) with *nucleoli* the plural form

3.5.1 No transformations applied. *In most cases* can be treated as referential to *in most animals*

3.5.2 Rel IIIb (*a cellular reaction*); Lin IVa (*a reaction of cells*)

3.5.3 Sub Ap I reconstructs *after the reinjection*, where *the reinjection* is referential to 2.3.1-2, under *in the early stages*; Lin I *in the lymph follicles was found*; Rep I under *although*

3.5.4 reconstructing the parallel zeroing *after the reinjection* from 3.5.3 and 2.4.1 by Rep I; Rep I (*the cells exhibited stages of development*)

3.5.5 Sub Ap I reconstructs *after the reinjection* from the trace *on the 2nd or 3rd day*; Rel I (*when the titer curve had still hardly begun to rise*); *titer* requires *antibody*; Rel I (*reacting reticulum cells*); Rel I and Rel IIIa (*large reticulum cells which were reacting*); Rel I and Rel IIIa (*reacting reticulum cells were large*); Rel I (*called transitional cells*)

3.5.6 Repl (*they*)

4.1.1 Lin III (*apparently ceased*); Sub Ap I, together with Con II, reconstructs *than the 2nd or 3rd day after the reinjection* under *some days later*; Lin II (*some days later...*); Lin IVc (*increasing numbers of mature plasma cells*)

5.1.1 Lin I (*in the red pulp*); *to cut out from the splenic tissue pieces of red pulp....and pieces of mainly follicular tissue* → *for pieces of red pulp,...and pieces of mainly follicular tissue to be cut out from the splenic tissue* by a passive transformation which zeroes the *N'* subject – see chapter 2, section 1 – of the procedural verb *to cut out* and fronts the direct object *pieces of red pulp,...and pieces of mainly follicular tissue* to subject position; Rel I (*which were abundant....*) Rep I (*which pieces of red pulp*), Rel I (*abundant in lymphocytes*); Rep I (*which pieces of follicular tissue were*)

5.1.2 Lin I (*between the red pulp*); Lin III (*in vitro*); *antibody formation capacity* is expanded as *capacity of anitbody formation* and then *capacity of formation of antibody* by successive applications of Rel IIIb; Rel I (*containing plasma cells*); Rep I (*in capacity of formation in vitro of antibody*)

6.7.1 Lin II (*to the follicular tissue*) which is moved from its position in S_1; Lin III (*in vitro*);Rep I (*in capacity of forming in vitro antibodies*)

6.8.1 Lin M (*if the splenic tissue was tested*): this material is segmented as **M** since the main operator is **M** (*tested*); Lin II (*on the 4th or 5th day after the reinjection*); Lin IVb (*the capacity of the red pulp*); Lin III (*was greater*); Rep I (*after the reinjection, of the red pulp the capacity was great to form antibodies*)

6.9.1 *of the piece of tissue from which the culture was made* is reconstructed from a neighboring row as the subject of *capacity*; Mp (*capacity of the piece of tissue...*); Rel IIIb (*antibody formation capacity in vitro*); Lin IVc (*an increased amount of transitional cells*); Rep I (*in the piece of tissue from which*

the culture was made); Rep I (*was always connected with*); Rep I (*an increased amount*)

7.1.1 Lin III (*(7th – 10th day)*); Sub Ap I reconstructs *after the reinjection* from the trace *at a later stage (7th – 10th day)*; Rel I (*when the mature plasma cell predominated*), see chapter 5.4; *in the pieces* is reconstructed from row 3; Lin III (*receded*)

8.2.1 the intensive red color of which makes it visible in histological sections is a non-recurrent adjunct and so does not receive representation in the formula; *almost exclusively* is a concessive which is not treated

9.1.1 Rel IIIb (*bacterial content*); Lin IVc (*the total content of bacteria*); the conjunction *and at a greater rate* is not expanded since this repeats an existing row; Rep I (*pulp*); row 2 under the comparative, Rep I; Con II (*than*); row 4 Rep I under the comparative; the second term of the comparative, *in the white pulp*, is from row 2

9.3.1 Lin M (*was studied*); Sub Ap II (*the secondary response*); Rel IIIb (*the rabbit spleen*)

9.3.2 Rel IIIb (*a very strong plasma cellular reaction*); Lin IVa (*a very strong reaction of plasma cells*); *when* occurs in the position of :; *employed* is represented as $\mathbf{J^2}$ since it classifies *reinjections* of row 1; Rep I (*of plasma cells a very strong reaction was obtained*); *a reaction* is referential to *of plasma cells a very strong reaction* in the preceding rows; *almost exclusively*, see notes to 8.2.1

9.3.3 Lin II (*large reticulum cells of characteristic appearance were found*); *at a time after the reinjection* is reconstructed from the preceding sentence and from succeeding rows; Rel IIIa (*the earliest stages of the reaction*); *the reaction* is referential to *the plasma cellula reaction*; Sub Ap I reconstructs *in the period after the reinjection* from the trace *earliest*; Rel IIIb (*antibody formation*); Lin IVa (*formation of antibody*); Rel IIIa (*the first phase of formation*); Sub Ap I reconstructs *in the period after reinjection* from the trace *first*

9.3.4 Lin I (*in those places*); Rel I (*where immature plasma cells appeared*); Con II and Sub Ap I reconstruct *than the time of 3.3 after the reinjection* from

the trace *1-2 days later*; Rep I (*where in those places*); *after 1-2 days later...after the reinjection* is reconstructed from the trace, *after a further few days*

10.1.1 *transitions* has *of cells* as appropriate argument; *different stages of development* is a classifier of *transitional cells, immature plasma cells, and mature plasma cells* as in 3.4.2 of which this sentence is a near repetition

10.1.2 No transformations applied

10.1.3 Lin I (*in culture fluids, where small pieces of tissue had been kept*); Lin IVa (*the presence of varying amounts of antibodies*)

10.1.4 *contained only 1/20 -1/200 of the amount* is represented $\mathbf{V_i}^{<}$ 'contained an amount which is less'; Con II (*as*); Rep (*the amount of antibody*); Lin IVc (*the amount of antibody*); *growth or metabolism of cells* could be decomposed as elementary sentences -however, since this material occurs under an **M** verb (*made*) in an otherwise non-recurrent adjunct phrase, this was not done here; Rel IIIb (*the tissue cultures*)

10.1.5 Rel I (*found in tissue culture fluid*); Lin III (*in vitro*); Rep I (*the antibody had...been*), (*which antibody was found in tissue culture fluid*)

10.2.1 Rel I (*abundant in pl.c*); Rep I (*were excised*) Rel I (*containing lymphocytes*)

10.2.2 Lin IVc (*the amount of antibody*); Lin III (*was considerably larger*); Rel IIIb (*tissue cultures*); Rep I (*of antibody the amount found was*); *the amount found* is referential to *the amount found in cultures of tissue of red pulp* of row 1, which is reconstructed; Rel IIIa (*circulating antibodies*); *antibodies which are circulating* is equivalent to *antibodies in the blood*; Lin III (*a reasonable amount of the total amount of*) is a local modifier of the zeroed $\mathbf{V_i}$ operator *present in*

10.2.3 Lin IVb (*the capacity of the red pulp*); Lin III (*in vitro, was greater*); Rel IIIb (*antibody production*); Lin IVa (*the rate of production of antibody*); Lin III (*was rising*); Rep I (*of antibody the rate of production, in vivo*); *its* refers to the possessive of *the rate of production of antibody in vivo* which, if expanded, repeats this row

10.2.4 Rel I (*when the animal's serum titer curve was leveling off*); Lin IVc (*the amount of antibody*); Lin III (*was smaller throughout*); *the culture fluids* is referential to *the tissue culture fluids*; M_p (*the animal's serum titer surve was leveling off*); Rel IIIb (*the serum titer curve was leveling off of the animal*) *titer* requires *antibody*

11.1.1 Lin I (*in pieces, removed on the 3rd or 4th day*), see notes to 10.1.3 above; Sub Ap I reconstructs *after the reinjection* from the trace *on the 3rd or 4th day*; *removed* is not represented, although an analysis can be given assigning it membership in $W_{\not}$, the subclass of procedural terms

11.1.2 Rel I (*containing only transitional cells*); Rel IIIb (*antibody-forming capacity*); Rel IIIb (*capacity of antibody-forming*)

11.1.3 Rel I (*more mature*); Rel IIIb (*the antibody content*); Lin IVc (*an increase in the content of antibody*)

11.1.4 *the maturation process* has *cells* as appropriate argument by 11.1.3; Rel IIIb (*the tissue cultures*); Rel IIIb (*antibody formation*); Lin IVa (*the rate of formation of antibody*); Lin III (*increased*); *during the first 24 hours of incubation* is treated as M although *during* is a temporal conjunction, since *incubation* is an otherwise non-recurring procedural term

11.1.5 Rel IIIb (*antibody content*); Lin IVc (*content of antibody*); Lin IVc (*the number of immature plasma cells*); Sub Ap IIIa reconstructs *present* as W_i

11.1.6 Repl (*the latter*) by *immature plasma cells*); Lin IVb (*the maximum capacity of the tissue*); Lin III (*in vitro*)

11.1.7 Lin IVa (*the transition of the immature pl.c.*); *this capacity* is referential by 11.1.6 to *of the tissue the maximum capacity to form in vitro antibody*

11.1.8 Lin M (*under the conditions described*); Rep III (*reticuloendothelial elements*); Rel I (*with the morphological characteristics of plasma cells*)

11.2.1 Passive (*the appearance of pl.c. were conditioned by the antigen injected*); Lin IVc (*an accumulation of the antigen*); Rel I (*where subsequently pl.c. appear*)

11.2.2 Br S *but little antigen* is reconstructed as *but little amount of antigen*; Lin IVc (*but little amount of antigen*)

11.2.3 Lin IVa (*the great development of pl.c.*); Lin IVc (*a considerable concentration of bacteria*); *there* pronouns *in the red pulp of the spleen*

12.4.1 *the participation of the lymphocytes, of N* has *N's* as a variant; Lin III (*takes place*)

12.4.2 Lin III (*in vitro*); Rel I (*where the chief production of lymphocytes takes place*); *thymus has an insignificant antigenphagocytizing capacity → thymus has an insignificant capacity for phagocytizing antigen*, represented $\mathbf{GU_d^{k-}T_t}$ 'thymus has little capacity for destroying/disintegrating antigen'; Rep I (*thymus*); Lin III (*in vitro*)

12.4.3 Lin IVa (*the disintegration of lymphocytes*); *occurring in lengthy culture experiments* is represented as 'in culture'; Lin IVc (*only in significant amounts of antibody*)

Paper 5 – Notes

204.2.1 Rel IIIb (*the injection... virus*); **B** in second row is *local*; Lin IVc

204.2.2 Rel I; Lin M (*at first*). *Diffuse* is treated as $\mathbf{W_i}$, referring to the manner of appearance of increased cells – see chapter 4.6 where this sentence is discussed

204.2.3 Rel I (*the viral protein injected*): Rep I under *and*

204.2.4 Lin III (*in these tissues*); *earlier* can be moved onto a zeroed GJB: (chapter 5.4.4.1); the **GJB:** zeroing is reconstructed both from *earlier*, referring to the time of injection, and *these tissues*, referential to (2.3) which notes the injection; Rep I under comparative; in row 3: SubAp I, Rep I under *and*; in row 4, Rep I under comparative

204.2.5 Neg (*no antibodies to influenzal virus*). *Legs opposite to the leg injected* receives the index $\mathbf{B}\sim$, indicating that it is not conferential with the 'B' in the **GJB** sentence (chapter 4.2.2). Rep I in 2nd-4th rows; Rel I (*unmanipulated rabbits*): (*unmanipulated*) is indexed $\mathbf{GJ}\sim$ = 'not injected with antigen'; in row 3, Rel I. *Antigens other than influenzal virus* could be represented by a rare $\mathbf{GY}\sim\mathbf{G}$ senntence – *antigens* | *other than* | *influenzal virus* – however, superscripting a $\sim$ to indicate its non-coreferential status with the other

G in the formula is informationally more specific. In the last row, *prior to* ('not after') is indexed :~

204.2.6 *the same system* here is a classifier (2.1) of *the footpad of rabbits* (**B**) and *injected* is reconstructed as the appropriate operator in the context **G—B**

204.2.7 no transformations applied here. for the inclusion of sublanguage words within **M**-segments, see chapter 2, section 1

204.4.1 Rep I (*of the antibodies*); Lin I (*of the antibodies*); M_p. *Site* here classifies *cell* – as may be seen in the unanalyzed Summary sentence – ... *the lymphocyte can be a primary source, or site of final synthesis, of antibodies to viral protein* (206.5.1). *Primary* is represented by V_p (as is also noted by the parallelism in 206.5.1): it is clearly not V_i since this is what the appended secondary states; if it is taken as the site of first appearnce, the conclusion drawn here is that it is the cell producing antibody. *Source* is represented by V_pC (here, a synonym of *primary site*). That *source* classifies **C** is noted in 205.2.1 *-the lymphocyte itself as a primary source.* In the sentences just cited, *source* occupies the position of *site* in this sentence and is accordingly represented **C**. cf. 205.1.8, 205.2.5

204.5.1 the arguments of *specificity* have been filled out from the preceding (unanalyzed) sentence – *...each titer can be accepted without reservation as a specific-antibody titer* (204.4.4)

204.5.2 *titer* requires *antibody* (**A**). *Homologous* and *heterologous* refer to sides on which the antigen is injected; *in a lymphnode* is reconstructed from Fig. 3 (202), referring to *lymphnode of leg injected with Lee (PRB)* and *opposite lymphnode tested against Lee (PRB). Homologous* = same side for antibody and antigen; the antibody on a side is presumed to be antibody in the lymphnode on that side, thus *homologous* is placed on *lymphnode. Heterologous* = opposite side for lymphnode and antigen; *antibody to the heterologous virus* = *antibody to the virus injected on the opposite side* (in a given lymphnode on a given side). The status of *homologous, heterologous* is indicated by the secondary sentences: *virus injected into a side* for *homologous* (with sides and antigen coreferential) and *virus injected into opposite side* for *heterologous* (without coreferential standing, thus **B**~, **G**~). Aside from these operations, the text-sentence is transformed as follows: in rows 1 and

2, repetitional reconstruction of *titer of antibody to the* and *virus*; by NOM IIIb, *the differences in titer of antibody to the homologous virus and titer of antibody to the heterologous virus are clearly marked* → *titer of antibody to the homologous virus and titer of antibody to the heterologous virus are clearly markedly different.* The reciprocal status (r) of *different* allows N_1 *and* N_2 *t* $A_r \rightarrow N_1$ *t* $A_r P$ (= *from*) N_2 (*titer of antibody to the homologous virus is clearly markedly different from titer of anibody to the heterologous virus*); M_p (*titer of antibody*); in row 2, Rel IIIb, Lin IVc (*of heterologous antibody*); *that antigen* refers to *the virus injected into the opposite side* (see discussion of *heterologous* above); *titer* requires *antibody*; in rows 6 and 7, Rel IIIb (*serum-antibodies*), Rel I

205.1.1 SubAp I (*through successive days*), (*toward the end of the first week*); *titer* requires *antibody*; *homologous antibody* in a given lymphnode is antibody in a homologous lymphnode, i.e. in a lymphnode on the side injected with the antigen to which this antibody is homologous. Rep III (*for homologous-antibody mean titers*); *there-* in *thereafter* pronouns *toward the end of the first week after* **GJB** in the 3rd row; in 3rd and 4th row, *in the lymphnode* is appropriately reconstructed (from 2nd row)

205.1.2 *the later rise* classifies the last row of (1.1) and the arguments of *rise* are reconstructed; the referential to 205.1.1 permits indication of **GJB:** in the formula; Lin I (*within the node itself*); Rel IIIb (*antibody production*); Lin I (*from the serum*)

205.1.3 Rep I under comparative; *local* (**B**) is local to the injection (**GJB**); Rel IIIb (*antibody production*); Lin M (*for two reasons*); *early* cannot be moved onto : – early days of production need not be early after injection

205.1.4 Lin IVc (*of a substance*); the degree of assertedness in row 1 is not fully indicated; *site* is here a classifier of tissue, cf. 205.1.3; Rel I; *production* has *antibody* as an argument; Rep I under comparative; Rel I: *into which X* is altered to *which X into*; *reservoir* is serum (T_b)

205.1.5 Lin III (*is quite small*); Rel IIIb (*antibody formation*); Lin IVa; *unless*, while in : position, is semantically hypothetical and the sequence is indicated in separate rows; in the 3rd row, **GJB:** reconstructed from the 1st; *as a result of* could be placed in colon position; *the popliteal* refers to *the popliteal node*

205.1.6 The M-operator (*is particularly significant*) is *it*-extracted wiht NOM II (*the finding of antibodies*); *earlier* is moved onto *after*; SubAp I (*earlier*) and *local* (= local to the injection) permits reconstruction of a zeroed **GJB:** Rep I under comparative, *and*

205.1.7 Passive I (*the serum was receiving antibody simultaneously from two source of supply*); Lin (*from two sources of supply*) to conform to ordering of modifiers (**ft**); *both legs* is indicated by subscripts **1** and **2** on **B**

205.1.8 Rel IIIb (*antibody-titer*); Lin IVc (*of antibody*); Lin II (*in the early days of this experiment*); Sub Ap I; Rep I under comparative: Rel I (*the antibodies found*); *the lymphatic source*, in line with 205.1.3-4 is $\mathbf{V_pT}_{\ell'}$

205.2.1 Lin M (*the concluding proof*); Rel IIIb (*the formation of antibody to viral protein*); **GJB:** is reconstructed from 205.1.8; *primary source* here falls into the position of V and is indexed $\mathbf{V_p}$ (cf. 204.4.1)

205.2.2 Lin III (*was found to be as high as 8192*); *this observed value* refers to *antibody titer* of row 1; the two comparatives are not expanded – in the first case, *as high as 8192* merely specifies the titer value; in the second, the titer compared is supposed and not asserted

205.2.3 Rel I (*interstitial fluid caught among them*). *Packed cells* occurs in the context **TW**— and is indexed $\mathbf{T^j}$; indeed, *packed cells* are an artificial, fractional tissue. Lin IVc (*of lymphocytes*); *titer* requires *antibody*; Rel IIIb (*lymphocyte-contents*); Con II and Rep II of second component of comparative (from 3rd row)

205.2.4 Lin M (*However*); *the values recorded* are those of *antibody* (titers); *the titer* requires *antibody*; *ratio* is not represented here and will be treated in later work; on *packed cells*, see 2.3 above.

205.2.5 *this ratio* refers to that in 2.4 above between packed cells and lymph plasma; Mp; Lin IVc; *the greatest ratio between X and Y* →*...of X to Y* (cf. 2.4); Rel IIIa (*primary source*): *source* occupies the position of **C** – *antibody's primary source* is the place where it is first found and presumed produced (thus $\mathbf{V_p}$ for *primary*); *that* pronouns *antibody concentration*; Rel IIIa (*secondary site*): *Site* classifies *tissue*; *secondary*, in contrast with *primary*, refers to where antibody is found, but not produced (hence, $\mathbf{T}_{\ell''}$); Repl (*its*) by

of antibody; Lin M (*in all probability*); Rel I; Repl (*those cells*) = *the lymphocytes*; *from the lymph-plasma* is permuted to conform to the ordering of modifiers, *from...to* on $\mathbf{V_u}$

Paper 6 – Notes

157.1.1 Rel IIIb (*the formation of antibody*).

157.1.2 Rel IIIb; Lin III (*by the 5th and 6th days*); StS (*amount*); *maximum* is represented by $>>$; Lin III (*was found to reach a maximum*); Rep I: *followed* in text is *after the 6th day*; the sublanguage appropriate arguments, *antibody* and *the popliteal lymph node* are reconstructed in the nominalized sentence: *a rapid decline.* This may be expanded to *from the maximum amount of antibody in the popliteal lymphnode by the 5th and 6th days after antigen injection into the footpads of rabbits.*

157.1.3 SubAp I (*on the 5th day*); Rep I under comparative; SubAp I (*on the 7th day*); representation of *the ratio* is inadequate: the magnitudes referred to are recovered from the 1st (*the lymphoid cells of the efferent lymph of this node*) and 2nd (*the supernatant lymph plasma*) formulas. **GJB:**$_t$ is indicated in the last formula, given previous rows.

157.1.4 Lin M (*also*); **GJB:** in formula is from *also*, referring to results of the same experiment where **GJB:** is indicated; *minced* = 'extracts.'

157.1.5 Rel IIIb (*antibody production*).

157 fn 1 no transformations applied. Note that *lymphocytes* and *lymphoid cells* in **M** are mentioned, not used.

157.3.1 Rel IIIb; *is related to* might be taken as an instance of **r** – in this sentence, however, unlike other instances of **r**, the 1st argument is *the synthesis of proteins* and **D** appears as 2nd argument: *is related to* is thus analyzed as conjunctional with a sublanguage appropriate reconstruction of the $\mathbf{V_i}$ operator *presence* (chapter 5.4.4). This analysis is supported by later mention (p. 160 ff.) of correlations of nucleic acid presence and amount of antibody synthesized.

157.3.2 Rel IIIb (*the multiplication of chromosomes*), (*the formation of desoxyribose nucleic acid (DNA)*), (*the production of cytoplasmic protein*), (*cytoplasmic protein*); Repl (*that*) by *production*; Rel IIIb (*production of ribose nucleic acid (PNA)*); in row 2, *chromosomes* are nucleic acids **(D).**

158.2.1 Mp; in 5th row: Lin I; BrS (*amount of*).

158.3.2 Lin I (*into each footpad*).

158.8.1 *the two nucleic acids* refers to DNA ($\mathbf{D_d}$) and PNA ($\mathbf{D_r}$); Lin IVc; Repl (*those*) by antecedent *the variations*; Rel IIIb; Lin III (*reported previously*)

164.3.1 SubAp I (*during the first 4 days*); for **w** on **t** in colon conjunction, see chapter 5.4.2; *the cellular reaction* is here a classifier of *multiplication*: expansion would yield no new information – *cellular rection* (= *reaction of cells*) $\mathbf{CW_a}$ *was* ||| *reaction of multiplication (of cells)* $\mathbf{CW_p}$ – with *cells* appropriately reconstructed and *reaction* replacing *one*), *especially* ||| (*multiplication of*) *plasmablasts* $\mathbf{C_z^bW_p}$ (with Rep II); Rel IIIb

164.3.2 SubAp I (*only on the 4th day*); Lin II; SubAp I (*on the 5th and 6th days*); Rel IIIa; zeroing of *wh- is*; *there* in *thereafter* pronouns *on the 5th and 6th days* together with its appropriately zeroed *after* **GJB**

164.3.3 Lin IVc (*in PNA*)

164.3.4 Lin IVc (*of PNA*); Repl (*the cells*) by *plasma cells* (of 3.3)

164.4.1 SubAp I (*on the 3rd and 4th days*), (*on the 4th and 5th days*), (*only on the 9th day*); Repl (*the latter*) by *germinal centers*

164.4.2 BrS (*numbers of*), (*amount*)

164.4.3 Lin III (*comparatively low*): the comparison ('with other results') is vague and is not indicated here

164.5.1 Lin II (*following*); Lin III (*occurs*)

164.5.2 *The highest concentrations* refers to *antibody in the regional lymph nodes* (5.1); SubAp I (*on the 5th and 6th days*): **1** on **J** is from (5.1)

164.5.3 Rep I under *and. This is preciesly the time when* (= *at which*) – *which* refers to *this time*, *when* = *at precisely this time*; SubAp I: *this* is referential to (5.2) and thus **t** is indicated as modifier on **:** and **J** receives superscript **1**; Rel IIIb (*the concentration of PNA*)

164.5.4 Lin II (*at this time*); SubAp I (*at this time*): *this time* refers to *on the 5th and 6th days* in 164.5.1 (thus **1** on **J**); *early* is on *stage of proliferation* – not necessarily early after injection; Repl (*they*); Rel IIIb; *peak* is 3rd unit represented by $>>$.

164.5.5 Lin I (*in these lymph nodes*)

164.6.1 no transformations applied

164.6.2 Lin M (*in contrast to plasma cell myeloma*); Rep II under contrastive conjunction *in contrast to* which requires that one of its conjuncts carries negative (cf. GEMP 9.6); on the symbol $\mathbf{G_f}$ for diseases, see chapter 2 section 2; *hyperglobulonemia* is by its component morphemes represented as $\mathbf{A_g V_i^+ T_b}$ (see section 9 of chapter 5)

164.6.3 Lin I (*from the thymus of immunized animals*); Rel I. The degree of assertedness here, as in other sentences with negation and other modalities, will be taken up in later work.

164.6.4 Lin IVc (*some*); Rel I with variant *that* replaced by *which*; *leave* = 'move from'; *which* has scope over *during*

165.1.1 Rep I under *and*; *were spun down with* is reciprocal:
N_1 *V* (*with*) $N_2 \leftrightarrow N_1$ *and* N_2 *V*

Paper 7 – Notes

1.2.1 Rep I (*as a possible producer of antibodies*)

1.3.1 No transformations applied

1.3.2 No transformations applied; *metabolism* as an intrusive operator on words of the **A** word-class is assigned to the word-class **Z**.

1.5.1 Nom IIIa (*the direct importance of lymphoid tissue*); Rel IIIb (*antibody formation*)

1.5.2 Lin II (*after subcutaneous injection of the antigen*); Lin III (*mainly*); Repl (*this production*)

2.1.1 Lin II (*after intravenous administration of antigen*); Sub Ap IIIb (*in production of antibody*)

2.2.1-2 These two sentences are combined since *they* in the **M** segment of 2.2.2 refers to the authors mentioned in 2.2.1. *By cannulating...they could detect* is left unexpanded as **M** since this procedure is reported as being performed by other investigators (unlike *cannulation* in paper 10); *after* **GJB:** is reconstructed from *antigen injection site*; *at a time which is before a time when after* ←: this employment of the relative clause using reconstructed appropriate time words is discussed in chapter 5.4.2; *before* is represented as indicating that the first time relation is *earlier than* the second

2.2.3 Lin II (*together with...node*); *lymphopoiesis* is factored $\mathbf{C_yW_p}$ 'production/generation of lymphocytes'; Rel IIIa (*marked lymphopoiesis*); Lin IVa (*increased output of lymphocytes*); *from the lymph node* is reconstructed as an appropriate zeroing from 2.2.2, with *from* an indicator of the reconstructed argument, *lymph node*; Lin IVa (*the synthesis of antibodies*)

2.2.4 Lin I (*in the node*); Lin IVc (*a high content of ribonucleic acid*); *in the lymphoid cells in the node*) is reconstructed from *content* 'amount contained in' and from the previous row

2.2.5 *this high nucleic acid content* is referential to *the high nucleic acid content in the lymphoid cells in the lymph node* which replaces it here; Rel IIIb (*nucleic acid content*); Lin IVc (*content of nucleic acid*); *in the lymphoid cells in the lymph node* is reconstructed from previous row

2.2.6 Lin I (*in the efferent lymph*); Lin IVc (*the greater quantity of antibody*); *the cell fractions* refer to *cell fractions of efferent lymph*; *of antibody* is reconstructed from the previous row and from *amounts*; the comparative is not

expanded since the compared sentence – presumably reporting amounts of antibody in the afferent lymph – is not mentioned; *the fluid in the efferent lymph* is indexed $T_{\ell''}$ (cf. *intersitial fluid* in 5, 205.2.3)

2.2.7 Lin IVc (*95 per cent of these cells*), where *95 percent* is represented by + + 'very many'; *these cells* is referential to *cells in the efferent lymph* of 2.2.6; Rel I (*in the efferent lymph*)

2.3.1 Rel IIIa (*normal animals*); for this use of *WH-* in colon position see chapter 5.5.2; Rel I (, *the tissue largely consisting of lymphocytes,*); Rel I (*electrophoretically identical with serum beta and gamma globulin*); Rel IIIb (*serum beta and gamma globulin*); Rel IIIa (*immunized animals*)

2.6.1 Lin M (*is well known*); for the representation of *chronic infections* as G_f, see chapter 2, section 2; Rep I (*the occurence of plasma cells*) twice

2.6.2 Rel IIIb (*antibody titers*); Lin IVc (*titers of antibody*); *extracts of plasma cell infiltrations* is represented C_zT^x 'extracts of tissue containing plasma cells'; Rel IIIa (*hyperimmune animals*)

2.6.3 Lin I (*in these infiltrate*); *these infiltrates* is referential to 2.6.2 above where *infiltrations* bearing an **x** superscript is a tissue; *these infiltrates* is accordingly decomposed into the (denominalized) form; *tissues which were infiltrated with plasma cells*

2.6.4 Rel I (*which could be held responsible...*); Sub Ap IIIa: *producing* (V_p) is reconstructed under **r** (*responsible*); Rel IIIb (*antibody titers*); Rel I (*found*)

3.4.1 Lin M (*respectively*); Lin IVb (*the role of lymphocytes*); Sub Ap IIIb *in formation of antibody* reconstructed under *role*; Rep I (*the role of, in formation of antibody*)

3.5.1 Lin M (*largely following the techniques of Fagraeus*)

3.5.2 Lin IVb (*the role of individual types of splenic cells*); Rel IIIb (*antibody formation*); Lin III (*by means of sedimentation*); *different fractions* is referential to *fraction I* and *fraction II*, below

5.1.1; Lin II (*from one to four days after the last antigen administration*); Rel IIIb (*antigen administration*); Lin I (*in all animals*), which is represented by superscript **B** because it is referential to (*animals receiving*) *the last administration of antigen*

5.1.2 *from one to four days after the last administration of antigen* is reconstructed in rows 1 and 2 from the previous sentence since the **TW** structures are parallel; Rep I (*from one to four days after...*); Rep I (*reaction centers*); *lymphopoesis* can be factored as in 2.2.3 above; rows 3-4 **GJ^{3}B:** is reconstructed in the formula from the first sentence of this paragraph and from rows 1 and 2; *of cells* is reconstructed as an appropriate zeroing under *mitoses*; Rel IIIa (*the predominate type of cell*); *large and middle-sized* is represented as 'large'; Rel I (*with strongly pyroninophilic (basophilic) cytoplasm*); Rel IIIa (*strongly pyroninophilic (basophilic) cytoplasm*); Rep I (*which large and middle-sized immature lymphoid cell was with*); Rel IIIa (*a large bright nucleus*); Rel I (*with conspicuous, pyroninophilic nucleoli*); Rel I (*conspicuous, pyroninophilic nucleoli*); for decomposition of several left modifiers see section 4.3 of chapter 5 and the references cited there, *pyroninophilic, conspicuous* is represented as *pyroninophilic*

5.1.4 No transformations applied

8.2.1 Lin IVa (*a production of agglutinin*)

8.3.1 Lin M (*however*) (*as estimated...titers*); Rel IIIb (*the antibody content*); Lin IVc (*the content of antibody*); Lin III (*at the moment of explanation was some two times*) *greater* (or: *higher*) may be reconstructed under the comparative *some two times*; Con II (*than*); Repl (*that*)

8.3.2 Lin M (*also*); Lin IVc (*the absolute quantity of newly produced agglutinin*); Rel I (*newly produced agglutinin*); *was newly produced* is taken as 'produced in vitro'; Lin III (*was much greater*); Repl (*that*)

11.2.1 *splenic cell suspensions* elsewhere (as in 2.6.4) has the environment of **T**, e.g., is subject of *containing cells*; the Roman superscripts **I, II** distinguish the two fractions; Rel I (*containing most of the large cells*); Rel I (*containing only a few large cells*); Rep I (*fraction II*)

11.3.1 Lin I 3 x (*in extracts of the cellular elements of these suspensions*); Lin M (*was never observed*); Rep I under *between...and*

11.3.2 *the extracts titers* is referential to *antibody titers in extracts of the cellular elements*; Repl (*these titers*); Lin IVc (*the total numbers of white cells*); *present* is reconstructed under *the total numbers* by Sup Ap IIIa; *the differentiation* is referential to *the differentiation of the white cells* which is denominalized (NOM II) to *the white cells being differentiated.* Here *differentiate* is meta-scientific "being distinguished"

11.3.3 Rep I (*do contain antibody*)

12.1.1 *in the tissue cultures* is treated as elsewhere as a local operator 'in culture', i.e., *in vitro* and is thus repeated in the science language rows; Rep I under the comparative

12.1.2 *the new productions* with the plural is referential to *the new productions of agglutinins in the two fractions*, this becomes *agglutinins' new production in the two fractions* by Mp; Lin M (*are compared*); *the "increase"* is referential to *the agglutinin increase* which is represented in the formula $\mathbf{AV_i}$; St S (*in amount*); *the respective production* is referential to *the production of fraction I and the production of fraction II*; Lin IVc (*the percentages of large cells*)

12.2.1 Lin IVa (*the production of agglutinin*); *in these cultures* is referential to *in cultures of these two fractions*

12.2.2 Lin II (*although probably containing antibody*); Lin III (*under the conditions of the experiment*) which refers to *in culture*, represented by the superscript **v**; Repl (*it*); (*the smaller ones, lymphocytes*) is a reconstruction of subject zeroing, see chapter 5.3.2, and is represented $\mathbf{C^{g}{\sim}, C_y}$; reconstructing the subject transforms *containing* to its variant *contain.* This appositional construction might be expanded *the smaller ones which are mainly lymphocytes* (cf. 2.2.7)

14.2.1 Lin IVb (*the role of immature plasma cells*); Lin III (*is beyond any doubt*) which is treated as a non-recurrent **M** operator upon *role*; Rel IIIb (*antibody formation*); Lin IVb (*the role of lymphoblasts proper*); Lin III (*is still questionable*), treated as above; *the role* is referential to *the role in formation of antibody*; *lymphocytogenesis*: see the notes to 2.2.3 above for *lymphopoiesis*

14.3.1 Lin M (*exists*); *the lymphocytogenesis process* and *the plasmacytogenesis process* replace *the two processes* which is referential to them

14.3.2 Rel I (*occurring in acute infections, etc.*); Lin III (*in its ameboid movements*)

14.3.3 Rel I (*lymphoblast according to our nomenclature*) which is deparenthesized by reconstructing the metalinguistic verb *called*; Lin III moves *according to our nomenclature* to its host as a local operator; *stem cell* is treated as 'cell from which is descended/stems'

15.9.1 No transformations applied; *refute* is factored into 'establish... not', hence $\sim$ on $\mathbf{V_p}$

Paper 8 – Notes

49.1.2 Rel IIIb (*antibody formation*); *site* is a classifier of *a family of cells* and is included in the $\mathbf{V_p}$ segment because its modifier, *major*, is a specifier of *formation*; Lin IVa (*formation of antibody*); Rel I (*which first appear*); *the stimulus* is referential to *antigenic stimulation* in the previous sentence

49.1.3 *the response* is referential to *the response of the family of cells*: *to the stimulus* is referential to 49.1.2 and reconstructed by Sub Ap II; the **AV** *response* designation here classifies **CW** structures as well, see the discussion of *response* in chapter 4.3; *the concurrent synthesis* → *the synthesis which is concurrent* → *the synthesis concurrently* with the *-ly* suffix resulting from returning the operator to its free standing adverbial form, cf. the notes to paper 9, 67.3.4; Lin M (*concurrently*); *the* is referential to *the cells'* (or: *the cellular*); *a specific protein* as $\mathbf{A^G}$ reconstructs **GJB:** by Sub Ap IV

49.1.4 Lin IVb (*the mature member of this cell family*) with *mature member* represented $\mathbf{Y^t_c}$ 'develops into' as we elsewhere have *immature cells developed into mature cells*

54.4.1 No transformations applied

54.4.4 Rel IIIa (*single antibody-containing cells*)

57.5.1 *the islands of cells* is represented as *cells*; Rel I (*which appear in the spleen...*); Rel I (*hyperimmune animals*); Rep I (*islands of cells*); *them* is pleonastic

57.5.2 *these cells* refers to *cells identified as plasma cells* in the previous sentence; *synthesis*, under *in vitro*, appropriately zeros *of antibody*, reconstructed here

57.5.3 Passive I (*the demonstration that...confirms this observation*); Repl (*they*) by *the plasma cells*

58.3.1 Rel IIIb (*antigen injections*); Rel IIIa (*intravenous injections of antigen*); Lin IVa (*the last of a series of injections of antigen*); *last* on *series of injections* is represented as **3**

58.3.3 Lin Ivc (*small amounts of antibody*) Lin IVb (*a minor contribution by lymphocytes*); Rel IIIb (*antibody synthesis*)

Paper 9 – Notes

61.1.1 Lin I (*into the homolateral foot-pad*); Lin IVa (*the presence of antibody*); *the individual cells*) is reconstructed under *immunohistological reactions* as *reaction* selects a **C** or **T** subject and **C** is available as *the individual cells*, in the previous row, is reconstructed as an appropriate zeroing from row 1 (*cellular changes*) and row 3 (*the individual cells*).

61.1.2 Br S (*contents of*); Lin IVc (*the sharp rise in contents of antibody*); Sub Ap IIIa (*present*) reconstructed under *numbers of*; Rel I (*engaged in antibody synthesis*); *first* is treated here as 'early'; Lin II (*during this period*); *during this period* reconstructs *within the 1st days after stimulation by antigen* by Sub Ap I; Lin IVc (*most if not all of the antibody*); Rel I (*produced*); Rep II (*antibody*); Rel I (*synthesized*); Rep I (*of a cell family*); Rep I (*during*) (*the*); Lin IVa (*the differentiation of a cell family*); Rel I (*of which the mature member...*).

61.1.3 Lin M (*in fact*); replacement of *these cells* by *the cells of a cell family of which the mature member is the plasma cell* from 61.1.2

62.2.1 Lin M (*however*); Rel IIIb (*antibody synthesis*); Mp (*the complicated and changing character of the cell population*) – N_1 *of* N_2 has as variant N_2*'s*

N_1; Lin II (*after antigenic stimulation*) which can be segmented *after antigenic stimulation*, i.e., 'after stimulation by an antigen'; Rep I (*the undifferentiated cells in such tissue*)

62.2.2 Rel I (*associated with...*); Rel IIIb (*antibody production*)

62.2.3 Sub Ap II (*primary response*); Sub Ap IIIb – reconstruction of *for the production of antibody*); Repl (*its*); Rel I (*antibody-containing*); Rel I (*once stimulated*); *once stimulated lymph nodes* is reconstructed as *lymph nodes which were once stimulated by antigen*, an instance of a **GUT** sentence; *antigen* may be reconstructed on the grounds that *stimulated lymph nodes* is **UT** and the environment **–UT** is that of **G**; *once* is a frequency modifier of *stimulated*, represented by **1** superscripted to **U** as in 67.3.5 below.

63.2.1 *an agglutinin reaction of the surface of cells* is given the index $\mathbf{GJ{:}A^{G}V_{a}C}$ 'the event of the reaction of antibody to the antigen on the surface of cells' where 'the antigen' specifies 'the antigen injected'; *intra-cellular antibody* is decomposed (by Rel IIIa) *antibody which is intracellular* which is equivalent to 'antibody within cells'

63.2.2 *the same reaction* is referential to *an agglutinin reaction* of 63.2.1; Lin IVa (*adherence of the organisms*) *the organisms* is perhaps an unusual designation of *the agglutinins*; here, *adherence to* is given the same index as *reaction on the surface* on grounds of parallelism, but with a **t** superscript representing the indicator *to*

64.2.1 Sub Ap II (*the secondary response*); Lin II (*following two injections into the foot-pad*); Lin IVa (*the formation of colonies of cells*)

64.4.1 front positioning the *PN* (*in the foot-pad*); cf. GEMP sect. 3.11; *4 weeks after* and *6 weeks after*, although temporal conjunctions, do not occur in the environment of **':'** since both arguments of these are **GJB** sentences; Rep I; *the first* and *the other* are referentials permitting reconstructions; *the same dosage* is taken here as a classifier of *fluid diptheria toxoid*

64.5.1 front positioning, *in the section of the homolateral popliteal lymph node stained for antibody* in the primary sentence; Rel I (*stained for antibody*); Rel I (*with a thin rim...*); Rel IIIc (*flourescent cytoplasm*); Lin IVc (*a low but*

definite concentration of antibody); *in the large cells* is reconstructed as an appropriate zeroing from row 1

64.7.1 *By the 4th day* is the trace of zeroing of *after a secondary stimulus* which is reconstructed by Sub Ap I; Lin I (*there were clusters of smaller...cells*); Rel I (*antibody-containing*); Rel I (*brightly flourescent*); Rel I (*smaller*)

65.1.1 *the flourescence* is taken as referntial to *the flourescence in/of the cells* (or: *cellular flourescence*) given 64.7.1, row 3; Rel I (*due to antibody*); here conformity with existing structures requires that the pro-ed sentence which is subject of *due to* be written as a separate row, with *due to* (an O_{oo}) a conjunction; we reconstruct from rows 1-3 *content in the cell* over *antibody* since a sentence is required in this row; *increase from...to* is represented as a comparative with the higher amount being the amount that the increase is to; Rep I (*the degree of brilliance of flourescence of...*) 2 times; Rel I (*cells*)

65.2.1 Lin I (*in the animals sacrificed*) Lin IVc (*the number of antibody-containing cells*); *present* is reconstructed under *numbers of* by Sub Ap IIIa; Rel I (*antibody-containing*) *section* refers to *sections of the homolateral popliteal lymph node* of 64.5.1

65.2.2 Lin IVc (*most of them*)

65.5.1 Lin II (*on the 4th day*); Lin IVa (*a single injection of antigen*); Lin III (*first*); St.S (*at a time*) is reconstructed under *first*, cf. chapter 5.4.2; Rel IIIa (*first at a time*); Rel I (*antibody-containing*)

65.5.2 Rel I (*with a thin rim...*); Rel IIIa (*faintly to moderately brightly flourescent cytoplasm*); Rel I (*scattered singly...*) with *singly*, as an A-ly adverb moved to before the operator, cf. GEMP chapter 3, section 3.12; *large cells with a thin rim of cytoplasm* is represented as $\mathbf{C_g S_c^-}$ which abbreviates $\mathbf{S_c W_i^- C^g}$ 'cytoplasm present in little amount in large cells'

66.4.1 Rel I (*responsible for...*); Rel IIIb (*antigenic stimulus*); Rel I (*arise from some differentiated precursor...*)

66.4.2 Lin III (*first*); Sub Ap I (*first*); Rel I (*which demonstrably contain antibody*); Lin M (*therefore*); Rep I (*which cells*); *this family* is referential to

66.4.1; Rel I (*with a thin rim of basophilic cytoplasm*) cf. notes to 65.5.2 for representation of *a thin rim of cytoplasm*; Rel IIIa (*basophilic cytoplasm*); row 6 Rel I) (*large cells with*); Rel IIIa (*large nuclei*); row 6 Rel I (*whose appearance...*)

66.4.3 Lin II; (*their*); Lin III (*first*); Sub Ap I (*first*); Repl (*they*) row 3 Rep I (*the larger cells*); Sub Ap IV: reconstruction of **GJ²:** under *the antigen*; Rel I (*which stimulated* into a **J** and **:**, 'stimulus resulted in'; Repl (*their*); row 5 Rep I (*the large cells*); Rep II (*plasma cells*)

67.1.1 *their descendents* is reconstructed as *the cells which descend from large cells*; *these colonies often merge with others to form larger colonies* is represented simply as $\mathbf{CW_p^{>}T_m}$ 'cells have more proliferation in the medullary areas' since the conjunction *merger with...to form* does not otherwise occur

67.2.1 Lin II (*when only one injection of antigen is administered*) with *when* in the grammatical position of **':'**; Lin IVa (*only one injection of antigen*); *course of events* is a classifier which is given here the classifier index **CW** 'histological changes of cells'; Rel I (*described above...*) Sub Ap II (*secondary response*); *the cell types involved* is referential to *the cells types involved in the course of events when only one injection of antigen is administered* and to *the cell types involved in the secondary response*; since *involved* is **r**, we reconstruct $\mathbf{AV_p}$ under it by Sub Ap IIIb; *from* is an appropriate indicator for *indistinguishable*; *when* is treated conjunctionally, a variant in this environment of *if...(then)*; Rep II (*the cell types*); *stained for* which occurs in a **V** position, i.e., **A–C** is treated as $\mathbf{V_i}$ since the staining indicates antibody (or: protein) content; *specific antibody* by Sub Ap IV reconstructs **GJ:**

67.2.2 *this paucity of cells* is represented as $\mathbf{CW_i^{-}}$ 'this few number of cells present'; Sub Ap II (*primary response*); *during the response to* as environment of **:** linking **GJ** and **CW** sentences; Rel I (*responsible for this limited response*) where *this limited response* refers to *the response to primary injection*; *responsible* as **r** permits representation of *response* as $\mathbf{AV_p}$; *complex cell population* is represented as $\mathbf{C^{\Delta}}$ 'various cell types'; Rel I (*of the lymph node*)

67.3.1 Lin I (*by previously unstimulated cells*); Rel I (*previously unstimulated*); *by antigen* is reconstructed as an appropriate zeroing in the environment **–UC**; *it* 'extraction', see GEMP, pp. 355ff.

67.3.2 *of antigen* is reconstructed as an appropriate zeroing; *than 24 hours after a single injection of antigen* is reconstructed by Sub Ap I (*4 days later*) and Rep I

67.3.3 Rep I (*injection*); *a remarkable biological event engaging many cells* → *many cells being engaged in a remarkable biological event* by Passive II; Rel I (*first*); *of the injection* is recovered as an appropriate zeroing from row 3 (*the first injection*), and since *first* otherwise occurs on **J** but only in special circumstances on **G**

67.3.4 *the concurrent inauguration of cell differentiation* → *the inauguration of cell differentiation which is concurrent (with)* → *the inauguration of cell differentiation concurrent with* by Rel IIIa and zeroing of *which is* by Con I while *with* is reconstructed as an appropriate prepositional indicator of the second argument of *concurrent*; rows 3 and 4 Rep I (*concurrent with the inauguration of*); *the synthesis* is referential to *the cellular synthesis* (or: *the synthesis by the cell*)

67.3.5 Sub Ap II (*the "primary response"*); *the synthesis* here is referential to *the cellular synthesis*; Lin I (*by the same primitive cell of the proper variety*); Lin M (*intervening*); *intracellular* is decomposed as *in the cell*; *event*, as a classifier, is represented by unsubscripted **W**

67.3.6 Lin M (*perhaps*); Lin II (*after an injection*); Lin IVa (*the concentration of antigen*); Lin M (*unlikely*); *a secondary encounter* is reconstructed as a **GUC** sentence on grounds of parallelism with the previous row; *this event* is a referential classifier to 67.3.5

67.4.1 *the absence of stimulation* is represented as **GJ** 'not stimulation by antigen'; Rel I (*responsible*); *for production of antibody* is reconstructed under *responsible* by Sub Ap IIIb; *the plasma cell family is a specific response* is reconstructed as *the appearance of the plasma cell family is a specific response* since *response* is a classifier of sentences and not nouns; *antigenic stimulation* is decomposed as *stimulation by an antigen* by Rel IIIb; Rep I (*the plasma cell family*); Rel IIIb (*antibody synthesis*); Rep III (*the plasma cell family*); Rep I (*encountered*)

67.4.2 Lin M (*then always*); Rel I (*resulting globulin*) which is reconstructed as *globulin resulting from the plasma cell family* on grounds of **M** *if this is true*

referring to the previous sentence, with *resulting from* represented as $\mathbf{V_p}$; row 3 *"normal"* is taken as referential to *'uninjected animals'*, represented as **GJ~B**; *in* in **:** is reconstructed as an appropriate preposition to *present* which, in turn, is reconstructed under the negative quantifier *none* by Sub Ap IIIa and Neg

67.4.3 Rel IIIb (*cellular events*)

68.1.1 Rel IIIb (*cellular evidence*); Rel I (*which could be modified in its final stages*); Lin I (*in cells*); *normal* see notes to 67.4.2; Lin III (*in its final stages*); *in the cell* is reconstructed as an appropriate argument of *antigen presence* and from 68.1.2

68.1.2 *intracellular* is decomposed as *in the cell*; Lin I (*in the cell*); Lin IVa (*the presence of antigen*); Lin III (*at once*) which is represented by **i**, 'rapidly'; Rep I (*antibody formation*); *latent* is represented as $\mathbf{W_{a\sim}}$ 'inactive' which requires **C** as subject; Rep I (*antibody formation requires*); *a second stimulus* is here represented as $\mathbf{GU_s^2C}$ since row 2 has **GUC**, *of antigen the presence in the cell*

68.1.3 *the first exposure to antigen* is referential to *the cell's first exposure to antigen*; *can impose a complementary surface pattern on* is a new operator with **G** as first argument and **A** as second: see the discussion in chapter 4.6

68.3.5 row 2 Rep I (*the antibody detected...small lymphocytes*); *around* is reduced from *present around*, i.e., $\mathbf{V_i^y}$ where **y** indicates *around*, *by*; row 3 *of antibody* is reconstructed by the referential to *the appearance of antibody* or: *the antibody appearance*; row 5 *was the case* is a classifier, referential to *the antibody appearance morphologically was sharply limited to individual cells*; repl (*it*); row 7 Rep II (*antibody*); Lin III (*in an indistinct way*); row 8 *of antibody* is reconstructed by the referential modifier *particulate*; Lin M (*as well*)

68.3.6 Lin M (*obviously can not be excluded*); Repl (*its*); *to the formation of antibody*) is reconstructed under *contribution* as **r** with *to* an appropriate indicator of *contribution* by Sub Ap IIIb and on grounds of parallelism with row 1; *if present at all* is not clearly a comparative and so is not expanded

Paper 10 – Notes

Two special transformations applied in the analysis of this paper require additional comment. The word sequence *after closure of the fistula* in 306.5.1; *after the closure of the thoracic duct fistula, the interval between cannulation and closure of the fistula was increased* in 307.3.1; *cannulation of the thoracic duct* in rats in 314.3.1, etc., refer to the experimental procedure of draining lymphocyte-containing lymph from a cannula inserted (creating a fistuala) in the thoracic duct of rats and the subsequent removal of the cannula from the thoracic duct (closure of the fistula). This is established in the following text sentences from the "Methods" section of the paper which are not analyzed in the tables:

(303.3.2-2) Lymph from the thoracic duct of unanesthetized rats was allowed to drain away from a fistula for 5 days. The animals were then released from their restraining cages and their fistulae closed. (303.5.1) The thoracic duct was cannulated in its short intra-abdominal course by the method of Bellman, Cain and Grindlay. (304.1.1-3) Unless otherwise stated, lymph was allowed to drain away from the thoracic duct for 5 days before the rats were released from restraint. They were then anesthetized while the thoracic duct cannula was either gently pulled out and pushed under the skin. These procedures well be referred to as "closure of the fistula" although they resulted in a transient chylous ascites.
On this basis, we establish the following transformations:
after the closure of the fistula ← *after drainage ended with closure of the fistula*

following cannulation of the thoracic duct in rats ← *following drainage beginning upon cannulation of the thoracic duct in rats*

Also, in this paper the subclass $\mathbf{W_i^{\sim}}$ in the environment $\mathbf{C_y—T_h}$ or $\mathbf{C_y—B}$ represents lack of *depletion*; *drainage* and *loss* (*from*) in these environments are represented $\mathbf{W^f}$. A new subclass of **B** is established: $\mathbf{B_d}$, *donor animal*, which is distinguished as the first **B** argument of the three arguments (O_{nnn}) $\mathbf{I^{ft}}$ operator (whose first argument is **C**): *cells injected form donor animals into (lymphocyte-depleted) animals*

303.1.1 Causative (*Experimental procedures which deplete lymphoid tissue of small lymphocytes*), see chapter 5.6.3; Sub Ap II (*primary immune response*)

303.1.4 Lin M (*would be greatly strengthened*): *immulnological deficiency* has a dispositional character – here it is represented as a classifier, $\mathbf{AV}^{\sim}$; Sub Ap II: reconstruction of $\mathbf{GJ^{1}B}$: under the referential classifier *the unresponsiveness*; using the double negative ($\sim\sim$) to represent *correction* or *un-* is ad hoc; Lin IVa (*injections of small lymphocytes*); *into animals* is reconstructed as the third argument of the **I** operator *injection* (= 'transfer') which has O_{nnn} argument requirement; *normal animals* receives the index $\mathbf{C}^{\mathbf{g}}_{\mathbf{y}}{\sim}\mathbf{W}^{\mathbf{f}}{\sim}\mathbf{B}$, 'animals not drained of small lymphocytes, cf. 306.4.1. *Normal animals* (cf. *intact animals*) usually refers to *uninjected animals* but this is not the case in the experiments reported here, cf. *a "secondary" response to diphtheria toxin could be obtained in normal animals after a single dose of antigen* (316.2.7)

303.2.1 Lin IVa (*the chronic drainage of cells*); *thoracic duct fistula* is expanded as a *fistula (inserted) in the thoracic duct*; Sub Ap II (*secondary antibody response*); *normal* is an unexpanded comparative: *they will give a secondary antibody response which is equivalent to the secondary antibody response of normal adult rats*, where *normal* is factored *not depleted of cells*, see notes to 303.1.4 above

303.2.2 Sub Ap II (*primary antibody response*); Repl (*such rats*) by *rats depleted of small lymphocytes*; Rel I (*rats depleted of samll lymphocytes*) Repl (*it*) by *the primary antibody response which is severely depressed in such rats*; Repl (*such*); Rel I (*rats depleted of small lymphocytes*); *(X's) injecting small lymphocytes from other rats*, where *X* is a zeroed member of the $\mathbf{N}'$ class of meta-science noun subjects (e.g. *we*, *investigators*), is transferred by Passive I into *small lymphocytes being injected (by X) from other rats*) where we do not reconstruct the zero $\mathbf{N}'$ subject; *into such rats* is reconstructed as an appropriate zeroing of the second **B** argument of $\mathbf{I^{ft}}$, see the notes to 303.1.4 above

306.4.1 Lin IVa (*a single intraperitoneal injection of tetanus toxoid)*; Rel IIIa (*a single intraperitoneal injection*); Rel I (*normal*), factorized as above

306.4.2 Lin IVa (*a second intravenous injection of toxoid*); Rel IIIa (*a second intravenous injection of toxoid*); *sensitization* is taken as equivalent to *sensitization to the antigen*, for discussion of *sensitize*, see chapter 4.5

306.5.1 Rel I (*which rats*); we do not reconstruct a **GJB** sentence under *response* since its sentence can be connnected to **GJ^{1}B** by the relative pronoun; *closure of the fistula*, see above

306.5.2 Lin II (*when these animals were challenged with tetanus toxoid*); *(after) when* has the environment of : –this could be expanded as: *they fail to show an antibody response...in the period following the time which was three weeks later when these animals were challenged with tetanus toxoid*; *were challenged with tetanus toxoid* is **GJ^1** since it occurs *three weeks later (than) a first injection of tetanus toxoid*, in 306.5.1

307.2.1 Sub Ap II (*secondary immune response*); *injecting 2 inbred rats with a second injection of tetanus typhoid → 2 inbred rats being injected with a second injection of tetanus toxoid*: this transformation is discussed in the notes to sentence 303.2.2 above. The word sequence *being injected with a second injection*, although containing two occurrences of *inject*, nevertheless has the syntactic position of a single occurrence and so is represented as **J^2**; *the sensitizing injection* as *the injectionhaving been given 3 weeks earlier (than)...a second injection* is represented as **J^1**, 'the first injection'; see the discussion of *sensitize* in chapter 4.5.

307.2.2 Sub Ap II (*a brisk antibody response*); here, *response* appropriately zeroes a **GJ^{2}B** sentence as *the response* is of *these animals* (of 307.2.1)

307.3.1 Lin III (*become progressively smaller*); *progressively smaller* is represented **↓b**, 'began to decrease'; *a single intravenous injection*: the adjectives, which are unordered, have their linear order permuted since *intravenous* refers to *body*; Lin III (*was increased*) moves to its host (in **M**) *interval*; Rep I (*of the fistula*); *cannulation*, *closure*: see the note above

308.2.1 Lin I (*from the thoracic duct*); *chronic drainage from* is represented **W^{fn}** 'drainage from continuously'; *Rep I (from the thoracic duct the chronic drainage of)*; Sub Ap II: *to primary injection of sheep erythrocytes* is reconstructed as an appropriate zeroing of *the hemolysin response*; *once* is a temporal conjunction

310.1.1 *from fistula* is reconstructed as an appropriate argument of *loss*, cf. 314.3.3; Rel IIIb (*loss of lymphocytes*); Sub Ap II (*the immunological unresponsiveness*); Rel I (*which followed*); Con I (*-s → ø*); Lin I (*from the thoracic*

duct); *chronic drainage* appropriately zeroes *of lymph and cells*, from 308.2.1; *which followed* is treated conjunctionally and not expanded as a relative since doing so merely repeats an existing row; Lin IVa (*chronic drainage of lymph and cells*)

310.1.2 *reverse* and *-un* are the source of the double negative ($\sim \sim$) in the formula; Sub Ap II (*-responsive*); *state* appropriately zeroes *of the animal*; *by injecting...rats with thoracic duct cells from...rats...* → *thoracic duct cells being injected into...rats...from... rats*: for the passive denominalization, see the notes to 303.2.2; the order of arguments of **I** is imposed by the *from*, *to* argument indicators; Rel I (*thoracic duct cells*) which reconstructs *drained from* as appropriate operator; Rel I (*lymphocyte-depleted*) where the decompounding reconstructs the appropriate preposition *of*; Rel I (*non-immunizing*), equivalent to 'not injected'

310.3.1 Lin II (*restored*); Sub Ap II (*response*); *the response was restored* is taken as equivalent to *the unresponsiveness was reversed* as *the response* is referential to *the unresponsiveness* of 310.1.2; *injected intravenously into these rats* in rows 4 and 8 is reconstructed form the caption of Fig. 6, p. 311: *Hemolysin response to a single intravenous injection of 10^8 sheep erythrocytes in lymphocyte depleted rats injected intravenously with living and disintegrated thoracic duct cells*; *were drained from* in row 5 and 9 is reconstructed as an appropriate operator in the environment **C—T_h**; Rel I (*lymphocyte-depleted*)

314.3.1 Br S (*in a number*); Rel IIIa (*a number which was approximately 2.5 x 10^9*); *cannulation of the fistula*, see the note above; *90%* and *the remainder* are referential quantifiers which allow reconstruction of *of these cells*

314.3.2 Mp (*the loss of these cells*); *the loss of these cells from the fistula severely depressed or abolished the primary immune response of rats* is transformed by the causative transformation of chapter 5.6.3; Lin IVa (*of rats*); Sub Ap II (*the primary immune response*); Rep I under *or*

314.3.3 Sub Ap II (*-responsive*); *of the rats* is reconstructed under the classifier *state*; *from the thoracic duct fistula* is reconstructed as an appropriate argument of *loss*, cf. 314.3.2; Lin III (*could be corrected*)

314.3.4 *it* is replaced by its antecedent in 314.3.3, *the unresponsive state*; *equally well* is a comparative-like form left unexpanded; Sub Ap II (*-respon-*

sive); *suspensions of cells drained from the thoracic duct* on grounds of the wide recurrence of *drain from* (or: *loss from*) in the environment *cells—thoracic duct* (cf. 303.2.1; 306.5.1; 307.2.1; 307.3.1; 310.1.1 etc., and row 7 of the present analysis); *suspensions of cells* has the environment of **C**, i.e., as subject of *drained from*; *by injecting suspensions of cells... → by suspensions of cells being injected*, see the notes to 303.2.2; *into rats* is an appropriate argument of *inject*; Rel I (*drained from the thoracic duct*); Rel I (*from which large lymphocytes...*); *eliminate from* is taken as $\mathbf{Y}_i$ 'large lymphocytes were not among the cells'. The "elimination" comes from a procedure of culturing the cells before introducing them into a recipient animal during which the large lymphocytes die: from the "Methods" section of the paper, 304.3.4-5; Sub Ap II (*-responsiveness*); Lin IVa (*a loss of small lymphocytes*).

316.2.4 Sub Ap II (*response*); *if anything, greater than normal* is an imprecise comparative which is unexpanded; Rel I (*in which drainage from...*); Lin IVa (*drainage from the thoracic duct*); *of cells* is recovered as an appropriate zeroing under *drainage*; Rep I (*in which rats from the thoracic duct drainage was carried out of cells*); *immediately before* cannot be represented as **:** since its arguments reverse the order of the arguments of **:** ; *the second dose* is a classifier of $\mathbf{GJ^2B}$

316.2.5 DePassive (*the response is mediated by cells*); Sub Ap II (*the secondary response*); *mediate* as **r** allows *response* to be assigned the index $\mathbf{V}_p$ by Sub Ap IIIb; Rel I (*which cannot be withdrawn...*); *drainage* is reduced from *drainage of cells* which we denominalize into *the cells being drained*; rows 4-6 are reconstructed by parallel zeroing – Rep I – under the contrastive conjunction *unlike* which thus reconstructs *can be withdrawn*, with Sub Ap II (*primary response*)

316.2.6 *This does not mean that small lymphocytes play no part* is transformed to *This does not mean it is not the case that small lymphocytes play a part* in order to avoid a formula which asserts what the **M** segment over it denies; Rel IIIa (*circulating lymphocytes*); Lin I (*in the intact animal*); *circulating* is reconstructed as *present in circulation*, i.e. *in the blood*; *intact animals* can be decomposed into *animals which have not been lymphocyte-depleted*

316.2.7 Rel I (*normal*); *into rats* is appropriately reconstructed as an argument of **J**, *a single dose*; Repl (*this*) by *a single dose of antigen* in row 2; Lin IVa (*an injection of thoracic duct lymphocytes*); Rel I (*thoracic duct lymphocytes*

from...donors), for this expansion of *thoracic duct lymphocytes* see notes above to 314.3.4 *into rats* is reconstructed as an appropriate argument of $\mathbf{I^{ft}}$

316.2.8 Mp (*donors' lymphocytes*); *lymphocytes...had become specifically sensitized* is symbolized $\mathbf{GU_sC_y}$, see the discussion of *sensitize* in chapter 4.5

316.5.1 *mediate* as **r** allows *response* to receive the index $\mathbf{V_p}$ by Sub Ap IIIb; Sub Ap II (*primary responses*)

317.1.1 Rep I (*antibody is produced*); Rel I (*which divides and differentiates...*); Rep I (*which line of cells*); for discussion of parallel zeroings under the contrastive sonjunction *but*, see GEMP 3.43

317.1.2 *the small lymphocyte is not an "end" cell* is taken as equivalent to 'the small lymphocyte is not a cell from which no cell is descended' (or: 'which has no descendents'), hence *"end"* is in the **Y** segment; Repl (*it*); Rel I (*which divides*); Rep I (*"large pyroninophilic cell"*); *plasma cell precursor → a cell which is a precursor of plasma cells* where *precursor* is represented as $\mathbf{Y_c^f}$ 'develops from' i.e., a cell from which plasma cells develop; *precursor* can be analyzed as *that which precurses* (*that which comes, occurs before*), cf. the *Oxford English Dictionary.*

317.1.5 Rel I (*antibody-forming*)

317.2.1-2 two sentences are collapsed by semicolon since 317.2.1, analyzed as **M** introduces what follows; Mp (*the interaction of small lymphocytes*); Causative: *primary immune responses are intitiated by the interaction of small lymphocytes*; Rep I (*small lymphocytes' interaction*); Rel I (*which has been "processed"...*); Sub Ap I (*primary immune responses*)

317.2.4 (*the small lymphocytes'*) is reconstructed as the appropriate subject of *contact with antigen*, given 317.2.2 above; Rep I (*the small lymphocytes*); *between* has *from..to* as a variant; *small lymphocytes'* is reconstructed as an appropriate subject zeroing of *drainage*; Sub Ap II (*the primary response*)

317.2.5 Lin I (*in the lymphoid tissue*) which is taken as part of the secondary expanded as Rel I, given 317.2.4, row 1; Rel I (*the fixed lymphocytes*); Rep II (*the lymphocytes*); Rel IIIb (*cell line*); Rel I (*dividing cells*); Rel I (*which*

perpetuates itself): *perpetuates itself*) is represented $\mathbf{W_p}$ 'proliferates'; Rep I (*which line of cells*)

317.2.6 Lin II (*in the secondary response*); *further contact with antigen* is referential to *after (small lympocytes') contact with antigen* in 317.2.4; *further* is represented as 'second'; *further contact with antigen greatly increases the rate at which the dividing cells produce plasma cells* is transformed as follows: application of the Causative yields ...*causes a great increase of the rate at which the dividing cells produce plasma cells.* By Lin I, Rel IIIa and Mp we form ...*causes the dividing cells to produce plasma cells at a rate which has a great increase.* By Lin II and Rel IIIa this becomes ...*causes the dividing cells to produce at a greatly increased rate plasma cells* Rel I (*dividing cells*); Sub Ap II (*secondary response*)

317.2.7 Lin IVa (*the precise location of the dividing cells*); Rel I (*the dividing cells*)

317.2.8 Repl (*them*) by *dividing cells* of previous sentence; Lin IVc (*aggregates of dividing cells*); Rel I (*dividing cells*); Lin M (*either*); Rel I (*synthesize antibody*); Lin II (*during secondary responses*); Sub Ap II (*secondary responses*); here the classifier *response* has the environment : ; Rep I (*which germinal centers*); Rep I (*antibody-forming cells*)

317.3.1 *participate* as **r** allows representation of *response* as $\mathbf{V_p}$ by Sub Ap IIIb; Sub Ap II (*primary responses*); Rep I (*small lymphocytes*); Rel I *which eventually synthesize antibody*)

317.2.2-3 *small lymphocytes transfer some antigen-conditioned material to other cell types* is an instance of a sentence which can only with difficulty be fit into existing structures, or structures similar to them – see the discussion of this sentence in chapter 4.7. Since we have *antigen-conditioned material* which is similar to *antibody specific to antigen*, we take *material* as the $\mathbf{A_a}$ subclass of **A**, 'substance'; doing so, then enables us, by Passive II, to characterize the environment of **A—CC** as that of **V** – this fits the semantic fact that *transfer* is a verb of movement; 317.2.3, as the last sentence of this discussion, is appended as an **M** row.

Paper 11 – Notes

161.1.1 Rel IIIb (*the production of antibody*); Rel I (*in the lymph node*)

161.2.1 Lin M (*by Coons and his colleagues, using the indirect fluorescent antibody technique*)

161.2.2 *these cells* referential to previous $\mathbf{AV_iC}$ row in 161.2.1 which is reconstructed here as a secondary sentence modifying *cells*; Rel I (*antibody-producing*); Lin M (*soon also*); other situations, i.e. – 'not lymph nodes', $\mathbf{T_{n\sim}}$; Rel I (*antibody-containing*); Rel I (*plasma cells were found*); Rel I (*sites of deposition...*); Rel I (*transferred lymph node cells*) → *lymph node cells which were transferred* which we transform to *cells transferred from lymph nodes*, with *from* reconstructed as the appropriate indicator, given *other situations* (i.e., situations other than lymph nodes) of row 4; row 10 Rep I (*antibody-containing plasma cells were found*); Rel I (*antibody-stimulated*); decompounding *antigen-stimulated... cells stimulated by antigen* by Rel IIIb; Rel IIIb (*lymph node cells*); Rel I (*cells of the lymph node*)

161.2.3 *in single cell preparations from active lymph nodes* is represented as a **CWT** structure, with *preparation* a member of $\mathbf{W_{\ell}}$, the subclass of procedural terms; row 3 *virtually all the cells* → *virtually all the cells*: as a quantity noun, *all* can have *of* as a characteristic preposition (GEMP 2.12); Lin IVc (*virtually all of the cells*); row 3 Rel I; row 4 Rel I

161.3.1 Mp (*a role of the lymphocyte*); Rel IIIb (*antibody formation*)

161.3.2 Rel I (*antibody-forming*); Lin IVc (*the frequency of antibody-producing cells*); Rel I (*antibody-producing*); Rel I (*found*); Repl (*that*) by *the frequency of antibody-producing cells*); Rel I (*antibody-producing*)

162.2.1 Lin M (*by the indirect fluorescent antibody technique*); Lin IVc (*the amount or concentration of antibody*); *it* is a resumptive (pleonastic) pronoun; Lin II (*following primary stimulation*); Lin IVc (*the small number of cells*); St S (*present*); *thus identified* is referential to *identified (as) antibody-containing*); Rel IIIa (*antibody-synthesizing cells*); Con I (*wh-*, *-s*); Lin III (*most active*) moves to its host *synthesizing*, and is represented as superscripted > as active may be viewed as a modifier of appropriately zeroed *degree*: movement of *active* to its operator host *degree* yields the adverbial *-ly*

162.2.5 Rel IIIb (*antibody formation*); Lin IVa (*the induction of formation of antibody*); Rel I (*immunocompetent*) which is expanded as *cells competent to produce immunity*, cf. chapter 4.7; Lin IVa (*the presence of completed antibody*); Rel I (*completed*) which is taken as 'produced'; *such* pronouns *immunocompetent cells*; Rel I (*immunocompetent*)

162.2.6 Lin III (*in vitro*)

163.3.1-2 these two sentences are combined by a sublanguage transformation which combines a **GJB** sentence with a 'response' sentence containing a trace of the zeroing of **GJB:**, here, *after 4 days*, cf. Sub Ap I; *and* is a variant of :; Lin I (*in each hind foot pad*); Lin III (*(0.2 ml of a 50% suspension)*)

163.3.3 Lin I (*in such pooled suspension*); Lin IVc (*the yield of such cells*)

163.3.4 St (*present*); Rel I (*plaque-producing*)

163.3.5 Lin M (*in these experiments*); *in these suspensions* is an appropriate zeroing, reconstructed from the previous sentence; Rel I (*plaque-producing*)

164.3.1 *2 classes of cells* is represented $\mathbf{C}^{\prime}$, $\mathbf{C}^{\prime}$, 'a class of cells and a class of cells' (GEMP 5.54); *with distinct morphological features* as a classifying modifier is not presented in the formula

164.3.2 Rep I (*the category*)

164.4.3 No transformations applied

164.4.4 *the* of *the nucleus* is referential to *these lymphocytes*; Rel IIIa (*eccentric*); Rep II (*the nucleus of these lymphocytes*)

164.4.5 Rel IIIa (*relatively large and honeycombed*)

164.4.6 *fine and granular with most organelles confined to the larger pole of the cell* is distributionally distinguished as a new subclass $\mathbf{W}_{\mathbf{n}}$, characterized as operating solely on *cytoplasm* $\mathbf{S}_{\mathbf{c}}$; *cell* in the operator segment is a repetition of reference to *the cell* carried by *the* in *the cytoplasm*

164.4.7 Lin IVc (*the number of small mitochondria*); *in the lymphocytes* is a sublanguage appropriate zeroing reconstructed from the previous sentence and the next two rows; Lin III (, *even in relation to their size,*) which is not expanded as a comparative as doing so merely repeats exising rows; Rep I under the comparative *greater... than*

164.4.8 Lin M (*usually*); *in these lymphocytes* is reconstructed as a sublanguage appropriate zeroing; Repl (*it*); Rel I (*with few vesicles*)

164.5.1 Lin M (*was*); Rel I (*antibody-producing*); Rel IIIa (*rough*)

164.5.2 Lin II (*as has been described in the recent literature*); Lin I (*in the smaller lymphocytes*); Lin IVc (*a small amount of endoplasmic reticulum*); smaller lymphocytes is represented as $\mathbf{C}^{\mathbf{g}}_{\mathbf{y}}{}^{\sim}$, i.e., as 'small lymphocytes'

164.5.3 *was sparse, and was consistently widened* is represented as $\mathbf{W}_{\mathbf{w}}$ 'widened' since *sparse* does not occur independently of *widened*

164.5.4 *the resulting vacuoles* can be taken as an appropriate reduction from *the vacuoles resulting from the consistent widening of the endoplasmic reticulum*, mentioned as *consistently widened endoplasmic reticulum* in the previous sentence; *the* in *the endoplasmic reticulum* is referential to *the smaller lymphocytes*; *a grayish granular material* has environment of **A**, but is not *antibody*

164.5.5 Lin M (*also, however*) Lin I (*in the larger lymphocytes*; Rel I (*of a different form*) which is represented as $\mathbf{W}_{\mathbf{r}\sim}$, $\mathbf{W}_{\mathbf{w}\sim}$ 'not of the forms previously mentioned'; *larger lymphocytes* is represented as $\mathbf{C}^{\mathbf{g}}_{\mathbf{y}}$, 'large lymphocytes'

164.5.6 *of endoplasmic reticulum of the larger lymphocytes* is reconstructed as an appropriate zeroing under *the channels*; *narrow* is represented $\mathbf{W}_{\mathbf{w}\sim}$ 'not widened'

165.1.1 *of the channels of endoplasmic reticulum* is reconstructed (as ordered by Lin IV_{a}) as an appropriate zeroing from the previous sentence and as under the referential partitive *pieces*; *...observed, cut longitudinally, with apparently random orientation* is represented as $\mathbf{W}_{\mathbf{y}\sim}$ 'not parallel or lamellar'

165.1.2 *of the channels of endoplasmic reticulum* is reconstructed (as linearized by Lin IVa) as an appropriate zeroing under the predicate *organization into lamellae*, which operates only upon *channels of endoplasmic reticulum* or Golgi vesicles, not mentioned explicitly here

165.2.1 *exhibited a certain morphological unity, showed considerable pleomorphism*, as classifier phrases, are represented as unsubscripted **w** predicates; Rep I (*the lymphocytes*) 2 times; Rep I (*differing primarily*); *cytoplasmic organization* is reconstructed as *organization in their cytoplasm*, with the referential = *their*) by Rel IIIb; Lin I (*in their cytoplasm*)

165.2.4 Rel I (*several forms may represent...*); Con I (*-s*); *various stages of development* is reconstructed as *cells which are in various stages of development*, since **Y** requires **C** here and by Rel IIIa

165.2.5 Rel IIIa (*well developed and flattened*); Rep I (*all of the cells... reticulum which was*); Rep I (*all of the cells... by*); Rel IIIa (*distinct*); Rep I (*all of the cells... by*); Rel IIIa (*normal*); *round with evenly dispersed chromatin* is represented as $\mathbf{W}_{e\sim}$ 'not eccentric'

165.2.6 No transformations applied

165.7.1 Rel I (*which are clearly shown...*)

165.7.2 Rel I (*of the morphologic classification*)

165.7.3 No transformations applied

165.7.4 Lin M (*was originally presented in the 1940's*); Lin IVb (*a function of the lymphocyte*); Rel I (*in cells*); Rel I (*of the lymph node and spleen...*); *and with* has the environment of :; *injected into the mouse and rabbit* is reconstructed as a sublanguage appropriate zeroing given the environing : and **CWT** sentence

165.7.5 for the representation of *as a source of* as $\mathbf{V}_{\mathbf{p}}$, see the notes to paper 5; Lin IVa (*the synthesis of antibody*); *could be expected* is a metascientific assertion which would have to be depassivized in order to extract it from the science language; Rel IIIa (*well developed*); Rep I (*with its*); Rep I

(*antibody synthesis could... be expected*); Rel IIIb (*cytoplasmic differentiation*); Mp (*paucity of differentiation of cytoplasm*)

166.2.1 Lin M (*in this study, however*); Lin I (*in the lymphocytes found as single cells...*); Lin IVc (*there were definitely more of the structural units*); Rel I (*generally associated with...*); *generally associated with synthetic functions* is reduced from *generally associated with protein synthetic functions*, factored $\mathbf{A_p V_p^r}$; Rel I (*found as single cells in the center of plaques*) which is equivalent to 'producing plaque' and to 'producing antibody', cf. 166.2.2; Rep I under *than*; *the quantities* is an appropriate modifier of the $\mathbf{W_i}$ operator, cf. chapter 5.4.1; Rep II (*these structural units are*)

166.2.2 Lin IVb (*the significance of these structures*); Rel IIIb (*antibody synthesis*); Rel I (*in these cells*); *these cells* is referential to *the small lymphocytes*; Rel I (*were at the edge of plaques*); Lin M (*therefore*); Rel I (*were not producing antibody*)

166.4.1 Rel IIIa (*antibody-synthesizing*); Con I (*wh-, -s*); Rel IIIa (*protein-synthetic*)

166.4.2 Lin IVc (*many of the ribosomes of the lymphocytes*); Rel I (*apparently developing*) Rep I under *although*; *the substantial majority* is a referential quantifier referring to *the lymphocytes*

166.4.3 Lin I (*in mammalian cells*); Rel I (*secreted*); Rel I (*not bordering an organized endoplasmic reticulum*) with *organized endoplasmic reticulum* represented as $\mathbf{S_r^h}$ 'channels of enoplasmic reticulum' i.e., 'endoplasmic reticulum orgainized into channels' on the basis of 166.4.2, row 1

167.1.1 Lin IVb (*the effectiveness of these free ribosomes*); *free ribosomes* may be expanded as $\mathbf{S_b W_i \tilde{} S_r^h}$ 'ribosomes free of (or: 'not bordering on') an organized endoplasmic reticulum' or as $\mathbf{S_b W_i S_c}$ 'ribosomes free in the cytoplasm' as is done here; *the size of the plaque* is equivalent to 'the degree of production of plaque'

167.1.3 Rel IIIb (*single cell plaques*); Rel I (*of single cells*); Rep I under *or*; *with roughly equal frequency* is moved onto the *or* conjunction by Lin III; *the cells of the two cytological classes* is referntial to *the cells of the lymphocytic class and the cells of the plasmacytic class*; Lin III (*to the external medium*);

differ is expanded as a reciprocal with *from* reconstructed as an appropriate indicator: N_1 *and* N_2 *t Adj* → N_1 *t Adj from* N_2; Rep I under *differ from*

167.1.4 *in which* is treated as a conjunction; Lin III (*at a higher rate*) Lin I (*within its endoplasmic reticulum*); Repl (*it*); *disintegration of the cell releases this additional antibody* is expanded by the causative transformation discussed in chapter 5.6.3; Rep I under *but*; *this additional antibody* is referential to *the antibody which is stored within the endoplasmic reticulum*; *to be released* is perhaps not entirely correct as a member of $\mathbf{V_s}$

167.2.1 Lin IVa (*secretion of antibody*); Repl (*such*); Lin I (*in active lymph node cells*); Rel IIIb (*active lymph node cells*); Rel I (*of lymph nodes*); *a continuous secretry process* is represented as $\mathbf{AV_s^n}$ 'antibody continuously secreted' and is derivable from *process of continuous secretion of antibody*; *still active* is treated as 'continuously active'

167.5.1 *these diverse cell types* is referential to *antibody-producing lymphocytes* and *antibody-producing plasma cells* of row 4, and is a classifier of *lymphocytes, larger and smaller*; Rel IIIa (*antibody-producing lymphocytes*); Rel I (*different stages of development*), for this expansion see notes to 165.2.4

168.1.3 row 3 Rel I (*selected by their activity...*); *selected by their activity in the synthesis of* receives the index $\mathbf{V_p^+}$ 'producing a large amount', cf. 167.1.2 (not analyzed here): *In this study plaques were not selected for size, but were chosen for maximum clarity and distinctness, and thus represent a selection from among the most actively secreting cells.* where *most actively* is clearly a degree modifier of the operator *secreting*; row 4 Rep I (*a group of cells have shown*); row 5 Rel I (*progression of development*) *progression of development* in the secondary sentence receives a different representation as, in the secondary, it is modified by *of endoplasmic reticulum.* This can be avoided if, for example, we treat *a progression of development of endoplasmic reticulum through* as a single $\mathbf{Y_c}$ operator or, perhaps, as a new subclass, $\mathbf{Y_r}$; row 6 Rel I (*includes both lymphocytes and plasma cells*)

168.1.4 Lin M (*in fact*); Repl (*such developmental changes*) by *developmental changes in the endoplasmic reticulum*; Lin III (*can occur*); *synthetic apparatus* is equivalent to *apparatus which is for synthesis of protein*, where *of protein* is reconstructed as an appropriate zeroing from row 5; row 6 Rep I (*this cell*); Repl (*its*); row 7 Rel I (*stimulus*) which is represented as **GJ** since it

occurs in the environment *response to* ——, cf. Sub Ap II; Mp (*rapid synthesis of a special protein*)

Paper 12 – Notes

109.2.3 Lin I (*as an antigen*); Rep I; Lin IVa (*the distribution of the antibody*); Lin IVa (*the earliest appearance of antibody*); Repl (*its*); Rep I (*the booster...of antigen*). In this analysis *earliest*, as an unexpanded superlative is treated as a local operator upon the $\mathbf{V_i}$ verb *appearance* indicating the assertion of antibody's earliest appearance in the hemacytoblast – this, as against a full expansion which would place the temporal modifier in the colon segment, see chapter 5.4.4 and fn. 8

112.3.1 Rel I (*most primitive*); Con I (*wh-, -s* → *ø*); *the most primitive cell to contain antibody* is reduced from a form like 'the antibody-containing cell which is primitive more than all other antibody-containing cells are primitive', i.e., the most primitive of the cells to contain antibody is the hemocytoblast; row 7 Rel I (*large electron-lucent*); row 8-9 Rep I (*a cell characterized by its*) x 2; Rel I (*extensive and complex*): we do not decompose the conjunction since *complex* does not recur, thus providing a basis for distinguishing it from *extensive*; Con I; Rep I (*cytoplasm which is*); Br S (*number of*); Rep I (*a cell characterized by its cytoplasm which is*); Br S (*contents of*)

112.3.2 *the* in *the perinuclear space* is referential to *the hemacytoblast*; *the antibody present primarily in the perinuclear space* is analyzed as an unexpanded comparative 'the perinuclear space contained more antibody'; Rel IIIa (*the initial site of antibody synthesis*), analyzed as 'site where antibody synthesis begins'; Rel IIIb (*antibody synthesis*)

112.3.3 Lin M (*sometimes also*); Repl (*this cell*); Rel I (*rare in the hemoblast*); Rep I (*the ergastoplasmic cisternae...contain antibody*); for *do*, see GEMP 6.53; Rel I (*are rare in hemocytoblast*)

112.3.4 Sub Ap II reconstructs **GJ^{3}B:** under *reaction*; *the reaction product* is $\mathbf{A^G}$, cf. 112.5.5, *the reaction product of peroxidase*; the concessive *even* is not expanded

112.4.1 *Subsequent* is a temporal conjunction not expanded here; Rep I (*the gradual development of the*); Rel I (*the ribosome-associated*); we de-com-

pound *ribosome-associated* as *associated with* (= *containing*) *ribosomes* on grounds of the high liklihood of *with* to occur as an indicator of the second argument of *associate*, cf. 112.5.8

112.4.2 *In the earliest of the differentiating cells* is taken as reduced from *in the cells earliest differentiating from hemocytoblast*; *said cells are of the cells differentiating from the hemocytoblast*, with *from the hemocytoblast* reconstructed as an appropriate zeroing from the previous paragraph; for *earliest* on *differentiate*, see footnote 8 in chapter 5; Rel I (*of the cells*); Rel I (*earliest differentiating*); Lin I (*by the term plasmablast)*

112.4.3 *the* in *the perinuclear space* is referential to *the plasmablast* of 112.4.2; *positive* is factored 'containing antibody'; Lin IVa (*the continuity of the endoplasmic reticulum*); Repl (*its*)

112.5.1 Rel IIIb (*cell differentiation*); Lin IVa (*differentiation of the cell*); *the next phase of differentiation, resulting in* is represented $\mathbf{Y}_{\mathbf{c}}^{\mathbf{t}}$ with **t** a variant indicator 'leading to'; Rep I (*its cisternae*); Repl (*its*); linearizing S_2 = *instead of (its cisternae) being flattened* to after S_1 which it interrupts, GEMP 3.12; Repl (*they*) by *its cisternae*; Rel I (*ribosome-studded*); we decompose *ribosome-studded* as *studded with ribosomes*, see the notes to 112.4.1 above

112.5.2 (*usually but not always*); Lin I (*at this stage*) which is referential to *the immature plasma cell* of 112.5.1; (*antibody*) is reconstructed as a subject zeroing; Rep I under *instead of*; *irregularly distributed* is perhaps inadequately represented $\mathbf{V}_{\mathbf{i}}^{-}$ 'contains little' – this representation is chosen as contrastive with *filling entirely*, represented $\mathbf{V}_{\mathbf{i}}^{+}$, in row 4; Lin III (*entirely*)

112.5.3 The construction *Not all N are A* (*Not all N are V*) is reduced from *Some N are A; I deny that said N are all*, cf. GEMP 7.13; here the negative has moved onto the verb *are* and we reconstruct as an appropriate zeroing the second *N* argument

112.5.4 Lin I (*of cisternae within the cytoplasm*); Rel I (*that are intensely or moderately positive*); *positive* is factored as 'containing antibody'; *that* is replaced by its variant *which*; Repl. (*those*); Rel I (*which are nonreactive*); *are non-reactive for peroxidase* is factored as $\mathbf{A}^{\mathbf{G}}\mathbf{V}_{\mathbf{i}}$ where the **G** superscript indicates a reference to the injected antigen on grounds that the environment —— for **G** is restricted to **A**, cf. 112.3.4; having $\mathbf{A}^{\mathbf{G}}$—**S** indicates the

operator is **V** – we recover $\mathbf{V_i}$ on grounds of parallelism with the previous row and place the negative on the verb

112.5.5 Repl (*the latter*) with its antecedent in the previous sentence; Rep I (*are distended*) under the comparative-like conjunction *like*; Rel I (*containing antibody*); Rel I (*is less dense than...*); *the reaction product of peroxidase* is represented by $\mathbf{A^G}$; representing *is less dense than* as a special ad hoc subclass of **Y** is in lieu of a separate predicate, *dense*, for *antibody* or *protein* which could then be expanded as a comparative

112.5.6 Lin I; Rel I (x 2)

112.5.7 *show* (sic); Rep I under *and*; *is restricted to* is inadequately represented as $\mathbf{V_i}$ 'contains'

112.5.8 Lin M; Repl (*it*); obviously the science language formula here is inadequate as it requires the negative which is segmented in **M**. A paraphrastic ad hoc transformation of the entire sentence is: *antibody was not discernably associated with ribosomes in non-counter-stained sections*, $\mathbf{AV_i \sim S_b C_z^m}$

112.6.1 Lin II

112.6.2 For this analysis of the *Not all N V N* construction see the notes to 112.5.3; Rep I (*plasma cells in a given spleen...*); *in a given spleen* is an appropriate zeroing from row 1; Rel IIIa (*positive*); *positive* is factored 'containing antibody'; Rel I (*negative*) factored as 'not containing antibody'

112.6.3 Lin M (*two types*)

112.6.4 Lin I (*in both cell types*)

113.1.1 Lin I (*in some cells*); Repl (*it*); Lin M (*often*); Rep I under *and*, (*Russell bodies?*) is expanded 'which may (possibly) be (what are called) Russell bodies'

113.1.2 Lin I (*in other cells*); *from* is reconstructed as an indicator of the 2nd argument of *escape*; Rep I (*the antibody*); *to be* replaced by its variant *is*

113.1.4 *Rep I (the nuclei)*; *antibody-free* is decompounded *free of antibody* by Rel IIIb; Lin M (*sometimes*); Repl (*they*); *are pushed to one side and indented* as a predicate of *nucleus* is treated as a member of $\mathbf{W}_e$ 'eccentric'; *with which the cytoplasm is engorged* → *with which is engorged the cytoplasm* by a transposition placing tense before subject, GEMP 3.15

113.2.1 Lin II (*throughout plasma cell development*); Lin M (*usually*); *throughout* is a temporal conjunction operating on an aspectual *PN* modifier of *plasma cell development*, e.g., *the course of*, *the period of*; *an occasional cell has been found* → *a cell has been found occassionally*, see chapter 1, section 3.3; the *SC* sequence in the index formula inverts the order of the **S** and **C** segments of the projection which results from the convention of reading the relative pronounced word first in a row reconstructed as a secondary sentence

113.2.2 (*antibody*) is a reconstruced subject zeroing, chapter 5.3.2; *the lamellar portion* referentially zeros *of the Golgi apparatus*, just as *the Golgi apparatis* referentially zeroes *of the cell*; Repl (*it*); Rep I (*antibody occurs*)

113.3.1 Neg (*no antibody could be identified*); Rep I under *or*; *extracellular spaces* is represented $\mathbf{C}^{\sim}$ 'not of cells'

113.4.1 No transformations applied

113.5.5 *to localize* is factored into *to establish/determine the ultrastructural location of antibody* on the basis of the title of this article and of the first sentence (109.1.1): *The localization of antibodies in cells of the plasmacytic series was established at the light microscope level,....*; Sub Ap II (*primary response*); Rel IIIb (*antibody synthesis*); *after primary injection* is reconstruced as an appropriate zeroing under the comparative-like form *are the same as*; *involved* is reconstructed form the presence of the indicator *in* and by parallelism with the previous row; Sub Ap II (*secondary response*); row 5 Repl (*they*); *are involved in synthesis of antibody after primary injeciton* is a referential zeroing

114.2.1 Lin M (*reveals by... system*), with *peroxidase-antiperoxidase antibody* treated as **M** since it is under the **M** verb, *revealed by*, and under an **M** classifier, *system*; Rel I (*antibody-containing cells*) x 2; *those* refers to *those antibody-containing cells*; row 6 Rep I (*the cells are*)

Paper 13 – Notes

448.1.1 row 4 *antigen-bearing red blood cells* is **G** on grounds of 451.2.1 (not analyzed here): *Rosettes of SRBC adherent to antibody-producing cells were prepared....* where SRBC is **G** in this environment; Rel IIIa (*individual...cells*); *hemo* as **G** in *hemolytic* $\mathbf{A^G}$ is not clearly referential here (cf. chapter 5.4.4); Lin IVa (*adherence of*), Rel I (*antibody-forming cells*); Rel IIIb (*antibody production*)

448.2.4 row 3 *which* is not expanded, as doing so merely repeats row 2; row 5 *these* is referential to *several hundred such cells* in the preceding row, see chapter 2.1, for discussion of the conditions for including science language material in **M**; row 7 Rel I (*such cells*); Repl (*such*) by *antibody-producing*; Rel IIIa (*antibody-producing*); row 8 Rel IIIb (*the rabbit lymph node*); row 9 the quantifier is referential to *several hundred such cells* of row 5; *great majority* is represented > > 'most'; Lin IVc (*of the cells*); row 10 *the two groups* is referential to row 5; *between the two groups* → *between one group and the other group*; here *between...and* is represented **ft** *from...to*, cf. chapter 2.4

449.1.1 Rel I (*plaque-producing*); Lin III (*both direct and facilitated*) which moves onto *producing*: this is a non-recurring procedural adjunct and so receives no index; *both categories* referential as above; *a substantial majority* is a referential use of the quantifier referring to *cells* of row 1; Lin IVc (*a substantial majority of the cells*); for treatment of *majority* see notes to 448.2.4

451.3.1 Lin IVa (*The classification of cells*); Lin M (*according to the description below*); *the endoplasmic reticulum* referential to *the cells*; *state* as a non-specific classifier is represented **W** without subclass designation

451.5.1 Rel I (*typical of small inactive lymphocytes*); Rel IIIa (*uninjected animals*)

453.1.1 row 3 Rep IIIa (*indented, electron-opaque*); row 2 Rep I; Rel IIIa; row 3 Rep I; Rel IIIa (*a narrow rim of cytoplasm*); row 4 Rel I (*with a few mitchondria*); row 5 Rep I (*which cytoplasm was with*); Rel IIIa (*rare narrow profiles of ER*)

453.1.2 row 2 Rel I (*rosette-forming*); *background* is equivalent to *of* (or: *in*) *uninjected animals* by 451.5.1; row 3 *those* referential to *rosette-forming lymphocytes*; Rep I (*were larger*) (*rosette-forming*); row 4 Rel I (*rosette-forming*); row 5 *lymphocytes which are* is reconstructed by Rel I under apposition to *lymphocytes* of rows 1-4; *which are* → ø by Con I; *cytoplasmic* is expanded *in their cytoplasm*; Lin I (*in their cytoplasm*)

453.1.4 Lin I (*in many of these cells*) with *these cells* referential to 453.1.2; *many represented by* + on $\mathbf{C_y}$

453.1.5 *the cytoplasm* is referential to *the cytoplasm in many of these cells* of 453.1.4; *broadened* is represented by $\mathbf{W_w}$ 'widened'; Rep I (*the cytoplasm in many of these cells*) under *and*; *in* is reconstructed as an appropriate preposition; neither comaparative is expanded as to do so requires a more detailed treatment of the quantifier *many*

453.1.8 *most* is represented by > > on **C**, *these cells* of preceding sentences; Rel IIIa (*rough*); Mp (*channels of...ER*); Rep I (*most of these cells had*); Rel IIIa (*rough*); Mp (*channels of...ER*); Rep I (*most of these cells had*); Rel IIIa (*partly distinct*) represented $\mathbf{W_m^-}$ 'little mature'

453.2.1 row 1 Repl (*this*) by *large lymphocytes*; Rel IIIb (*cytoplasmic components*); Lin I (*in their cytoplasm*); Rel I (*rosette-forming*); *as* is part of the comparative *same as* and is reconstructed by Con II; the comparison is to *the cytoplasmic components of the rosette-forming cells of the small to medium lymphocytes group* of the previous paragraph (451.5.1 – 453.1.8): this is reconstructed by Rep I under *same...as* and the transformations noted above are applied to yield the transformed sentence of the projection; *differ* is a reciprocal verb which permits the transformation: N_1 *and* N_2 *differ* → N_1 *differs from* N_2. However, we do not expand this as the basis of the comparison – as to more or less – is not stated for the respective cell groups

453.2.6 *the ample cytoplasm* is referential to *the cytoplasm which is ample in the large lymphocytes*; the representation $\mathbf{S_c^+C_y^g}$ has the quantifier represented as occurring on the noun category which abbreviates its occurrence on a zeroed $\mathbf{W_i}$ verb, i.e., $\mathbf{S_sW_i^+C_y^g}$; *free ribosomes* may be decomposed as 'ribosomes not bordering on an organized endoplasmic reticulum' (cf. paper 11,166.4.2-3); Lin M (*either*) Rel I (*which appeared to be randomly distributed*); *in the ample cytoplasm of the large lymphocyte* is appropriately

reconstructed as the second argument of *distribute*; Rep I (*which free ribosomes...lymphocytes*)

453.3.1 No transformations applied. In a more refined treatment of quantifiers, *some* would be moved onto the verb *demonstrable in*; *almost every* is symbolized + + 'very many'

453.3.2 *of ER* is appropriately reconstructed form its modifier *channels*; Rep I (*the channels of ER in these lymphocytes were with*); Rel IIIb (*protein storage*)

456.2.1 Lin III (*was noted*); Lin I (*in the ER*); row 2 *the channels* is referential to *the channels of ER in some of the large lymphocytes*; Rep I (*the channels*)

456.2.2 Lin IVa

456.2.3 Rel IIIa (*transitional forms*); Con I (*forms which are transitional*); Rel I (*which still had a predominantly ribosomal cytoplasm*); *the lymphocytes described in the previous paragraphs* are*the small to medium lymphocytes* and *the large lymphocytes*; *from*, *to* the indicators of *transition*, are variants of *between*, *and*

456.5.1 *these* is referential to section heading: *plasmablasts*; Mp (*further increase in number, length, and width of the channels of ER*); Lin I (*within them*), Repl (*them*)

456.5.2 Lin M (*corresponding*); Mp (*increasing volume of the ER*); *the* in *the ER* is referential to *the plasmablasts*; Rel I (*which were in random distribution*); *the* in *the cytoplasm* is referential to *the plasmablasts*; *in the cytoplasm* is appropriately reconstructed as the second argument of *distribute* when the first argument is *free ribosomes*, see 453.2.6 above; Rep I (*which free ribosomes were...in the cytoplasm* of *the plasmablasts*)

456.6.1 Rel I (*with regular circular lamellae of ER channels*); Mp (*regular circular lamellae of ER channels*); Rep I (*cells with*); Repl (*them*); Lin I (*between the ER channels*)

463.4.1 No transformations applied

463.4.2 Repl (*they*) by *plaque-producing cells*; Rel I (*plaque-producing*); *the* in *the cytoplasm* is referential; Rel I (*with only a few solitary, unoriented channels...*); Rel I (*very narrow...seen*); *unoriented* is represented by the superscript $\mathbf{y}\sim$ 'not parallel, lamellar'; *main* is represented $>>$ 'most'

464.2.1 Rep I (*if, the ER*); *the* in *the ER* is referential; Lin I (*in the widened channels*); Rel IIIb (*protein deposition*); Rep I (*the ER*); *the* of *the cytoplasm* is referential; *did* is a tense carrier (GEMP 2.05) *which* in the text has been transposed to before the subject *the area of free ribosomes* (GEMP 3.15); *did occupy* is replaced by its variant *occupied* in the reconstruction under Rep II

464.2.2 Lin I (*within the group of mature plasma cells*); Rep II (*the ER*); Rep I (*the ER being distributed*)

464.2.3 Rep II (*ER*); Lin IVa (*a transition from lamellar ER*)

469.3.1 *RFC* abbreviates *rosette-forming cells*

469.3.2 Lin IVb (*the involvement of antibody*); Rel IIIb (*rosette formation*); Rep. (*this*); *involvement* is not represented as a local modifier, i.e., as **r** since *involvement in formation* does not recur in this environment; *antiglobulin* is taken here as **G**, *antigen*, with *specific to* an operator on **G** and **A** (which is reconstructed); this operator cannot be **:** since its subject is **G**, not **A**, hence the designation **X**, cf. paper 9, 68.1.3 – *can impose a complementary surface pattern on*

469.4.1 Repl (*this*); *surface of the macrophage cell* is perhaps inadequately represented by $\mathbf{C_m}$ 'macrophage cell'

469.4.5 *cannot be coated passively* might be represented as an operational or meta-science subclass of **V**, e.g., $\mathbf{V}\tilde{\gamma}$ – here, it receives the index of 469.4.1 together with the negative since it is contrastive to this sentence

469.5.1 No transformations applied: *small and medium lymphocytes* is represented as $\mathbf{C}^{\mathbf{g}}_{\mathbf{y}}\sim$ 'small lymphocytes', cf. 451.5.1; note that a more detailed treatment of temporal conjunctions would relate the $\mathbf{AV}^{\mathbf{b}}_{\mathbf{p}}$ and $\mathbf{C}^{\mathbf{g}}_{\mathbf{y}}$, $\mathbf{C_bW_p}$ formulas

469.5.2 Lin II (*to reach the full rate of antibody secretion*); Rep III (*for cells*); Rel IIIb (*antibody secretion*)

469.5.3 Repl (*varying degrees of this adaptation or differentiation*) by *varying degrees of adaptation or differention of cells from the inactive stage*, to which is applied Mp; *population* is a classifier which is referential to *cell population*; Rel IIIa (*rosette-forming*); Con I (*wh-*, *-s* → ø); *heterogeneity of the cell population* is represented as **C** 'various cell lines'

470.2.1 Rel IIIb (*lymph node cells*); Rel I (*cells of the lymph node*); Rel I (*with the greatest rate of synthesis of antibody*); Rel I (*which had some points of similarity to the plasmablasts*); Rel I (*the most differentiated cells*); Repl (*RFC, PFC*) by *rosette-forming cells, plaque-forming cells* to which Rel I is applied; Rep I (*the transitional cells found among cells*)

470.3.1 Repl (*RFC*); Rel I (*rosette-forming cells*); Rep I under *especially*; Rel I (*among cells*); Rel IIIb (*lymph node lymphocytes*); Rel I (*lymphocytes*) x 4; Rel IIIa (*prominent*); Rep I (*equipped with*) x 2; Rep I (*prominent*) x 2; last row Rep II (*lymphocytes of the lymph node*); Lin M (*therefore judged*); which is expanded as *therefore it was judged that* by the transformation N_1 *were* V_M*ed to be* V → *It was* V_M*ed that* N_1 *t* V, cf. GEMP 8.2; *to be* is replaced by its variant *were*

470.3.2 Lin M (*even by the sensitive methods...*); Sub Ap IV: reconstruction of *GJB:* by referential *antiferritin*, *antiperoxidase*, represented $\mathbf{A}^{\mathbf{G}}$; the concessive *only* is not treated

470.3.3 Repl (*these*) by *plasmablasts, immature blast cells* of previous sentence, last row; *this stage* referential to *the blast stages*, i.e., *plasmablasts, immature blast cells*; Lin IVa (*no evidence of antibody*); Rel I (*small lymphocytes...*); Br S (*amounts of*)

470.3.4 Rel IIIb (*antibody production*); Rep I (*quantitative differences*)

470.3.5 Lin M (*referred to above*); Lin III (*in sufficient concentration*); Rep III (*to be detectable*)

471.1.1 Rel I (*which cells can be...*); Rel I (*most of the antibody*); Rel I (*which they are synthesizing*); Passive I (*which they are synthesizing*)

471.1.2 Rep I (*antibody*); Rep I (*a cell could be*); (*present*) (*in an amount*) are reconstructed by Sub Ap IIIa and Br S; Rep III (*for the cell*); *without* is factored into the conjunction *with* and the negative which moves onto the main operator *contain*; Rep II (*the cell*); Rel I (*completed*), taken as equivalent to 'produced'; Rep III (*for antibody*); (*in the cell*) is reconstructed as an appropriate argument and prepositional indicator

Paper 14 – Notes

573.3.2 *the process* refers, as a classifier, to *agglutinin formation* (in row 2)

574.2.1 Rel IIIb (*antibody formation*)

574.2.2 Lin M (*not only*); Rel IIIb (*administration of antigens*), (*the production of antibody*). $\mathbf{T_s}$ (*the spleen*) is reconstructed as an appropriate argument from *the spleen* in the **M**-segment. Rep I (*antigen administration*) under *but*. Lin M (*also*). The reconstructed secondary: *the formation of immature plasma cells is from reticulum cells* is denominalized (under the colon operator) and becomes *immature plasma cells being formed from reticulum cells. Especially...* may be expanded further

577.1.3 *obtained* might be factored into *established the presence of* to provide an **M**-operator and $\mathbf{W}_{\ell}$, cf. chapter 2, section 5; Rel IIIb (*thoracic duct lymph*): see article 10, 314.3.4

577.1.4 *the lymphocytes* refers to those of the thoracic duct lymph (1.3), the material in $\mathbf{W}_{\ell}$ pertains to procedural operations, which, since non-recurrent, are not expanded. *which* in the text pronouns *portion* (*of the lymphocytes*)

577.1.5 Rel I (*the lysed lymphocytes*); *specific agglutinin* is *agglutinin specific to antigen injected* (1.3): on *specific*, see chapter 5 section 4.4; Rel IIIa (*the cultured lymphocytes*); Rep II under *whereas*

577.1.6 Repl (*they*) by antecedent *the cells in thoracic duct lymph*; Repl (*it*) by *antibody*

579.2.1 Lin II (*when...*); Rep I (*the efferent lymph was*); Neg. (*no general immunity developed*); Rep I (*the popliteal node*); *the seat* classifies *the popliteal node. immune response* is a classifier of $\mathbf{AV_p}$

579.2.2 Rel I in rows 2 and 3. *the amount absorbed* referentially zeroes *gamma globulin in the blood streams.* Rel IIIb (*blood concentration*). the comparative-related *too...for* is not expanded in order to place within the row the degree of assertedness

579.2.3 Lin M (*either*); Rel I (*which in the intact animal*); Lin I (*in the intact animal*); Rel I (*which they entered*); Repl (*they*); Rep I under *or, and*; *ultimate fate* is clearly a classifier (cf. succeeding **CW**-sentences); in row 3, *intact animal* may be brought down as a secondary: 'animal not drained of lymph' ($\mathbf{T_{\ell}W^fB}$), contrasting with 579.2.1 in which efferent lymph was collected externally

579.2.4 Repl (*they*); *another* is not in respect to some independent survey of lymph nodes, but in respect to the *pass thru/settle* sequence (2.3); i.e. other than pass through. Hence in the sublanguage sentence structure it is on *settle*, not on *lymph node. their* on *development* is not regarded as a serious occurrence of $\mathbf{C_z^{m\sim}}$, since the subject of *continue* and *development* is identical (chapter 4.2.3).

579.2.5 *labelled* (*with thymidine*) is indicated as a $\mathbf{W_{\ell}}$ operator, an **M**-operator might be established via the causative $N_1\ V\ N_2 \rightarrow N_1$ *cause* N_2 *to be V-ed.* Rel I (*antigenically-stimulated node*); Passive I with zeroed (**M**) subject); **w** is indicated on $\mathbf{T_n}$ in row 4 to indicate *another* which is expanded to *which node was not stimulated with antigen* contrastive with *antigenically-stimulated node* of row 3; Rel I (*in which node*); Repl (*they*) by *lymphocytes*; Rel I in last row

583.3.1 This sentence involves a transformation related to Sub Ap II (*response*), in this case to *an antigen reaching the node, primary* on *reaching* is an adverbial and indexed by **1** on **U** (similarly for *secondary*). Rep I (under *and*) in row 2, *changes* is indexed as $\mathbf{CW_c}$ as it classifies the **CW** sentences of subsequent text-sentences

583.3.2 Sub Ap II (*response*) (cf. 583.3.1), for treatment of *the primary response*, see ch. 5, section 4.4.1; *response* is clearly a classifier of **W**, as seen

by subsequent rows (cf. 579.2.1); *cellular proliferation* by Rel IIIb becomes *proliferation of cells*, Rel I (*which* (*cellular proliferation*) *subsides*), Lin M (*after a few days*), Rep I of *cellular proliferation* under *and*

583.3.4 Lin M (*either*); *their* is left on *original site* since expansion would repeat the sentence $\mathbf{C_yW_iT_n}$. Rep I (under *or*); *respond* here may classify both **CW** and**AV**; *secondary stimulus* is here represented as **U** as it occurs with a $\mathbf{C_y^{g\sim}}$ argument (*their*), although it might also be represented by the sequence: $\mathbf{GJ^2{:}GU^2C_y^{g\sim}}$ (on *conditioned* as **c**, see chapter 4 section 7), *a further stimulus* is treated as $\mathbf{GU^2C_y^{g\sim}}$, given the preceding row – it may also abbreviate a **J/U** sequence; *cause* is discussed in section 6.3 of ch. 5; Rel I (*their secondary response*) Sub Ap II (*response*): *response* is treated as *response to secondary* (*stimulus*) with *secondary stimulus* as $\mathbf{U^2}$, given *their* on *secondary* (*the small lymphocytes'*), *which* is not indicated as it would merely repeat the preceding row; the argument *small lymphocytes* is appropriately recovered in row 6 from preceding rows, with *production* as $\mathbf{Y_c}$; *humoral antibody* is *antibody in blood* ($\mathbf{AV_iT_b}$).

584.2.2 Rep I under *whether...or;* the degree of assertedness is not indicated here and so the formulas only apparently represent a contradiction

584.2.5 In this sentence and in 2.6 below, transformations apply to an otherwise "inert" quote, since to quote is to assert as mentioned; the reciprocal status of *independence* permits us to transfrom *the* V_n (reciprocal) *of* N_1 *and* N_2 to N_1*'s* V_n *of* N_2; *series* is repetitionally zeroed; *the two series* is referential to *the lymphocytic series and the plasmacytic series* (row 2); *between* has *from...to* as variant, and is so represented in the index (cf. GEMP, p. 389)

584.2.6 See notes to 2.5 on transformations and quotation. *It* - extraction of the **M**-material *becomes a matter of semantics*; Lin I (*of rough-surfaced endoplasmic reticulum*), Rep III of subject *a lymphocyte*; *full-fledged* is treated as *mature* (**m**)

585.3.1 Lin I (*in the cheek pouch of irradiated hamsters*); Rel I (*sensitized lymphocytes*): *sensitized* with *lymphocytes* ($\mathbf{C_y}$) is indexed **GU**; *irradiated*, given a definitional statement could be represented as $\mathbf{AV_p^{k\sim}B}$ (*hamsters not capable of producing antibody*)

585.3.3 Rel I (*small lymphocyte population started to enlarge*): *enlarge* here = 'increase'; Sub Ap I: *after 24 hours,* here *24 hours after sensitization*, given 585.3.1; Rep I under *and* (*which* (*small lymphocyte population*) *started to...24 hours after sensitization*)

585.3.4 *these labelled cells* refer to *the labelled small lymphocytes*; Rel I (*labelled small lymphocytes*)

587.5.1 Lin M (*part of*); Rel I; on *secondary stimulus*, see 585.3.1, 3.4

587.5.2 Lin IVc (*a number*): *a number of* applies not to lymphocytes but to their participation in antibody-production; therefore, it is moved onto the operator; Rel IIIb (*antibody producers*).

587.5.3 Lin III (*in vitro*)

588.1.2 Lin I (*in regional lymph nodes*), Rel I (*antibody-producing cells*)

588.1.3 Lin M (*presumably*); Rel I (*the cells in the center of the haemolytic plaques*); *haemolysin* is **A**, *anti-* is a variant of **specific to**, *sheep-erythrocyte* is **G**. *in the center of haemolytic plaques* = 'producing antibody.' See chapter 3.5

588.1.4 Lin M (*too*); Rep II (*in regional lymph nodes*) from 588.1.2 under conjunctional *too*); **GJ^{1}B:** is reconstructed from 588.1.2 with *too*

588.1.5 Rel I (*pachychromatic small lymphocytes with...*). Lin (*in the cytoplasm*); *in these two instances* refers to *lymph and blood*

LIST OF SYMBOLS

I. Noun Categories:

A - *antibody*
A_p - *protein*
A_g - *globulin*
A_q - *plaque*
A_r - *rosette*
A^G - G is referential
D_r - *RNA*
D_d - *DNA*

G - *antigen*

C - *cell*
C_ℓ - *lymphoid cell*
C_y - *lymphocyte*
C_z - *plasma cell*
C^ℓ - *cell family*
C_r - *reticulum cell*
C_y^b - *lymphoblast*
C_z^b - *plasmablast*
$C_y^{g\sim}$ - *small lymphocyte*
$C_z^{m\sim}$ - *immature plasma cell*
C_b - *hemocytoblast*

T - *tissue*
T_n - *lymph node*
T_m - *Malpighian bodies*
T_x - *cortex of lymph node*
T_u - *medullary area of lymph node*
T_ℓ - *lymph; lymph plasma*
$T_{\ell'}$ - *lymphatic system*
$T_{\ell'}$ - *lymphatic capillaries*
$T_{\ell''}$ - *interstitial fluid*
T_s - *spleen*
T_d - *red pulp of spleen*
T_f - *white pulp of spleen; follicular tissue*
T^B - B is referential
B - animal, body part or region
S - ultrastructure of cell
S_n - *nucleus*
S_c - *cytoplasm*
T_b - *blood; serum*
T_t - *thymus*
T_k - *adipose tissue of renal sinus*
T_p - *retroperitoneal adipose tissue*
T_h - *thoracic duct*
T_v - *liver*
T_c - *muscle*
T_o - *bone marrow*
T^c - *packed cells*
T_n^x - *lymph node extract*
T_s^s - *splenic cell suspension*
T_s^u - *splenic tissue culture fluid*
T_ℓ^f - *efferent lymph*
T_ℓ^t - *afferent lymph*
S_r^h - *channels of ER*
S_r^s - *cisternae of ergastoplasm*
S_r^y - *parallel or lamellar ER structures*

S_u - *nucleolus*
S_g - *Golgi apparatus*
S_p - *perinuclear space*
S_r - *endoplasmic reticulum (ER); ergastoplasm*
S_v - *vesicles in ER*
$S_{v'}$ - *vacoules*
S_b - *ribosomes*
S_m - *mitochondria*

II. Verb (main operator) categories:

V operators selecting A — S/C/T
V_i - *present in*; *contain* ←
V_p - *produce* ← ; *synthesize*
V_s - *secrete* ←
V_t - *store* ←
V_u^f - *move from*
V_u^t - *move to*

W (histological) operators
i) selecting C — T, S — C, S — SC, T — T, T — B
W_i - *present in*; *contain* ←
ii) selecting C —, SC —, T —
W_a - *active*; *reaction*
W_c - *change*; *develop* (intransitive)
W_d - *disintegrate*
W_e - *eccentric* (of S_n)
$W_{e\sim}$ - *intact*; *round* (of S_n)
W_f - *inflamed* (of T_n)
W_g - *large*; *enlarged*
W_ℓ - procedural, operational terms
W_m - *mature*; *distinct*
$W_{m\sim}$ - *immature*; *primitive*
W_n - *fine and granular* (of S_c)
W_o - *mitosis* (of C)
W_p - *proliferation*
W_r - *rough* (of S_r)
W_s - *stained*; *pyroniniphilic*; *basophilic*; *fluorescent*
W_w - *widened* (of S_r or S_c)
$W_{w\sim}$ - *flattened*; *narrow* (of S_r or S_c)
W_y - *parallel*; *lamellar* (of S_r)
$W_{y\sim}$ - *random orientation* (of S_r)

U operators selecting G — C/T

U_i - *contain* ←, *present in*
U^{ft} - *move from ... to*
U_s - *sensitize*; *encounter with* ←
U_d - *destroy* ←
U^y - *pass through*

Y operators selecting two arguments of the same class

Y - *are*; *can be classified as*; *resembles* (in A — A, C — C, S — S)
Y^t_c - *develops to*; *transition to* (in C — C, S — S)
Y^f_c - *descends from*; *is a prescursor of* ← (in C — C)
Y_i - *are found among* (in C — C)

III. Superscripts to Verb categories:

a) quantity indicators

+ - *much*; *high*; *great*
> - *more*
< - *less*
↑ - *increase*
i - *rapid*
1 - *first* (on J or U)
2 - *second* (on J or U)
3 - *repeated*; *hyper* (on J)
- *little*; *low*
~ *none*; also *not*
e *early*; *first* (on ':', V or Y)
>> *maximum*; *highest*
Δ *vary*
o *rate*

b) aspectuals

b - *begin*
n - *continue*
s - *stop*
k - *capacity*
c - *competent*
r - *play a role in*, *participate in*)

c) other

v - *in vitro* (on V, W)

IV) Sample Sentence Types

GJB - 'antigen injected into animal'

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