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THE HEROIC AGE OF REPRODUCTIVE ENDOCRINOLOGY:
ITS DEVELOPMENT AND STRUCTURE*

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Endocrinology is usually understood to mean the study of the endocrine organs of the internal secretions concerned with the integration of the individual. The subject received a great fillip from Starling's discovery of secretin in 1902 and his subsequent coining of the word hormone, but it did not come to full flower until the 1920's and 1930's. Looking back, it is remarkable how many of the naturally-occurring hormones were either discovered or characterised in the twenty years between the two wars. So far as the endocrinology of mammalian reproduction is concerned, the time occupied by vital discovery was even less. The essential gonadal hormones, the ovarian oestrogens, progesterone and testosterone, as well as the pituitary and other gonadotrophins were all discovered or characterised in the eight years between 1927 and 1935. If it be true that, because there is only one universe, there can never be another Newton, then it is true that, because there is only one endocrine system, there can never be another era in endocrinology like that between the two wars. This view in no way detracts from the fact that an enormous amount of consolidation has since been achieved and still remains to be achieved.

A.S. Parkes (1963:33)

INTRODUCTION

For those of us whose conception of science has been shaped by our experiences in the post-World War II era, it is difficult to put in perspective the explosion of biological knowledge described by Parkes. Because it was biological science and not physical science which was rapidly expanding, it challenges our understanding of a type of scientific and technological growth dominated by the physical sciences. This fact alone would provide a sufficient rationale for studying what Guy Marrian has called "the heroic age of reproductive endocrinology" (quoted in Parkes, 1966:xx): it would provide us with clues concerning the nature of past growth in biology and sensitize us to the mechanisms whereby this growth has been perpetuated into the present. Just as important a consideration for beginning our research into reproductive physiology in the pre-World War II era

is the fact that an historian or sociologist of science can grasp this "unity of effort" more readily than in later, post-War, developments. Because it was an age of continuous fundamental discoveries for reproductive physiology, the fragmentations created by a post-War drive for refinement and specialization were not very apparent. On the other hand, pre-War "centrifugal" forces were specifying the parameters for the post-War "centripetal" convergence onto other "problem domains".¹ Thus, by studying the heroic age--when knowledge was growing rapidly because of a few great laboratories and a few great men--it will be possible to better formulate research on growth in biological science.

The questions addressed in this paper should lead both to a better understanding of one period of biological growth, namely the pre-1950 era, and also to insights into the techniques and methodologies needed to monitor such developments. The data which we shall utilize will be of various types, ranging from historical treatments, autobiographical notes, and bibliographic (literature, citations) data. The initial goal of our analysis is simply to systematically grasp the flavor of an era from different perspectives, i.e., to extend our grasp beyond the particular period under investigation and prepare us for an analysis of the contemporary period.

Researchers active during the pre-War period have testified to an awareness of professional "pressures" which were to come. For instance, Guy Marrian describes the climate during the discovery of 'oestrin' as an

...exciting and confused situation which prevailed during the period 1929-30 when crystalline oestrogenic substances were being isolated from human pregnancy urine in several different laboratories. This was a period of keen rivalry and of fierce competition for priority: and everyone concerned was guilty of publishing too much and too frequently (Marrian, 1967, italics added).

Were scientists beginning to perceive the publications could conceivably grow out of all proportion to the growth of knowledge?² Perhaps this period marks some

kind of historical threshold for the realization of this phenomenon. Certain testimony concerning the professional development of biologists during this era seems to suggest that many such forces relating to informational diffusion and control were at work. Roy Greep recalls that in his early career he "found it convenient to keep [his] fingers simultaneously in a number of different endocrine pies" (Greep, 1967:vii). This was becoming increasingly impossible, however, in the face of specialization. By the late thirties, Evans and Cowles (1940:908) could lament,

It is apparent that even the individual endocrinologist can not hope to pursue both his work and the copious literature of his field, and is compelled to depend to a large extent upon the review journals for his knowledge of what is being done outside the boundaries of his own experience.

When a figure of Evans' stature--he had discovered, among other things, growth hormone--must face a new age where bibliographic control was becoming as important as experimental ingenuity, a sense of the new realities of science begins to emerge. The statistics presented in the Evans and Cowles paper (Table 1) certainly indicate that if endocrinology in general was being confronted by this new type of explosion, it was reproductive endocrinology that was leading the trend. Problems were being born during this period; solutions were being offered which would provide the foundations for the post-war organization of this area of biological science. If ever an analysis of citation patterns should delineate lines of intellectual indebtedness, we would expect them to emerge from our "exhaustive" data on the pre-explosion period.³

BACKGROUND FOR THE STUDY

Early in our research we were assured by biologists familiar with reproductive endocrinology that it would be an ideal area for sociological study. It seemingly possessed a "vibrance" throughout its history, frequently interacting with pressing social issues, e.g., birth control, and persisting as a subject of wide public and

TABLE I

	No. of endocrine papers published by kind and interest value* (221 journals)		Relation of papers abstracted in 1939 to those published in 221 journals	
	Total papers published in 1939	Interest value, in percentage	Papers abstracted in 1939	Percentage abstracted
Adrenals				
Gonads	249	8.9	143	57
Female reproductive system	635	22.7	374	43
Male reproductive system	339	8.6	103	43
Mammary glands	61	2.1	17	28
General and/or mixed papers	99	3.9	60	66
Pancreas	339	12.1	190	44
Parathyroid	40	1.3	23	57
Pineal	8	0.3	5	63
Pituitary				
Anterior	216	7.8	125	57
Posterior	96	2.0	37	66
General	91	1.8	24	47
Spleen	17	0.6	6	37
Thymus	36	0.9	5	19
Thyroid	201	7.1	78	38
General	88	3.1	32	37
Glandular interrelationships	378	13.5	221	58
Metabolic interrelationships	79	2.8	45	57
Vitamin-Endocrine Interrelationships	25	0.9	16	64
Total	2807	100%	1362	48%

*Source: Evans and Cowles (1940:908): "An analysis of the interest in the individual glands is possible by a count of the papers appearing about each, and Table 1 indicates the numerical and relative interest value of all the papers published during the year in these 221 journals."

governmental concern. Because we quickly found that the entire field of reproductive physiology was unmanageable--both in terms of our data gathering techniques and our ability (methodologically and intellectually) to grasp such a large area--we decided to concentrate on the reproductive physiology of non-human primates. The data which we sought to gather were, first, a complete bibliographical file of the field⁴ and second, all of the references contained in the article set.⁵ The data set was, ideally at least, to be longitudinally complete, representing an historically varied spectrum of research types and styles. The biases associated with ad hoc selections of specific research epochs or research topics (disciplines, specialties, cf. Chubin, 1976) were to be moderated by our determined effort to create a data set containing a "slice" of an entire scientific subject area. The status of researchers, their papers, their nationality, their centrality, were not to be considered in defining and collecting the data within the field. In short, we started our research as bibliographers, perhaps even archivists, with the hope that eventually our entry into the area of research would speak directly to the question of how biological thought progresses and its social structure develops.

I. The Historians' Record Examined

An immediate temptation was to look at what textbooks and histories of reproductive physiology have said about the area. Textbooks abound (we consulted, in particular, van Tienhoven, 1968), but where were the comparable histories of the field? We soon discovered that historical treatments, especially of the 20th century developments of reproductive endocrinology, were scarce. The "histories"⁶ that are written are most typically written by the protagonists of the unfolding scientific drama: the participant endocrine researchers and funding agents have been the chief chroniclers of Marrian's "heroic age" (in particular, Aberle and Corner, 1953; W. Allen, 1970; Corner, 1947, 1950, 1951, 1958, 1965; Dale, 1963;

Greep, 1967; Klein, 1963, 1968; Marrian, 1967; Parkes, 1962, 1965, 1966; Parkes and Zondek, 1966; Zondek, 1941).

As we sifted our way through various treatments of reproductive endocrinology (Battelle, 1973; Maisel, 1965; Simmer, 1971, 1972), it became apparent that there was a great deal of unanimity among these accounts. The same literature, the same scientists, the same breakthroughs were being rehearsed--priorities might be disputed, precursors might be acknowledged, but the "heroes" and their work seemed to recur. We are not going to recount these histories for many of them rightfully belong to a genre which suffers in its retelling. It is best to learn "first hand" about the tons of bull testes and sow uteri that were needed for the unravelling of so many endocrine mysteries. What we have done is to distill (if we may use the term) in Appendix A what we judge to be the main pre-1950 events in reproductive endocrinology. The main sources for these lists are Garrison and Morton (1954), Fulton and Wilson (1966), and Shefner and Hawrylewicz' (1969) contribution to TRACES.⁷ What these sources provide are bibliographic references to the key works alluded to in other historical treatments. Thus we have a chronology of important papers--this, of course, is not a sufficient history--which will allow us to make comparisons with chronologies developed from other sources, particularly, citations.

A cursory overview of Appendix A alone yields insights into the historiography of reproductive endocrinology. Certain events tend to be stressed and certain orientations within the field seem to be singled out by the historian which provides a particular view of the field. The model that seemingly fits the historical narrative has been clearly enunciated in Marc Klein's (1963:293) description of endocrine research:

Once morphological exploration is complete, we have to turn to experimental investigation to clear up a problem. The simplest way is to remove an organ and observe the effects on the body as a whole. Then come attempts to replace the missing gland, first by grafting the whole

organ or parts of it, followed by extracting active products, first in crude and later in purified form. At that stage the exploration has already passed into the hands of chemists and physicists, who in the end specify the chemical formula and succeed in synthesizing the active principle.

Klein realizes that this is an ideal situation which in practice has often been modified. When we inspect the historical events that are chosen to elucidate growth and development in reproductive endocrinology, we indeed see the observed progression as Klein describes it: the progression in Appendix A appears to be from morphological description to chemical synthesis. What is being enunciated is more than a simple observation of fact; it is a statement of a model of how biological sciences progress and the nature of the dependency of one unit of biological research upon another unit. It is, in turn, extremely difficult to refute Klein's model if one uses criteria of significance which single out the type of articles listed in Appendix A. The criteria for what constitutes a meaningful unit of analysis, a set of research themata, have a priori pressed sociologists of science adopting certain research strategies. These strategies tend to fulfill sociologists' own prophecy about the nature of scientific specialties.

What our strategy has forced us to do is to further examine some of the selective forces at work in the histories of reproductive physiology. We would suggest that the following emphases are present in most of the narratives and that some adumbration of them can still be perceived in the list which we have compiled:

A. There is a latent belief in some form of reductionism within the historical treatments (cf. Schaffner, 1974). This is implicit in Klein's model which assumes that the research task is completed only upon the successful chemical analysis and synthesis of the compounds, e.g., hormones, involved in a physiological process. Defining a specialty for historical or sociological analysis from this perspective involves a "slice" of the scientific world

encompassing the entire range of a reduction process.

B. Scientific events are stressed which have a claim to priority. The discovery events are singled out for special treatment: they seem to appear at the vortex of scientific activities, controlling and directing the flow of science. Because individuals and papers can be attached to these events, such histories become the histories of great men, heroes.

C. The events and men which are stressed have the potential for broad scientific and often cultural change. Their historical significance resides in their potential for cultural (in the broadest sense of the term) modifications, e.g., in birth control, scientific agriculture, and the debunking of age-old myths concerning sex. It must be remembered that the funds for the National Research Council Committee for research in Problems of Sex were largely supplied by John D. Rockefeller, Jr. who wanted to "study amelioration, and prevention of those social conditions, crimes, and diseases which adversely affect the well-being of society, with special reference to prostitution and the evils associated therewith" (Aberle and Corner, 1953:4). At a later date Pincus, who was intimately associated with the development of birth control pills, would be greatly influenced by another social reformer, Margaret Sanger, in her efforts toward liberation of women (Shefner and Hawrylewicz, 1969:48). We note that the broader historical significance of these scientific efforts reinforces and is reinforced by the reductionistic motif discussed under A above. Those individuals and events which acquire lasting significance are not only part of a progression from morphology to synthesis, but also of a stream of cultural alterations, e.g., therapeutic applications, attitude changes, social amelioration. Such alterations may be seen as the culmination of Klein's model.

D. Because the narrative of such histories is defined in terms of a particular type of goal-seeking activity, it can be argued that any techniques

or methods which facilitate this activity should be singled out for special treatment. The tons of testes and uteri are important precisely because at a later date chemical techniques would facilitate the acquisition of hormones. What happens to the historical narrative in such situations is instructive. Techniques such as vaginal smears (Stockard and Papanicolaou, 1917), hypophysectomy (Smith, 1926), and electrophoresis (Tiselius, 1937) fit into the historical narrative as crucial events which explain the quantum leaps of a field. As a direct result of this emphasis, there appears to be a certain devaluation of the work "internal" to a field such as reproductive physiology. Developments in steroid chemistry, for instance, create advances that are disproportionate to physiological analysis and experimental ingenuity. Such an interpretation fosters an artificial separation between imported methods and experimentation that would appear to be "foreign" to the daily routines in most biological disciplines (Studer and Chubin, 1975:22ff).

It must be emphasized that an enumeration of these views is meant in no way to debunk the latent models found in various histories. The point is that more is being said and claimed than is usually realized. By making such models explicit, we may perhaps find that there are equally realistic alternative hypotheses that also require testing. Derek Price (1972:7ff) has noted that the results of research such as that involved in TRACES, which among other things studied the development of the oral contraceptive pill, can usually be predicted "as soon as you know the name of the funding agency." Why? Because we suspect that an historical scenario, much as those outlined above, predetermines the parameters of investigation. So constrained, the analysis remains within certain structural limitations which blind one to alternative hypotheses.

II. History and Citation Analysis

A review of an early perplexity which we encountered in our research will

help to illustrate the "blinding" phenomenon. It was stated in the TRACES report (Shefner and Hawrylewicz, 1968:64; cf. 1969:44) that,

In 1937, Makepeace at the University of Pennsylvania published what must have been the most definitive research up to that time into the effects of progesterone upon ovulation in the rabbit. Almost every scientist who subsequently reviewed or reassessed the information relating to the inhibition of ovulation by progesterone has referred to this publication. It can be considered a classic item of literature in this field.

Precisely such momentous events ("shocks") on the growth and development of a scientific field must be located by researchers attempts to interpret shifts in discipline structure are to succeed. Such "shocks" to the system of science can provide points of reference for the calibration of science indicators. What, however, precedes such discoveries and what alterations occur in the social structure subsequent to their publication? In what respects may such intellectual events be considered independent and dependent variables of the science system?

To our surprise we found very few papers within our data set of articles on reproductive physiology of non-human primates which referenced the Makepeace article. In the pre-1950 period, only five articles mention it. With the caveats that we are (1) presently collecting references only from articles and (2) in the process of cleaning these same data, it is still important to report the specific articles which reference the Makepeace article. They are:

- Dempsey, E.W. (ID=2393, CIT=13)
1939 "The reproductive cycle of New World monkeys."
Amer. J. Anat. 64:381-405.
- Dempsey, E.W. (ID=2394, CIT=7)
1940 "The structure of the reproductive tract in the
female gibbon." Amer. J. Anat. 67:229-253.
- Brooks, C. McC. (ID=1342, CIT=0)
1940 "Relation of the hypothalamus to gonadotropic
functions of the hypophysis." Res. Publ. Ass.
Nerv. Ment. Dis. 20:525-550.

- Sturgis, S.H. (ID=2503, CIT=2)
1949 "Rate and significance of atresia of the ovarian
follicles of the rhesus monkey." Contr. Embryol.
Carneg. Inst. 33:67-80.
- Sturgis, S.H. (ID=1669, CIT=0)
1950 "The mechanism and control of primate ovulation."
Fertil. and Steril. 1:40-52.

After each of these bibliographic references we have noted the number of times the respective articles themselves have been cited by other reproductive physiology of non-human primate articles (e.g., CIT=13). Thus we find that although progesterone effects are quite central to the reproductive physiology of non-human primate research, this particular focus of research did not make a momentous impact upon this subject area. The Makepeace research neither received a high citation count nor was it referenced by highly cited papers. An attempt to explain such an unexpected result introduces us to the interpretive complexity of biological disciplines. Why is the Makepeace article not more highly cited by papers in our reproductive physiology on non-human primate data set?

By offering a series of plausible answers to this question, we shall begin to see that the scenarios assumed in the historical treatment of such areas may be questionable.

A. First, there would appear to be a great reluctance on the part of physiologists to make facile generalizations across species (see Klein, 1963: 296ff.). Rabbits (Makepeace's laboratory animal) have some peculiarities in their ovulation pattern ("reflex ovulation," see Eckstein and Zuckerman, 1956) which make immediate generalizations to other species difficult. It can be seen from Appendix A how a research progression from specie to specie developed when the estrous cycle was being studied. In 1917, Stockard and Papanicolaou developed a technique for studying the estrous cycle by analyzing the cellular changes in the vagina, i.e., the "vaginal smear." They applied their method to an analysis of the estrous cycle in the guinea pig. In 1920, Long and Evans applied the

method of vaginal smears to learn the estrous cycle of the rat (this work was elaborated in a monograph, Evans and Long, 1922). Allen (1922) accomplished a similar feat with the mouse and, in 1923, Corner published his exceedingly important work on "Ovulation and menstruation in *Macacus rhesus*." A look at the citation counts (Table 2) for these respective articles referenced in our non-human primate data base is instructive.

Table 2

Vaginal Histology and the Estrous Cycle		
<u>Year</u>	<u>Author</u>	<u>Citation N</u>
1917	Stockard and Papanicolaou	6
1920	Long and Evans	0
1922	Allen	8
1922	Evans and Long (monograph)	16
1923	Corner	62

Although other species were also used in this research (cf. Corner, 1951), it is clearly Corner's research which fell most directly into the problem domains of researchers in the reproductive physiology of non-human primates. Species made a difference: the problem was "solved" when the analysis became relevant for the respective research animals.

B. Other evidence can be found in Appendix B where we have listed the most highly cited articles by authors within our non-human primate set. From a glance at the works which received attention during the 1930's, it can be seen that a solid tradition of progesterone research was entrenched within primate studies. Thus, researchers using non-human primates could easily find a body of literature to reference without turning to Makepeace. All of this does not detract from Makepeace's work on progesterone effects; rather it suggests that the "relevancy space"⁸ from which citations were being drawn in the non-human primate literature intersected in complex ways with his work. The momentum of the developments in

the field favored articles which were directly relevant to non-human primate research.

C. A third consideration is that from the early 1920's through the 1930's the reproductive physiology of non-human primates was becoming a "problem domain" in its own right. Monkeys are not mere laboratory animals; they are much more difficult to maintain than other test species. However, they were rapidly becoming models for the physiological analysis of human sexual cycles. "Better a cat than a frog, better a monkey than a dog, better a man than a marmoset," but researchers became concerned during the 1920's, "If not man, then a monkey" (quoted in Fulton, 1941:xii). In Appendix B this nascent interest in non-human primates emerges. For example, Engle (1932) was creating a menstrual cycle in monkeys which was analogous to that of the human female--by injections of pregnancy urine. Hartman (1939) and others were setting forth the relevancy of non-human primate research to that of the human endocrine system. Researchers were performing brilliant experiments that could only be carried out on a model research animal. Markee (1940), for instance, transplanted pieces of the endometrium into the ocular chamber of rhesus monkeys and studied its vascular structure (its menstruation cycle) with a microscope through the cornea of the eye (see Corner, 1951, for further discussion). Reproductive physiologists during this period found a meaningful rationale for converging onto a set of problems circumscribed by the non-human primate model of man. By 1941, enough research on primates other than man had been accomplished to warrant the collection of an extensive bibliography and coinage of the term "primatology" (Ruch, 1941).

D. More generally, it is plausible that criteria used for historical importance are not the criteria that scientists use in their selection of references. We explore this possibility in the following section, but must note here that although Makepeace's article may have been tremendously important for the reproductive physiology of non-human primates, the logic of collating information in

the form of references in articles may have a different rationale. Granted that the type of reference (see Chubin and Moitra, 1975) may confound citation analysis, there remains the problem of determining the criteria of selection of references in the different classes or types. In short, Makepeace's work may have been vital from the historians' perspective, but perhaps was circumvented in references which satisfied other criteria of relevance.

The above considerations are offered not as "answers" but as suggestive explanations in need of more rigorous testing. They bring us further in our understanding of reproductive endocrinology in that they have forced us to entertain alternative explanations that are rarely weighed when only one perspective is pursued. Because obviously important contributions to reproductive endocrinology have been virtually overlooked, in terms of citation counts anyway, we are now in a better position to critically evaluate the demands of both the historiography and the bibliometrics (Pritchard, 1969⁹) of this domain of research.

III. An Historiography of Reproductive Endocrinology

In discussing the model of historical development of endocrinology described by Klein, we emphasized that it possessed more than merely a descriptive character. The model becomes prescriptive for the history and sociology of science if one elects to study specialties which are a priori defined in terms of such criteria. Of course, all research on scientific and social structure finds itself in the same definitional dilemma. Defining specialties according to any criteria entails a judgment concerning what is worthy of the sociologists' or historians' explanatory methods.

The sociologist, or those impressed by certain striking social features of science, is inclined to define specialties according to organizational criteria associated with the growth of science. Anderson and van Gelder (1970:949) clearly express such criteria in their groundbreaking study of a scientific specialty.

Mammology, as a recognizable branch of science, is a 20th-century phenomenon. The criteria for its recognition are the organization of distinct professional societies of persons identifying themselves as mammologists and the publication of journals devoted to the subject. Previously, mammology had been considered a part of "natural history" or "vertebrate biology," or its findings had been included in comparative anatomy, taxonomy, econogy, embryology, and other fields.

If such criteria are employed, however, there is a natural tendency to create theories of organizational development to explain scientific growth. Theories concerning the "stages of scientific institutionalization" (see Clark, 1972, but also Crane, 1972) are erected to explain scientific development. For the sociologist, the development can then be conceived as a linear movement from (1) the solitary scientist to (2) amateur science to (3) emerging academic science to (4) established science to (5) big science (Clark, 1972:662). Of course, other organizational criteria could be selected to mediate the developmental progress, but they effectuate the same type of judgment concerning what is relevant for the sociologist to study. We would argue that methodologically they prematurely constrain the study of scientific development much the same as the historians' theory of development from morphological description to chemical synthesis constrains the historical analysis of reproductive endocrinology.

Both the historians' views and those of organizational sociologists begin with what we believe to be a strong criterion of the nature of science. They are accordingly hampered in their effort to uncover the existing structure of scientific progress. Their effort is impeded because they assume too much about intellectual and social organization before they begin their study. What we are attempting, in effect, is to relax these criteria and to begin our study of scientific growth from the perspective of subject matter. By relaxing the historians' implicit criteria of intellectual progress and the sociologists' assumptions concerning organizational development, we hope to submit these

criteria to further scrutiny. This does not mean that criteria of subject matter or cognitive content of a literature are devoid of problems. A forerunner to the type of analysis we propose can be found in the work of Wilson and Fred (1935). The definitional problems which they encountered in their study of the literature on nitrogen fixation by plants is characteristic of the problems faced by any researcher who places the cognitive dimension of science in a central position.

In order to lend itself to an analysis such as that proposed, the body of relevant material should possess certain characteristics. For example, interest in the subject-matter of the literature to be examined should have extended over a number of years. This insures that a more or less steady development rather than the mushroom type of growth has occurred. Likewise, the subject-matter should cover a fairly large but definite problem. The field should not be too sharply delimited; otherwise the volume of publications will not be sufficiently large to allow statistical treatment. On the other hand, unless the papers are concerned with a perfectly definite problem, the growth curve will represent the sum of a number of interlocking developments and as a result may defy rational analysis. Finally, the field of study represented by the literature being examined should be coherent and stable. If this is so, the research at a given time is intimately connected with past work and does not depend on the whim of the fad type of scientist (Wilson and Fred, 1935:240-241).

This quote summarizes some of the major difficulties inherent in a study of subject literatures. The existence of such a body of literature is based on knowledge of the field; its intellectual coherence must seem defensible, the definitions of the area's problems must seem fairly well circumscribed, and the growth structure must appear interpretable once it is statistically described. Wilson and Fred studied nitrogen fixation by plants, an area which circumscribes a problem domain within bacteriology and plant chemistry. We have chosen the reproductive physiology of non-human primates because it seemingly represents a similar coherent problem domain within endocrinology, physiology, and biochemistry. We would have to admit that we did not choose this area because it would represent some preconceived social structural development or because it would follow some

preconceived intellectual pattern. It was chosen because it seemed like an intellectually viable area of research in endocrinology and, more pragmatically, because excellent subject bibliographies of the field exist.

Based on a comparison of the bibliographies contained in Appendices A and B, it is already apparent that our approach harbors some broad implications for historical and sociological studies of specialties. When the latent assumptions of the histories of reproductive endocrinology are compared with the intellectual patterns displayed in the citation patterns, it becomes clear that a bibliometric analysis of reproductive endocrinology will greatly differ from that of the traditional historical treatments. From our initial analysis, the following interpretations seem, at least tentatively, warranted.

A. Instead of the reductionism assumed by the historical treatments, there appears to be a continual interaction of different levels of analysis centering upon distinct problems within reproductive endocrinology. Perhaps this is best described as a confluence of specialists, e.g., steroid chemists, primatologists, pituitary experts, onto a specific problem or puzzle within reproductive endocrinology. We shall see, in the following section, that for reproductive endocrinology of non-human primate researchers, the puzzle was the estrous cycle of all primates. The fact that a very high percentage (90%) of those articles receiving more than 10 citations (Appendix B) were included within our reproductive physiology of non-human primates article set, suggests that a continuity of problems undergirds the area, and that these problems are more than likely organized around the systematic properties of the reproductive endocrine system. Further analysis will be aimed at uncovering the network structure of these citation patterns to see if they indeed mirror systemic biological structures.

B. Are priority rights reflected in citation patterns? The articles judged to be of great importance by historians because of their claims to priority make a relatively poor showing in terms of our citation counts. The exceptions to this,

as mentioned earlier, are those historically important articles which concentrate on the reproductive physiology of non-human primates. The difficulties with testing any hypothesis dealing with priority center on definitions of priority. Does Wislocki and Streeter's (1938) article, "On the placentation of the macaque (Macaca mulatta), from the time of implantation until the formation of the definitive placenta," have any claims to priority? One senses that such articles are best described as highly accurate, definitive treatments of their subject matter which make advances possible. Priority rights stress the radical jumps that a field makes when a breakthrough occurs (Merton, 1957). What seems to be reflected in the citation patterns is a continuity of subject analysis combined with definitive accounts. When legitimate breakthroughs do occur, the historian and not the bibliometrician will probably stress their importance.

C. Whereas the historian tends to stress events which potentially possess broad cultural significance, the citation patterns in Appendix B seem to reflect an "internalist" view of science. The broader implications of the field are not as casually apparent as the internal concentration on the reproductive cycle of monkeys. Even though it is generally known that non-human primates serve as a model for man, the broader implications of the day-to-day research reports seem to leave this aspect of the research unspoken. Perhaps this is one reason why historians often see breakthroughs where researchers see only continuity and a slow progression of findings: the breakthroughs may simply occur when the research in one specialty, reproductive physiology of non-human primates, comes to rapid fruition on another plane, e.g., human reproduction. But the fact that such cultural externalities are unspoken should not lead one to conclude that for our subject area, any more than for nitrogen fixation by plants, broader cultural forces do not come into play. It can be shown from an analysis of the funding of sex research by the National Research Council for the period 1922-1947 that funding correlates highly ($r=.84$) with a one-year lag of article production

stimulated by this funding source (computed from Aberle and Corner, 1953). The increasing growth of the literature can be seen to interact with the increased availability of funding. This, in turn, resulted from change in attitudes toward sex and the needs for social reform (see Hollender, 1970). What one is led to conclude is that externalities to the science system must be taken into account even where the cognitive structure seems to be "self-sufficient." On the other hand, it is not clear how such exogenous forces should be taken into account, i.e., utilized to explain scientific growth.

D. Techniques and methodologies do not seem to be emphasized in the citation structure to the extent that occurs within historical treatments of reproductive endocrinology. It would appear that such techniques rapidly diffuse, become general knowledge, and thus seldom need citation. Or, if they are cited, they are rarely mentioned apart from the experimental situation which necessitated their use. Our discussion of Markee's intraocular transplantation of endometrial tissue is a good case in point. The technique had been developed in intimate conjunction with an experimental question and would appear to "qualify" as a citation in this context rather than as a technique in its own right. When Corner used vaginal smears to analyse ovulation and menstruation in *Macacus rhesus*, the techniques became important within the concrete experimental context: they helped answer specific questions. Corner's work became pivotal within the problem domain of the estrous cycle, and not because of some independent methodological role.

The emphasis in the points discussed above has been to contrast what we believe to be some of the more important differences between the reigning tradition of historiography and a bibliometric approach to reproductive endocrinology. Of course, the real test of the fruitfulness of the bibliometric approach to specialities is the light it sheds on the social and intellectual structures of subject areas. The contrasts which are visible in any comparison of Appendices A and B

enable bibliometrically inclined researchers to proceed in their research unencumbered by many entrenched views of scientific progress and growth. By focusing on such interpretive problems early in one's research, the more formal modeling of various scientific research programs can proceed with greater facility and understanding.

IV. Interpreting the Development of Reproductive Physiology of Non-human Primates

As Parkes (1963) stressed in our opening quote, reproductive endocrinology in general experienced tremendous growth during the 1920's and 1930's. Accordingly, one wonders if it is possible to interpret a segment of this research delimited by the modifier, "non-human primate." Is this a meaningful unit for analysis? We have argued above that it is a meaningful unit because of the growing importance of non-human primates as models of man during this period. But what we need to emphasize is that even this specification of a problem domain is only one possible slice of the endocrine world. Other perspectives could have been chosen, in fact many others are suggested by the citation counts in Appendix B. For instance, Zuckerman's (1935) work on "The Aschheim-Zondek diagnosis of pregnancy in the chimpanzee" or Elder and Bruhn's (1939) "Use of the Friedman test for pregnancy with chimpanzees" suggests that other problem areas intersect with non-human primate research. To underscore the importance of these other research domains we have provided a summary of the bibliographic growth of the pregnancy diagnosis literature in Figure 1. The growth of the literature in this area of reproductive endocrinology follows a pattern similar to that of the non-human primate segment. We are reminded of Wilson and Fred's (1935:241) dictum that "unless the papers are concerned with a perfectly definite problem, the growth curve will represent the sum of the number of interlocking developments and as a result may defy rational analysis." What our definition of a problem domain accomplishes is an informed separation of problems so that interpretation can meaningfully proceed. But the fact that other

interpretive axes would slice the literature of a field differently should always temper the explanations which are offered. Without pretention of generalization, we thus offer the following statistical description of reproductive endocrinology for the pre-1950 period.

In Table 3 some basic macro-level statistics concerning reproductive physiology of non-human primates are presented, i.e., the number of articles per year, the number of citations to these same articles per year from these articles, and the total number of citations from the entire article set. What is of immediate interest is that during the 1920's and 1930's the expected expansion of the literature is clearly observed. In terms of the cumulative percentage of all of the distributions, 1935 represents the midpoint of the 40-year span from 1910-1950. The decline of the literature curve in the 1940's appears to be real and not due to effects of bibliographic coverage.¹⁰ One could attribute this phenomenon to the effects of war, the demise of research funds, the need to build up primate colonies after the war, or perhaps even to the solution of the major problems prior to the war. No doubt many explanations will be needed in the final analysis to derive a satisfactory understanding of this period of research. In passing, however, we note that a similar decline in the pregnancy diagnosis literature (Figure 1) is also visible in this period and may represent a case where major solutions actually depressed the literature growth curve.

Because the citations contained in Table 3 include references from articles into the 1970's, the decline of citations in the 1940's is not simply an artifact of data collection. It mirrors, to some extent, the article production curve and the decline in the number of articles at risk of being cited. A better indication of the shifting citation structures can be found in Table 4. This latter table reflects the relative proportion of citations to different data sets: 1) to all reproductive physiology of non-human primate articles; 2) to the highly cited

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PREGNANCY DIAGNOSIS TESTS LITERATURE
(Compiled from Cowie (1948))
(1900-1948)

Figure 1

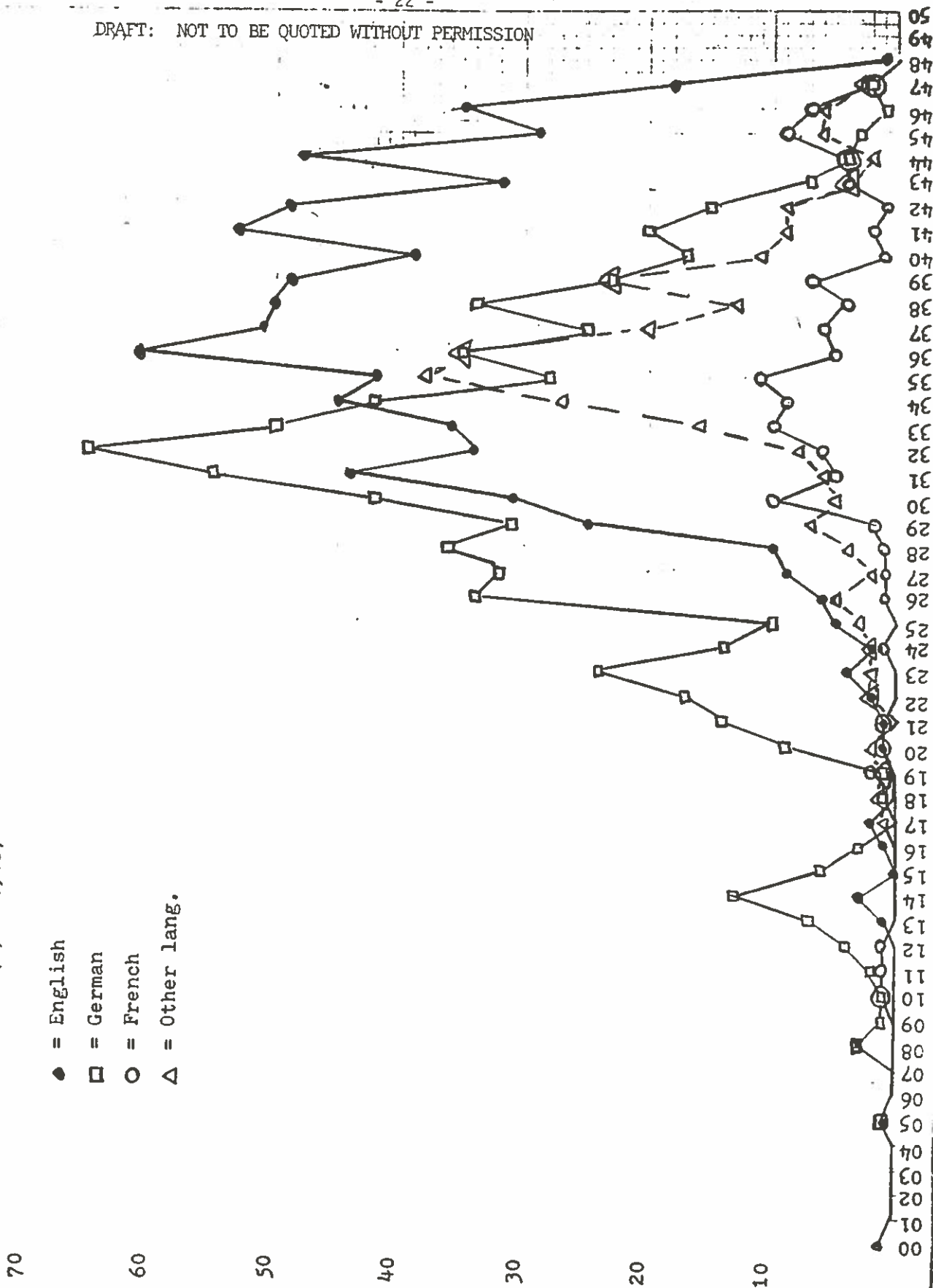


TABLE 3

ARTICLE AND CITATION PROFILES OF LITERATURE IN REPRODUCTIVE PHYSIOLOGY
OF NON-HUMAN PRIMATES (RP)

Year	Art. in RP set	% of Total 1910-50	Cum %	Cits into RP	% of Total 1910-50	Cum %	Total Cits	% of Total 1910-50	Cum %
1910	6	1	1	3	0	0	142	1	1
1911	4	1	2	1	0	0	125	1	2
1912	6	1	3	0	0	0	129	1	3
1913	1	0	3	0	0	0	127	1	4
1914	10	2	5	17	1	1	115	1	5
1915	13	2	7	14	1	2	92	1	6
1916	1	0	7	3	0	2	83	1	7
1917	6	1	8	29	1	3	126	1	8
1918	3	0	8	0	0	3	64	0	8
1919	1	0	8	0	0	3	67	0	8
1920	3	0	8	14	1	4	161	1	9
1921	8	1	9	16	1	5	158	1	10
1922	4	1	10	9	0	5	189	1	11
1923	10	2	12	93	3	8	311	2	13
1924	6	1	13	12	0	8	243	2	15
1925	5	1	14	7	0	8	285	2	17
1926	17	3	17	62	2	10	340	2	19
1927	14	2	19	110	4	14	498	3	22
1928	24	4	23	151	6	20	453	3	25
1929	18	3	26	80	3	23	477	3	28
1930	25	4	30	69	3	26	492	3	31
1931	28	4	34	100	4	30	489	3	34
1932	33	5	39	192	7	37	792	5	39
1933	29	4	43	123	5	42	626	4	43
1934	21	3	46	80	3	45	428	3	46
1935	57	9	55	288	11	56	723	5	51
1936	53	8	63	231	9	65	669	5	56
1937	42	6	69	119	4	69	719	5	61
1938	47	7	76	137	5	74	624	4	65
1939	13	2	78	77	3	77	579	4	69
1940	18	3	81	81	3	80	549	4	73
1941	30	5	86	131	5	85	598	4	77
1942	15	2	88	99	4	89	561	4	81
1943	12	2	90	59	2	91	330	2	83
1944	12	2	92	41	2	93	307	2	85
1945	8	1	93	78	3	96	387	3	88
1946	7	1	94	21	1	97	282	2	90
1947	11	2	96	26	1	98	331	2	92
1948	13	2	98	28	1	99	369	2	94
1949	8	1	99	35	1	100	373	3	97
1950	8	1	100	29	1	101	435	3	100
TOTAL	650	100		2,665	101		14,848	100	

articles in Appendix B; and 3) to the historically significant articles in Appendix A. The various citation counts are expressed as proportions of the total citations to articles in that year. Knowing, for instance, that there were a total of 2,665 citations to reproductive physiology of non-human primate literature from 1910 to 1950 and that the total number of citations to all articles for this period was 14,848, then any great departure from this 18 percent norm is noteworthy.

It is especially instructive to look in Table 4 at the composition of the cited articles within the reproductive physiology of non-human primate sets where the yearly proportion exceeds 18 percent. One important question to ask is whether or not the proportion can be significantly reduced by simply eliminating the highly cited articles included in Appendix B. If the highly cited articles from within the set (10 or more citations) are subtracted from the total number of citations to articles within the set, a great leveling process occurs. The increase of citations into the set which is visible in the raw citation counts is effectively eliminated when the citations to such papers are removed. The citations to single papers in certain years considerably increase the within-the-set citation percentage. The removal of the following papers, for instance, greatly alters the overall impression of increased visibility of within-the-set citation patterns: Kempf (1917); Corner (1923); Allen (1927); Hartman (1931); Hartman (1932); Tinklepaugh (1933); Carpenter (1934); Wislocki (1938); Heuser (1941); Corner (1945). In some years, e.g., 1928, 1935, and 1936, the citations are more dispersed among highly cited papers and more papers must therefore be removed to force the proportion below 18 percent.

The temptation is to credit the visibility of within-the-set citations totally to the highly cited papers, with other citation structures being relegated to "random risk" origins. Such conclusions always demand careful scrutiny because subject area definitions accepted by the researcher may create an aura of randomness

CITATIONS TO HISTORICALLY SIGNIFICANT ARTICLES (APPENDIX A), HIGHLY
CITED ARTICLES (APPENDIX B), AND TO ALL ARTICLES IN REPRODUCTIVE
PHYSIOLOGY OF NON-HUMAN PRIMATES

Year	Histor. Sig. Articles ¹	% of Total	Highly Cited Art ²	% of Total	Art in RP ³	% of Total	Total Citations
1910	6	4	0	0	3	2	142
1911	5	4	0	0	1	1	125
1912	1	1	0	0	0	0	129
1913	0	0	11	9	0	0	127
1914	0	0	0	0	17	15	115
1915	0	0	0	0	14	15	92
1916	0	0	0	0	3	4	83
1917	6	5	14	11	29	23	126
1918	0	0	0	0	0	0	64
1919	0	0	0	0	0	0	67
1920	0	0	0	0	14	9	161
1921	0	0	0	0	16	10	158
1922	25	13	16	8	9	5	189
1923	71	23	76	24	93	30	311
1924	5	2	0	0	12	5	243
1925	0	0	13	5	7	2	285
1926	0	0	38	11	62	18	340
1927	86	17	86	17	110	22	498
1928	3	1	110	24	151	33	453
1929	10	2	47	10	80	17	477
1930	4	1	60	12	69	14	492
1931	5	1	62	13	100	20	489
1932	11	1	197	25	192	24	792
1933	1	0	58	9	123	20	626
1934	6	1	45	11	80	19	428
1935	2	0	195	27	288	40	723
1936	2	0	121	18	231	35	669
1937	15	2	59	8	119	17	719
1938	4	1	60	10	137	22	624
1939	0	0	75	13	77	13	579
1940	0	0	66	12	81	15	549
1941	0	0	63	11	131	22	598
1942	0	0	86	15	99	18	561
1943	0	0	22	7	59	18	330
1944	0	0	37	12	41	13	307
1945	0	0	75	19	78	20	387
1946	0	0	24	9	21	7	282
1947	0	0	0	0	26	8	331
1948	0	0	10	3	28	8	369
1949	0	0	19	5	35	9	373
1950	0	0	10	2	29	7	435

¹Citations to all articles within Appendix A from references in our reproductive physiology of non-human primate data set.

²Citations to all articles within Appendix B from references in our reproductive physiology of non-human primate data set.

³Citations to all articles within our reproductive physiology of non-human primate data set from references in that same set.

where it does not exist. If, for instance, in the pre-1920 era or in the post-1945 era, the research problems addressed were in reality more closely linked to anatomy or chemistry than was the case for the 1920-1945 period, we could conceivably miss the "center" of a problem domain for certain periods. If this were the case, then to attribute to randomness a structural feature of science would only obscure the larger confluence patterns (Studer and Chubin, 1975:38) present within a field. One thus should not assume randomness, even where the random hypothesis is difficult to reject, until some of the structural parameters of the process of problem domain formation are better understood. What might appear as randomness may result from peripherality to the center of a research domain's focus; it may be created by the definitional fiat of the researcher.

A more meaningful formulation of the formation of cognitive and social structures in biology involves the analysis of network shifts over time. Although we are not presently prepared to offer such an analysis, we plan to do so in the near future. Armed with such concepts as network closure and centrality, one could then ask where the center of a problem domain lay for a certain period. It is altogether conceivable that in the early period of reproductive physiology, the "center" of the field actually lay outside the literature collected according to our definitional criteria. At another period--we would surmise this to be true for the 1920-1940 period--the center may be quite reasonably captured by our data set. The aim of our research effort is to explicate precisely how such shifts occur and how they create a confluence of interrelated research themes along structural paths. When one discovers what creates these paths of relevance and what is characteristic of the shifts within subject areas in biology, then one will have progressed a long way in the reformulation of the concept of scientific growth.

We would assert at this point that our data confirm this hypothesis: research

on the menstruation and ovulation cycle in the non-human primate provided a centripetal, i.e., problem domain creating, force in the 1920's and 1930's. As emphasized at the outset, later periods were times of consolidation of earlier achievements; they once again permitted fragmentation along other problem lines which would, in their turn, allow new research programs to develop. Our general impression is that, in the 1950's, other forces at work in the field of reproductive endocrinology would once again shape the field into a new coherence. Whether or not such pulsations of research interest are characteristic of all "cognitively" defined subject areas is interesting to ponder. More important, however, is the development of a theoretical framework which can properly encompass the structural prerequisites of such developmental phenomena.

Other evidence (discussed below) suggests that the structural perceptions which we have initially perceived are indeed at work in reproductive endocrinology. From basic journal distributions of articles and citations, it becomes apparent that intellectual foci call upon broad areas of relevance and that patterns of confluence onto such problem domains define potential migratory (both intellectual and individual) channels for the field (cf. Chubin, 1976). What will perhaps become even more apparent as we progress with our study is the relationship of such traditionally studied phenomena in bibliometrics as journal scatter (Bradford, 1953:144-159) and subject matter structure. It is conceivable that the reason why physical science has less journal scatter than biological science and the latter less scatter than the social sciences is related to the necessary confluence patterns of the respective subject fields.

V. Bibliometric Structures as Indicators

The fact that journal scatter has long been a concern of endocrinologists (Evans and Cowles, 1940; Gregory, 1935; Mengert, 1934) is itself suggestive.

Mengert, for instance, was concerned about bibliographical control of the field: "The subject of the physiology of the ductless glands relating to sex and sex function is so complex that the average physician is staggered by the number of periodicals which must be read in order to gain any sort of orderly knowledge" (Mengert, 1934:421). To support his contention, Mengert counted the references to various journal articles in the encyclopedic volume edited by Edgar Allen (1932) on Sex and Internal Secretions: A Survey of Recent Research. Mengert found (see Table 5) that it took only 16 journals to capture half of the literature cited in this work but that 319 other journals were also referenced.

Many have wondered (Brodman, 1944; Morgan, 1957; Postell, 1946) how or if such journal citation patterns reflect the structures of a field. Would, for instance, experts identify the most highly cited journals as the most important journals, and would library use of the various journals reflect the same patterns as the citation counts? Such questions speak to the stability of indicators, given different methods of indicator construction (cf. Cawkell, 1976; Narin, 1976). The question which we will now briefly pursue is pivotal: how do the lists of the most highly published and cited journals (we have arbitrarily limited our lists to 12 journals) of a field compare with one another (see Tables 6-8)?

In Table 6 we have listed the 12 journals with the highest publication counts within reproductive physiology of non-human primates for the pre-1950 era. Articles in these 12 journals account for over half of this literature. When this table is compared with Table 7, which contains the citations from all of the articles in reproductive physiology of non-human primates to the same literature (indeed, with greater concentration), we see that 9 of the journals from Table 5 remain on the list. The ascendance of 4 journals, i.e., Contr Embryol Carneg Instn, J Mammol, Amer J Physiol, and Amer J Anat, suggests that certain problems treated in these journals are more central to the ongoing life of the subject area

TABLE 5*

JOURNALS PUBLISHING THE MAJORITY OF THE ARTICLES REFERRED
TO IN "SEX AND INTERNAL SECRETIONS"

Journal	Number of References to Each Journal	Cumulative Total of References	
		Number	Per Cent
1. American Journal of Physiology.....	169	169	6.8
2. Comptes rendus des séances et mémoires de la Société de Biologie.....	142	311	12.6
3. Proceedings of the Society for Experimental Biology and Medicine.....	125	436	17.6
4. Anatomical Record.....	116	552	22.3
5. American Journal of Anatomy.....	106	658	26.6
6. Journal of Experimental Zoology.....	99	757	30.6
7. Archiv für Gynäkologie.....	75	832	33.6
8. Endocrinology.....	61	893	36.1
9. Klinische Wochenschrift.....	51	944	38.3
10. Proceedings of the Royal Society of London.....	52	996	40.4
11. Zentralblatt für Gynäkologie.....	51	1047	42.5
12. Journal of the American Medical Association.....	49	1096	44.5
13. Journal of Physiology.....	41	1137	46.1
14. Biological Bulletin of the Marine Biological Laboratory.....	38	1175	47.6
15. Johns Hopkins Hospital Bulletin.....	35	1213	49.0
16. British Journal of Experimental Biology.....	33	1246	50.4
17. Carnegie Institute of Washington Publications.....	33	1279	51.7
18. Archiv für die gesamte Physiologie des Menschen und der Tiere (Pflüger's).....	32	1311	53.1
19. Archiv für Entwicklungsmechanik der Organismen.....	32	1343	54.3
20. American Naturalist.....	25	1371	55.5
315 other journals.....	1103	2474	100.0

The table shows the 20 journals most frequently cited, the number of references to each and cumulative totals and percentages. For example: The first 10 journals listed published 999 articles, or 40.4 per cent of the total of the 2474 references appearing in "Sex and Internal Secretions."

*Source: Mengert (1934)

TABLE 6

TWELVE JOURNALS WITH HIGHEST PUBLICATION COUNTS WITHIN
REPRODUCTIVE PHYSIOLOGY OF NON-HUMAN PRIMATES

Journals	# of pre-1950 Articles	% of Total pre-1950 Articles
Anat Rec	63	9.7
Endocrinology	51	7.8
Proc Soc Exp Biol Med	49	7.5
Proc Zool Soc London	29	4.5
Contr Embryol Carneg Instn	25	3.8
C R Soc Biol (Paris)	22	3.4
Anat Anz	19	2.9
Amer J Obstet Gynec	18	2.8
J Anat	17	2.6
J Mammol	16	2.5
Amer J Physiol	16	2.5
Amer J Anat	14	2.2
	<u>339</u>	<u>52.2</u>
	650	

TABLE 7

TWELVE JOURNALS WHICH RECEIVE THE HIGHEST NUMBER OF CITATIONS TO
REPRODUCTIVE PHYSIOLOGY OF NON-HUMAN PRIMATE LITERATURE

Journal	# of pre-1950 Citations	% of pre-1950 Citation to Articles in the Set
Contr Embryol Carneg Instn	505	18.9
Anat Rec	263	9.9
Endocrinology	153	5.7
J Mammol	152	5.7
Proc Soc Exp Biol Med	137	5.1
Amer J Physiol	118	4.4
Amer J Anat	114	4.3
Amer J Obstet Gynec	104	3.9
J Comp Physiol Psychol	103	3.9
J Anat	78	2.9
Comp Psychol Monogr	74	2.8
Yale J Biol Med	68	2.6
	<u>1869</u>	<u>70.1</u>
	2665	

TABLE 8

TWELVE JOURNALS WHICH RECEIVED THE HIGHEST NUMBER OF CITATIONS
TO ARTICLES WHICH WERE NOT IN THE AREA OF REPRODUCTIVE
PHYSIOLOGY OF NON-HUMAN PRIMATES

Journal	# of pre-1950, non- RP Citations	% of Total pre-1950 Citations
Anat Rec	555	3.7
Proc Zool Soc Lond	512	3.4
Endocrinology	504	3.4
Amer J Physiol	387	2.6
Amer J Anat	380	2.6
Contr Embryol Carneg Instn	378	2.5
Amer J Obstet Cynece	330	2.2
Arch Gynaek	217	1.5
J Biol Chem	204	1.4
J Physiol (London)	187	1.3
J Comp Physiol Psychol	165	1.1
	<u>3819</u>	<u>25.7</u>
	14848	

than was even the case of the distribution presented in Table 6. Notice that one need not impute greater value or prestige to such journals if one is aware of the broad structural dimensions of biological fields. Rather, one can appeal to these journals as dealing with questions posed by the problem domain. The "honing in" on a different journal set does not necessarily mean that these journals are better, only that channels of information into a problem area shift the focus to another structural dimension of the field.

Further illustration of shifts is found in Table 8, where the most cited journals containing articles which are not in the area of reproductive physiology of non-human primates are displayed. Compared with Table 6, three journals rise in the distribution, i.e., Proc Zool Soc Lond, Amer J Physiol, and Amer J Anat; comparing Tables 7 and 8, we see only two journals from Table 6 advancing in rank outside of the set, namely, Amer J Physiol and Amer J Anat. It would appear that as one moves from the articles to the citations within the article set, to citations outside the article set, more generalized journals ascend in citation counts. This suggests that the three journal rankings presented do in fact mirror some structural characteristics of the field.

From Table 8, one could further hypothesize that if the entire list of journals were presented, as one moves out from the center of the problem foci of a field, the main auxiliary journals become concomitantly visible. If one could map the movement of such specialty journals through citation patterns, one could obtain a better sense of the confluence patterns within biology.

Does the appearance, for instance, of several highly cited articles in one journal shift the citation patterns of a research domain in the following period? Such a question requires refinement of our data preliminary to the construction of intellectual indicators within reproductive endocrinology.

CONCLUSION

Throughout this paper we have tried to present something of the atmosphere of our entrée into a specialty study. In attempting to understand the field of reproductive physiology of non-human primates, we have searched histories of the field, turned to textbook discussions of the subject matter, and finally, availed ourselves of bibliometric techniques. Perhaps our most fruitful efforts have been directed at comparisons of clues from these various sources. It was the seeming incongruities that forced us on: we have gradually recognized the need for a more comprehensive theoretical orientation to specialty studies. Our method has forced us to think in terms that are frequently denied as relevant or possible in current interpretations of scientific specialties. In this sense, the work that we are pursuing is fundamental as well as critical. We are attempting to reorder our thinking so that the integrity of the cognitive subject structure of biological specialties can emerge intact.

Finally, what we have found is that the "heroic age of reproductive endocrinology" is an elusive era. How one studies it, how one defines various subject areas and problem domains within it, all interact with the interpretive process. Indeed, our analysis has shown that the interpretations afforded by chroniclers of the era and by citation patterns differ. Reconciling these interpretations will require a full-fledged theoretical framework to enhance both the potency of our research tools and the perspective they yield on the world of biological science.

FOOTNOTES

¹"Problem domain" is a term coined (Studer and Chubin, 1975:6, 37-41) to describe the properties of a research area within biology that is too small and short-lived to be called a specialty. Unlike Ben-David's (1960:566) process of "role-hybridization," a new scientific role is neither synthesized nor institutionalized out of established scientific disciplines. Rather, ideas, theories and techniques converge -- a sort of "conceptual migration" (Mulkay, 1974) -- on a new site to form a problem domain. The ideas or problem foci themselves may or may not be hybrids -- in the Ben-David and Collins (1966) sense -- of earlier concepts. Further, Edge and Mulkay's (1974) notion of "transient network" applies to problem domains insofar as it denotes impermanence. However, we conceive of a biological domain as an intellectually engendered result of a confluence of researchers and their tools. A domain, therefore, has its own "rationality" and derivative social structure.

²This is a particularly interesting interpretation of the situation because it places some of the responsibility for unnecessary literature growth on the shoulders of the main protagonists of this era. The drive for priority among the giants of the field was apparently creating a disparity between meaningful and superfluous growth.

³This is a strong methodological recommendation: since the area was small enough for researchers to oversee all the developments in it, there was apparently little intellectual "noise" or artifact to clutter the citation picture as it now exists. The use of experts to define a specialty's literature is anything but novel (e.g., Crane, 1972). What is novel is the ultimate mode of interpretation we propose to use for the sake of comparison.

⁴A graduate student in animal physiology, Daniel Brass, was employed to cull the following bibliographies for relevant pre-1950 articles in reproductive physiology of non-human primates: Aberle and Corner (1953), Hafez (1971), Ruch (1941), and a bibliography provided by the University of Washington Primate Center.

⁵The only references that have been coded to date are from articles (85

percent complete) in the set. The importance of books for the development of the field is also distorted by the fact that journal articles can be uniquely identified in coded form but books are not easily matched by computer citation matching algorithms. We recognize, therefore, that we have not given due recognition to non-serial published materials and plan to soon remedy this situation.

⁶We are well aware that not all descriptions of the past are historical; indeed, they may be anti-historical (Williams, 1966). For the present, we shall continue to refer to these works as histories although we realize their limitations and biases.

⁷TRACES (Technology in Retrospect and Critical Events in Science) was a research project conducted at the IIT Research Institute, Chicago, to discern the influences of mission-oriented and nonmission-oriented research on scientific progress. Because the Shefner and Hawrylewicz contribution to this research intersects with our own research interests, we have found it of great help in constructing Appendix A. A sequel to TRACES (Battelle, 1973) includes a chapter on oral contraceptives which does not, unfortunately, consider developments beyond 1960. Consequently, it was of no use in supplementing the literature in Appendix A.

⁸The potential intellectual connections among various problem domains at any given time circumscribes its "relevancy space " (Studer and Chubin, 1975: 36). Such a space, in practice, resists empirical specification since the literature of biology in toto could be considered a relevant resource, i.e., containing important theories or methods ripe for importation and application.

⁹Pritchard's (1969: not paginated) definition of statistical bibliography encompasses what we are calling bibliometrics, namely, "the statistical analysis of the means of communication in order to illuminate the processes of communication, the factors which influence them and the inter-relationships between the history and sociology of a science and the literature of the science."

¹⁰See Footnote 4 for a listing of the sources used in constructing our article data set. In theory, the Ruch (1941) bibliography has been continued without interruption by the Washington Primate Center, but we have also attempted to

supplement the post-1941 article set by using other sources. The supplementation has not greatly increased the number of articles for this period. Although we will attempt to trace citations to find additional articles which should be incorporated into the set, we suspect that the decline in article production for this period will be sustained.

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Substantive articles on reproductive endocrinology referred to in the text are found in Appendices A and B and not repeated here.

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APPENDIX A

AN HISTORICALLY SIGNIFICANT ANNOTATED BIBLIOGRAPHY OF REPRODUCTIVE ENDOCRINOLOGY ARTICLES

The annotated bibliography of historically significant articles in reproductive endocrinology which we have assembled in chronological order is greatly indebted to three sources, Garrison and Morton (1954), Fulton and Wilson (1966), and Shefner and Hawrylewicz (1969). These sources are abbreviated in this Appendix as G, F, and T, respectively, and immediately follow each entry. Each source seemed to represent the type of historical interest found in the histories of reproduction through the mid-twentieth century (again see the references noted in Part I of the text). We are not arguing that the sources have articles and events listed which are identical to those found in the histories; but only that the articles on the lists are exceedingly important ones in the view of historians of the era. Other articles could have been chosen, but what we judge to be necessary for the type of comparison in which we are engaged is simply a list of systematically gathered "important articles."

Below the date of each appendix item is the number of times it was referenced by articles in our reproductive physiology of non-human primates set. This data set is further described in footnote 5 and the foreward to Appendix B.

- 1561 Gablele Falloppio (1523-1567) discovered the ovarian-uterine tubes which we still know as the Falloppian tubes. *Observationes anatomicae*, Venice, Marco Antonio Ulmo, 1561, 221pp. (G F)
- 1651 William Harvey (1578-1657) publishes *Exercitationes de generatione animalium*. Londini:O. Pulleyn. (G F)
- 1668 Regner de Graaf (1641-1673) gave an exact and detailed account of the male reproductive system. *De virorum organis generationi inservientibus, de clysteribus et de usu siphonis in anatomia*. Lugdoni Batavorum, Hackiana, 1668. (G F)
- 1672 Regner de Graaf (1641-1673) publishes his study on the organs of reproduction of the human female. *De mulierum organis generationi inservientibus tractatus novus demonstrans tam homines et animalia caetera omnia, quae vivipara dicuntur, haud minus quam ovipara ab ova origine ducere*, Leyden, 1672. Describes what is now called the "Graafian follicles." (G F)
- 1774 William Hunter (1718-1783) described with anatomical precision the gravid human uterus during the second half of pregnancy. *Anatomia uteri humani gravidi tabulis illustrata. The anatomy of the human gravid uterus exhibited in figures*. Birmingham:John Baskerville. (G F)
- 1797 CIT=0 William Cumberland Cruikshank (1745-1800) solved Harvey's problem of why after mating there was no implantation in the uterus. "Experiments in which on the third day after impregnation, the ova of rabbits were found in the fallopian tubes; and on the fourth day after impregnation in the uterus itself; with the first appearances of the foetus," *Phil. Trans.*, 87:197-214. (G F)
- 1827 Karl Ernst von Baer. Discovered the mammalian ovum. Written up in the letter in Latin to the St. Petersburg Academy of Science. Developed in *De ovi mammalium et hominis genesi*, Lipsiae:L. Vossius. (G see also Corner, 1958)
- 1849 CIT=1 Arnold Adolph Berthold (1803-1861) showed that the transplantation of the testicles of a cock to another location in the body prevents atrophy of the comb. "Transplantation der Hoden," *Arch. Anat. Physiol. wiss. Med.*, 1849, 42-46. (G F T)
- 1850 CIT=4 Franz Leydig (1821-1908) was the first to describe the cells of the testis now know as the "Leydig cells." "Zur Anatomie der männlichen Geschlechtsorgane und Analdrüsen der Säugethiere," *Z. wiss. Zool.* 2:1-57. (G)
- 1889 CIT=0 Charles Edouard Brown-Sequard (1817-1894). The first to inject testicular extracts into a human subject (himself). He thought this would bring about rejuvenation of the body. "Experience démontrant la puissance dynamogénique chez l'homme d'un liquide extrait de testicules d'animaux." *Arch. Physiol. norm. path.* 5 ser. 1:651-658. Other papers followed on the same subject. (G F)
- 1891 CIT=0 Alexandr Vassilievitch Pöehl (1850-1898). Isolates spermin from testis. [On spermin]. *J. Russk. fis. -chim. Obsh.* 23:151-155. (G)
- 1896 CIT=0 E. Knauer. The first to report the existence of the female sex hormone. "Einige Versuche über Ovarien-Transplantation von Kaninchen." *Centralbl. f. Leipz.* 20:524- . (T)
- 1896 CIT=3 Robert Heinrich Johannes Sobotta (1869-). Discussed the structure of the mouse Corpus luteum. "Über die Bildung des Corpus luteum bei der Maus." *Arch. mikr. Anat.* 47:261-308. (G)
- 1898 CIT=0 J. Beard. Described the role of the Corpus luteum in inhibiting ovulation. "The rhythm of reproduction in mammalia." *Anat. Anz.* 14:97- . (T)
- 1898 CIT=0 A. Prenant. Described the role of the Corpus luteum in inhibiting ovulation. "De la valeur morphologique du corps jaune sur action physiologique et thérapeutique possible." *Rev. Gen. Sci. Pures Appl.* 9:646- . (T)
- 1903 CIT=3 L. Fraenkel. Confirmed Beard's and Prenant's findings concerning the Corpus luteum and showed that it was necessary for the maintenance of pregnancy. "Die Funktion des Corpus-Luteum." *Arch. Gynaekol.* 68:438- . (T)
- 1905 CIT=0 Ernest H. Starling (1866-1927) discusses for the first time a general theory of hormones. The first usage of the word "hormone" was in this article. "The Croonian Lectures on the chemical correlation of the functions of the body." *Lancet* 2:339-341, 423-425, 501-503, 579-583. (G)
- 1906 CIT=2 Janet Elizabeth Lane-Claydon (1877-) and Ernest Henry Starling were the first to apply experimental methods to the development of the mammary gland. They attributed changes in the mammary gland during pregnancy to the foetus. "An experimental inquiry into the factors which determine the growth and activity of the mammary glands," *Proc. roy. Soc. b.*, 77, 505-22, 1906. (G)
- 1907 CIT=1 L. Loeb. Demonstrated that the Corpus luteum was necessary for implantation of the ovum in the uterus. "Über die experimentelle Erzeugung von Knoten Deciduagewebe in dem Uterus des Meerschweinchens nach stattgefundener Copulation." *Zentr. Allgem. Pathol. Pathol. Anat.* 18:563- . (T)
- 1908 CIT=9 Fritz Hitschmann (1870-1926) and Ludwig Adler, first accurate description of the cyclical changes of the endometrium. "Der Bau der Uterusschleimhaut des geschlechtsreifen Weibes besonderer Berücksichtigung der Menstruation." *Mschr. Geburt. Gynäk.*, 27, 1-82, 1908. (G)
- 1909 CIT=0 H.H. Dale shows the effects of extracts of posterior pituitary stimulate the contraction of smooth muscle. "The action of extracts of the pituitary body," *Biochem. J.*, 1909, 4, 427-447. (G F)
- 1910 CIT=6 P. Bouin and P. Ancel. Describe the progestational proliferation in the endometrium after injecting with an extract of corpora lutea. "Recherches sur les fonctions du corps jaune gestatif." *J. Physiol.* 12:1- . (T)
- 1910 CIT=0 Samuel James Crowe (1883-), Harvey Williams Cushing (1869-1939), and John Homans () presented the first experimental evidence of the relationship between the pituitary and the reproductive system. "Experimental hypophysectomy," *Johns Hopkins Hospital Bulletin*, 21, 126-169, 1910. (G F)

- 1910 Francis H. A. Marshall. Publisher one of the first modern comprehensive physiological treatments of reproduction. *The Physiology of Reproduction*. London: Longmans, Green and Co. A second edition appeared in 1922 and a third edition in 1949. (F)
- 1911 CIT=3 Leo Loeb. Demonstrated that the presence of a Corpus luteum inhibits spontaneous ovulation in mammals. "The cyclic changes in the ovary of the guinea pig." *J. Morphol.* 22:37- . (T)
- 1911 CIT=2 Leo Loeb. Demonstrated that the presence of a Corpus luteum inhibits spontaneous ovulation in mammals. "Über die Bedeutung des Corpus-luteum für die Periodizität des Sexuellen Zyklus beim weiblichen Säugetierorganismus." *Deut. Med. Wochschr.* 37:17- . (T)
- 1912 CIT=1 Bernard Aschner (1883-) succeeded in keeping alive indefinitely hypophysectomized dogs. "Über die Funktion der Hypophyse." *Pflug. Arch. ges. Physiol.* 146, 1-146, 1912. (G)
- 1915 CIT=0 Walter Lee Gaines (1881-) demonstrates the role of oxytocin in the let-down of milk. "A contribution of the physiology of lactation" *Amer. J. Physiol.*, 1915, 38, 285-312. (F)
- 1917 CIT=6 Charles Rupert Stockard (1879-1939) and George Nicholas Papanicolaou (1883-1962) demonstrate that the ovulation cycle of the guinea pig can be followed by cellular changes of a vaginal smear. "The existence of a typical oestrous cycle in the guinea pig--with a study of its histological and physiological changes," *Amer. J. Anat.*, 1917, 22, 225-265. (G F T)
- 1920 CIT=0 Joseph Abraham Long and Herbert McLean Evans. Unravel the estrous cycle of the rat. "The oestrus cycle in the rat." *Anat. Rec.* 18:241-244. (F)
- 1921 CIT=0 Herbert McLean Evans (1882-) and Joseph Abraham Long (1879-) showed that continued injections of an anterior pituitary extract produced an acceleration in the growth-rate of laboratory animals. "The effect of the anterior lobe administered intraperitoneally upon growth, maturity and oestrus cycles of the rat," *Anat. Rec.*, 21, 62-63, 1921. (G F)
- 1921 CIT=0 L. Harberlandt. Sterility ensued when the ovaries of pregnant animals were transplanted into nonpregnant animals. "Über Hormonal Sterilisierung des weiblichen Tierkörpers." *Munch. Med. Wochschr.* 68:1577- . (T)
- 1922 CIT=8 Edgar Allen. Unravels the estrous cycle of the mouse. "The oestrus cycle in the mouse." *Am. J. Anat.* 30:297- . (F)
- 1922 CIT=1 Herbert McLean Evans (1882-) and Joseph Abraham Long (1879-). Showed that the anterior pituitary produced two gonad stimulating hormones, i.e., FSH and ICSH (or LH). "Characteristic effects upon growth of oestrus and ovulation induced by the intraperitoneal administration of fresh anterior hypophyseal substance." *Proc. Natl. Acad. Sci.* 8:38- . (T)
- 1922 CIT=16 Herbert McLean Evans (1882-) and Joseph Abraham Long (1879-). Publish their monograph, *The Oestrous Cycle in the Rat and its Associated Phenomena*. *Mems. Univ. Calif.* 6(2), June 28. (F)
- 1923 CIT=9 Edgar Allen (1892-1943) and Edward Adelbert Doisy (1893-) discovered that the ovarian follicles affect the oestrus cycle by producing a hormone, namely estrogen. This was a ground breaking work that was to stimulate further studies of hormonal controls in reproductive physiology. "An ovarian hormone: preliminary report on its localization, extraction and partial purification, and action in test animals," *J. Amer. Med. Ass.*, 1923, 81, 319. (G F T)
- 1923 CIT=62 George W. Corner. Unravels the estrous cycle of the monkey. "Ovulation and menstruation in *Macacus rhesus*." *Cont. Embry. (No. 75) Carneg. Inst.* 15:73- . (F)
- 1924 CIT=5 Edgar Allen and E.A. Doisy. Attempt to isolate pure active female hormone and develop a test for the recognition of its presence. "The induction of a sexually mature condition in immature females by injection of the ovarian follicular hormone." *Amer. J. Physiol.* 69:577-588. (G T)
- 1926 CIT=0 J.O. Ralls, C.H. Jordan, and E.A. Doisy. Attempted to isolate pure female hormone and failed. "An improved procedure for extraction of the ovarian hormone and some chemical properties of the product." *J. Biol. Chem.* 69(2):392. (T)
- 1926 CIT=0 J.O. Ralls, C.H. Jordan, and E.A. Doisy. Attempted to isolate pure female hormone and failed. "Simplified method of preparation of ovarian hormone and properties of the purified product." *Proc. Soc. Exp. Biol. Med.* 23(7):592- . (T)
- 1927 CIT=70 Edgar Allen (1892-1943) starts unraveling the pattern of hormonal control of the estral cycle. Shows that uterine bleeding occurs in the monkey as a withdrawal effect when estrogen ceases to act on the endometrium. "The menstrual cycle of the monkey, *Macacus rhesus*: Observations on normal animals, the effects of removal of the ovaries and the effects of injection of ovarian and placental extracts into the spayed animals." *Contr. Embryol. Carneg. Instn.*, 19, 1-44, 1927. (G)
- 1927 CIT=2 Ernst Laqueur (), E. Dingemans, P.C. Hart, discovered the estrogenic activity of male urine. "Über das Vorkommen weiblichen Sexualhormons (Menformon) im Harn von Männern," *Klin. Wschr.*, 6 1859, 1927. (G)
- 1927 CIT=0 Lemuel Clyde McGee (1902-) prepared the first active male hormone extract from the lipid fraction of bull testes. "The effect of the injection of lipid fraction of bull testicle in capons." *Proc. Inst. Med. Chicago*, 6, 242-4, 1927. (G)
- 1927 CIT=2 Philip Edward Smith (1884-) succeeded in perfecting the operation of hypophysectomy on rats. See subsequent article "The disabilities caused by Hypophysectomy and their Repair," *J. Amer. Med. Ass.*, 1927, 88, 158-161, where Smith presents his pioneering work on the effects of anterior pituitary transplants. (F)
- 1927 CIT=1 Philip Edward Smith (1884-) and Earl Theron Engle (1896-). Caused precocious sexual maturity in immature mice by the implantation of pituitary tissue. "Experimental evidence regarding the role of the anterior pituitary in the development and regulation of the genital system." *Amer. J. Anat.* 40:159-217. (G F)

- 1927
CIT=1 Philip Edward Smith (1884-). Demonstrated the effects of pituitary secretions on gonads. "The induction of precocious sexual maturity by pituitary homotransplants." Amer. J. Physiol. 80:114-125. (G)
- 1927
CIT=7 B. Zondek and S. Aschheim. Study the estrogenic hormones in urine. "Ovum and Hormone." Klin. Wochschr. 6:1321- . (T)
- 1927
CIT=3 Bernhard Zondek (1891-) and Selmar Aschheim (1878-). Isolated the gonadotrophic hormone of the anterior pituitary (Prolan A and B). "Das Hormon des Hypophysenvorderlappens." Klin. Wschr. 1927, 6:248-52, 1928, 7:831-835. (G T)
- 1928
CIT=0 Selmar Aschheim (1878-) and Bernhard Zondek (1891-) developed a pregnancy test. "Schwangerschaftsdiagnose aus dem Harn (durch Hormonnachweis)". Klin. Wschr., 1928, 7, 8-9. (F)
- 1928
CIT=0 B. Zondek. Continues study of the estrogenic hormones in urine. "Preparation of female sexual hormone from urine particularly from urine of pregnant women." Klin. Wochschr. 7:485. (T)
- 1928
CIT=1 S. Aschheim and B. Zondek. Continue study of the estrogenic hormones in urine. "Diagnosis of pregnancy by demonstrating the presence of the hormone of the anterior lobe of the hypophysis in the urine." Klin. Wochschr. 7:1404- . (T)
- 1928
CIT=2 S. Aschheim and B. Zondek. Continue study of the estrogenic hormones in urine. "Diagnosis of pregnancy by demonstrating the presence of the hormone of the anterior lobe of the hypophysis in the urine, II." Klin. Wochschr. 7:1453. (T)
- 1929
CIT=0 A. Butenandt. Second to announce the isolation and crystallization of pure female hormone. "Progynon, a crystalline female sexual hormone." Naturwissenschaften 17:879- . (T)
- 1929
CIT=6 George Washington Corner (1889-) and Willard Myron Allen (1904-) discovered progesterone. "Physiology of the corpus luteum." Amer. J. Physiol., 1929, 88:326-339. (G F T)
- 1929
CIT=0 E.A. Doisy, C.D. Veler, and S. Thayer. First article to announce the isolation and crystallization of pure female hormone. "Folliculin from Urine of Pregnant Women." Am. J. Physiol. 90(2):329- . (T)
- 1929
CIT=0 Casimir Funk (1884-) and Benjamin Harrow (1888-) obtain crude extracts of male hormone from male urine. "The male hormone." Proc. Soc. Exp. Biol. (NY) 26:325-6, 1929. (G)
- 1929
CIT=4 Guy F. Marrian. The isolation of estriol from pregnancy urine. "The chemistry of oestrin: I; preparation from urine and separated from an unidentified solid alcohol." Biochem. J. 23(5):1090-1098. (G T)
- 1929
CIT=0 Guy F. Marrian. The isolation of estriol from pregnancy urine. "The chemistry of oestrin: II; methods of preparation." Biochem. J. 23(6):1233- . (T)
- 1929
CIT=0 Carl Richard Moore (1892-) T.F. Gallagher (), and F.C. Koch. Were the first to obtain a concentrated testicular extract containing male sex hormone (testosterone). "The effects of extracts of testis in correcting the castrated condition in the fowl and in the mammal." Endocrinology, 13, 367-74, 1929. (G)
- 1929
CIT=0 Carl Richard Moore (1892-) and T.F. Gallagher () vindicate Brown-Sequard (1889 above). "On the prevention of castration effects in mammals by testis extract injection." Amer. J. Physiol. 1929, 89:388-394. (F)
- 1930
CIT=2 W.M. Allen (1904-). Developed a crude method for isolation and extraction of progesterone from the corpus luteum. "Physiology of the corpus luteum: the preparation and some of the properties of progestin, a hormone of the corpus luteum which produces progestational proliferation of the endometrium of the immature rabbit by progestin (an extract of the corpus luteum) after preliminary treatment with estrin." Am. J. Physiol. 92:174- , 612- . (T)
- 1930
CIT=0 A. Butenandt and E.V. Ziegner. Further discussion concerning the isolation and crystallization of female hormone. "The female sexual hormone: III; the physiological activity of the crystalized female sexual hormone in the Allen-Doisy text." Z. Physiol. Chem. 188:1- . (T)
- 1930
CIT=0 James Bertram Collip (1892-) discovered Collip's anterior-pituitary-like (APL) factor. "The ovary-stimulating hormone of the placenta." Canad. med. Ass. J., 22, 215-19, 761-74, 1930. (G)
- 1930
CIT=1 Edward Adelbert Doisy (1893-), Clement D. Veler () and Sidney A. Thayer, first isolation of pure crystalline hormone estrone. "The preparation of the crystalline ovarian hormone from the urine of pregnant women." J. Biol. Chem. 1930, 86:499-509. (G T)
- 1930
CIT=0 Guy F. Marrian. The isolation of estriol from pregnancy urine. "Preparation of Oestrin." Nature 125:90- . (T)
- 1930
CIT=0 Guy F. Marrian. Prepared crystalline estrin. "The chemistry of oestrin: III; an improved method of preparation and the isolation of active crystalline material." Biochem. J. 24:435-445. (G)
- 1930
CIT=1 C.D. Veler, S. Thayer, and E.A. Doisy. Further elaborations on the crystallization of female hormone. "The preparation of the crystalline follicular hormone." J. Biol. Chem. 87:357- . (T)
- 1931
CIT=0 Adolph Friedrich Johann Butenandt (1903-) first to isolate in crystalline form the male sex hormone, testosterone. "Ueber die chemische Untersuchung der Sexualhormone." Z. Angew. Chem., 44:905-8, 1931. (G F)
- 1931
CIT=0 A. Butenandt. Determined that female hormone had a steroid structure and was similar to cholesterol. "Untersuchungen uber das weibliche Sexual Hormone (Follikel-oder Brunsthormon)." Abhandl. Ges. Wiss. Gottingen Math-Physik Kl. III, Folge, Heft. 2, Weideman, Berlin. (T)

DRAFT: NOT TO BE QUOTED WITHOUT PERMISSION

- 1931 CIT=0 M.C. Chang and G. Pincus. Reviewed the state of the field of the physiology of fertilization. "Physiology of fertilization in mammals." *Physiol. Rev.* 31:1- . (T)
- 1931 CIT=0 E. Fels and K.H. Slotta. Evaluate the crystallized female hormone obtained from animal sources. "Das rein dargestellte Hormon des corpus-luteum und seine biologischen Wirkungen." *Klin. Wochschr.* 10:1639- . (T)
- 1931 CIT=4 Harry Leonard Fevold (1902-), Frederick Lee Hisaw (1891-) and Samuel Leeson Leonard (1905-) discovered the follicle-stimulating hormone (FSH) and the interstitial-cell-stimulating hormone (ICSH). "The gonad stimulating and luteinizing hormones of the anterior lobe of the hypophysis." *Amer. J. Physiol.*, 1931, 97:291-301. (F)
- 1931 CIT=1 L. Levin, P.A. Katzman and E.A. Doisy. Prevent conception in rats with ovarian hormones. "Effects of estrogenic substances and the luteinizing factor on pregnancy in the albino rat." *Endocrinology* 15:207- . See also, L. Levin. *Chemical Characteristics and Certain Physiological Properties of the Estrogenic Substances Theelin and Theelol*. Thesis:St. Louis Univ., 1934. (T)
- 1931 Schering, Kahlbaum, Germany, Parke, Davis and Co., U.S.A., Manufacture hormones from animal sources (T).
- 1931 H. Taylor. Speculated on the possible hormonal control of fertility in males. "Report on the hormonal control of fertility." In *The Practice of Contraception*. William and Watkins Co. (T)
- 1931 Bernhard Zondek (1891-). The first edition of *Die Hormone des Ovariums und des Hypophysenvorderlappens*. Berlin:J. Springer. Second edition, 1935. (G)
- 1932 Edgar Allen (Ed.) (1892-1943). The first edition of *Sex and Internal Secretion: a Survey of recent research*. Baltimore:Williams and Wilkins. Second edition 1939, edited by Edgar Allen, C.H. Danforth, and E.A. Doisy. Third edition in 1961, two volumes, edited by William C. Young and George W. Corner. (G)
- 1932 CIT=0 W.M. Allen. "Preparation of purified progesterin." *J. Biol. Chem.* 98:591- . (T)
- 1932 CIT=0 H.L. Fevold and F.L. Hisaw. Evaluation of crystallized female hormone from animal sources. "Purification of Corporin." *Proc. Soc. Exp. Biol. Med.* 29:620- . (T)
- 1932 CIT=7 C. Moore and D. Price. Investigated the feedback effect of anterior pituitary on ovulation. "Gonad hormone functions and the reciprocal influence between gonads and hypophysis with its bearing on the problem of sex hormone antagonism." *Am. J. Anal.* 50:13- . (T)
- 1932 CIT=4 Oscar Riddle (1877-), Robert Wesley Bates (1904-) and Simon William Dykshorn (1903-1932) discovered prolactin. *Proceedings of Soc. Exp. Biol and Med* 1933, 29, June, 1211, and in *Anat. Rec.*, 1932, 54, 25. (G F)
- 1933 CIT=0 John Symonds Lyon Browne (1904-). Estriol obtained from placental tissue. "Chemical and physiological properties of crystalline oestrogenic hormones." *Canad. J. Res.* 8:180-197. (G)
- 1933 CIT=1 Carl Kaufmann. First use of estrogenic hormone in ovariectomized women which produced cyclical endometrial changes. "Die Behandlung der Amenorrhoe mit hohen Dosen der Ovarialhormone." *Klin. Wschr.* 12:1557-1562. (G)
- 1933 CIT=0 E. Schwenk and F. Hildebrandt. Convert estriol into estradiol. "Reduction of the follicular hormone." *Naturwissenschaften* 21:177- . (T)
- 1934 CIT=3 Willard Myson Allen (1904-) and Oskar Wintersteiner (1898-). Isolated pure crystalline progesterone from animal sources. "Crystalline progesterin." *Science* 80:190-191, and in *J. Biol. Chem.*, 107:321-336. (T)
- 1934 CIT=0 Adolph Friedrich Johann Butenandt (1903-). First to obtain progesterone in crystalline form. "Neuere Ergebnisse auf dem Gebiet der Sexualhormone." *Wien. Klin. Wschr.* 47:897-901, 934-936. (G)
- 1934 CIT=2 A. Butenandt, U. Westphal, and H. Coblér. Isolated pure progesterone from animal sources. "Über einen Abbau des Stigmasterens zu Corpus-luteum wirksamen Stoffen; ein Beitrag zur Konstitution des Corpus-luteum Hormons." *Chem. Ber.* 67:1611- . (F)
- 1934 CIT=0 M. Hartman and O. Wettstein. Isolated pure progesterone from animal sources. "Ein krystallisiertes Hormon aus Corpus-luteum." *Helv. Chim. Acta.* 17:878- . (T)
- 1934 CIT=0 K.H. Slotta, H. Ruschig, and E. Fels. Isolated pure progesterone from animals sources. "Reindarstellung der Hormone aus dem Corpus-luteum." *Ber. Deut. Chem. Ges.* 67:1270- . (T)
- 1934 CIT=1 Leopold Ruzicka (1887-), M.W. Goldberg, J. Meyer, H. Brungger, and E. Eichenberger. First complete synthesis of a sex hormone (androsterone). "Über die Synthese des Testikelhormons (androsteron) und Stereoisomerer desselben durch Abbau hydrierter Sterine." *Helv. Chim. Acta.* 17:1395-1406. (G)
- 1935 CIT=0 H.O. Burdick and G. Pincus. Animal studies of estrogen and progesterone effects on ovulation and menstrual cycle. "The effect of estrin injection upon the developing ova of mice and rabbits." *Am. J. Physiol.* 111:201- . (T)
- 1935 CIT=2 Donald William MacCorquodale (1898-), S.A. Thayer, and E.A. Doisy. Isolated estradiol. "Isolation of the principle estrogenic substance of liquor folliculi." *J. Biol. Chem.* 115:435-48, also in *Proc. Soc. Exp. Biol. Med.* 32:1182- . (G T)
- 1935 Marker, Penn State, Chemical conversion of cholesterol to a male hormone (T).
- 1936 CIT=1 H.L. Fevold, F.L. Hisaw and R. Greep. Studied estrogen and progesterone effects on ovulation and menstrual cycle. "Effect of estrin on the activity of the anterior lobe of the pituitary." *Am. J. Physiol.* 114:508- . (F)

- 1936 CIT=0 H.J. Gigerson, A.R. Clarke, and R. Kurzrok. Studied estrogen and progesterone effects on ovulation and menstrual cycle. "Studies on gonadotropic anti-hormones." *Proc. Soc. Exp. Biol. Med.* 35:193- (T)
- 1936 CIT=0 A.S. Parkes and I.W. Rowland. Studied estrogen and progesterone effects on ovulation and menstrual cycle. "Inhibition of ovulation in the rabbit by anti-gonadotropic serum." *J. Physiol.* 87:29-30. (T)
- 1936 CIT=1 H. Selye, J.S.L. Browne, and J.B. Callip. Studied estrogen and progesterone effects on ovulation and menstrual cycle. "Effect of large doses of progesterone in the female rat." *Proc. Soc. Exp. Biol. Med.* 34:472- (T)
- 1936 CIT=0 R. Whitney and H.O. Burdick. Studied the effects of estrin. "Tube locking of ova by estrogenic substances." *Endocrinology* 20:643- (T)
- 1937 CIT=8 E.W. Dempsey. Investigate use of hormones to alleviate menstrual disorders. "Follicular growth rate and ovulation after various experimental procedures in the guinea pig." *Am. J. Physiol.* 120:126- (T)
- 1937 CIT=0 R. Kurzrok. Discussed the normal anovulatory cycles of women. "The prospects for hormonal sterilization." *J. Contraception* 2(2):27- (T)
- 1937 CIT=6 A.W. Makepeace, C.L. Weinstein, and M.H. Friedman. Studied the effects of progesterone on ovulation and menstrual cycle. "The effect of progestin and progesterone in ovulation in the rabbit." *Am. J. Physiol.* 119:512-516. (T)
- 1937 CIT=1 J. Rock and M.K. Bartlett. Established the relationship of progestational effects on endometrium to the regularity of ovulation. "Biopsy studies of the human endometrium." *J. Am. Med. Assoc.* 108:2022- (T)
- 1937 CIT=0 Arne Wilhelm Kaurin Tiselius (1902-) discovers electrophoresis. "A new apparatus for electrophoretic analysis of colloidal mixtures." *Trans. Faraday Soc.* 1937, 33, 524 and "Electrophoretic analysis of protein mixtures with an improved apparatus." *Skand. Archiv. Physiol.*, 1937, 77. (F)
- 1938 CIT=3 H.H. Imhoffen and H. Hohlweg. Estrogen and progesterone used as ovulation inhibitors. "Neue per os wirksame weibliche Keimdrusen Hormon Derivate:17-Athiny1-Ostradiol und Pregnen-in-on-3-ol-17." *Naturwissenschaften* 26:96- (T)
- 1938 CIT=1 L. Wilson and R. Kurzrok. Investigate the use of hormones to alleviate menstrual disorders. "Studies on the mobility of the human uterus in vivo (a functional myometrical cycle)." *Endocrinology* 23:79- (T)
- 1939 Marker and Rohrman, Penn State. Chemical conversion of cholesterol to members of the male hormone series (T).
- 1940 CIT=0 Choh Hao Li, Miriam E. Simpson and Herbert M. Evans. Succeed in isolating the interstitial cell stimulating hormone (LH). "Purification of the pituitary interstitial cell stimulating hormone." *Science* 92:355-356. (F)
- 1940 CIT=0 S.H. Sturgis and F. Albright. Investigate use of hormones to alleviate menstrual disorders. "The mechanism of estrin therapy in dysmenorrhea." *Endocrinology* 26:68- (T)
- 1942 CIT=0 Abraham White, Roy W. Bonsnes, C.N.H. Long. Succeed in isolating prolactin. "Prolactin." *J. Biol. Chem.* 143:447-469. (F)
- 1943 CIT=0 Choh Hao Li, Miriam E. Simpson and Herbert M. Evans succeed in isolating adrenocorticotrophic hormone. "Adrenocorticotrophic hormone." *J. Biol. Chem.* 149:413-424. (G F)
- 1943 CIT=0 George Sayers, Abraham White, and C.N.H. Long. Succeed in isolating the adrenocorticotrophic hormone. "Preparation of pituitary adrenotropic hormone." *Proc. Soc. Exp. Biol. and Med.* 52(3):199-200.
- 1944 CIT=0 M. Allen, and M. Ehrenstein. Synthesized physiologically active homologs of progesterone. "10 Nor-progesterone, a physiologically lower homolog of progesterone." *Science* 100:251- (T)
- 1945 F. Albright. Study of the oral administration of ethynylestradiol. "Disorders of the Female Gonads." In, *Internal Medicine - Its Theory and Practice*, Ed. by J.J. Musser, Philadelphia. (T)
- 1945 CIT=0 Choh Hao Li, Herbert M. Evans, Miriam E. Simpson. Succeed in isolating the growth hormone. "Isolation and properties of the anterior hypophyseal growth hormone." *J. Biol. Chem.* 159:353-366. (F)
- 1947 CIT=0 L.H. Boyarsky, H. Baylies, L.E. Casida, and R.K. Meyer. Estrogen and progesterone used as ovulation inhibitors. "Influence of progesterone upon the fertility of gonadotrophin-treated female rabbits." *Endocrinology* 41:312- (T)
- 1948 CIT=0 R.H. Dutt and L.E. Casida. Estrogen and progesterone used as ovulation inhibitors. "Alteration of the estrual cycle in sheep by use of progesterone and its effect upon subsequent ovulation and fertility." *Endocrinology* 43:208-217. (T)
- 1949 CIT=0 C.H. Li, Miriam E. Simpson, and H.M. Evans succeed in isolating the follicle-stimulating hormone (FSH). "Isolation of pituitary follicle-stimulating hormone (FSH)." *Science* 109:445-446. (F)
- 1949 CIT=0 A.H. Livermore and Vincent du Vigneaud purified oxytocin. "Preparation of high potency oxytocic material by the use of counter-current distribution." *J. Biol. Chem.*, 1949, 180:365-373. (F)
- 1950 CIT=0 M.E. Davis and N.W. Fugo. Discuss the use of progesterone to prevent early abortions. "Report on the value of steroids in the treatment of early pregnancy complications." *J. Am. Med. Assoc.* 142:778- (T)

APPENDIX B

ARTICLES RECEIVING TEN OR MORE CITATIONS FROM OUR REPRODUCTIVE
PHYSIOLOGY OF NON-HUMAN PRIMATE DATA SET

The reproductive physiology of non-human primates data set for the pre-1950 era was gathered from Aberle and Corner (1953), Hafez (1971), Ruch (1941), and a bibliography provided by the Washington Primate Center. After the article set had been determined by a graduate student in animal physiology, we began to code all of the references contained within articles of this set. When this task was substantially completed (85 percent of the articles reference coded), we matched the citations within the set. This appendix lists all of the articles which were matched ten or more times within the reference set. What we have attempted to construct is a list of highly cited articles which could in some sense be said to parallel the historically significant articles found in Appendix A.

Asterisks (***) before an item indicate that that particular item was not judged to be part of our reproductive physiology of non-human primate data set. After the authors' names on each article is the article identification number (ID) and the number of citations (CIT) it received from our data set.

Due to the great difficulties involved in matching citations to books, we have not included any highly cited books in this appendix. In the future we hope to remedy this omission, but for the present we will have to be satisfied with references to serial publications.

- 1845 Breschet, G. (ID=2119, CIT=10)
"Recherches anatomiques et physiologiques sur la gestation des quadrumanes." Mem. Acad. Sci. 19:401-490.
- 1890 Waldeyer, W. (ID=2088, CIT=12)
"Bemerkungen über den Bau der Menschen- und Affen-Placenta." Arch. Mikr. Anat. 35:1-51.
- 1894 Walter Heape. (ID=25043, CIT=14)
"The menstruation of *Scenopithecus entellus*." Philosophical Transactions of the Royal Society of London, Series B 185:411-471.
- 1897 Walter Heape. (ID=25050, CIT=10)
"The menstruation and ovulation of *Macacus rhesus*, with observations on the changes undergone by the discharged follicle.--Park II." Philosophical Transactions of the Royal Society of London, Series B 188:135-166.
- 1906 van Herwerden, M. (ID=1818, CIT=15)
"Beitrag zur Kenntnis des menstruellen Cyklus." Mschr. Geburtsh. Gynak. 24:730-748.
- 1907 Bolk, L. (ID=2227, CIT=13)
"Beiträge zur Affenanatomie. VI. Zur Entwicklung und vergleichenden Anatomie des Tractus urethrovaginalis der Primaten." Z. Morph. Anthropol. 10:250-316.
- 1908 ***Hubrecht, A.A.W. (ID=25867, CIT=)
"Early ontogenetic phenomena in mammals and their bearing on our interpretation of the phylogeny of the vertebrates." Quart. J. Micro. Sci. 53:1-101.
- 1913 Lyon, Marcus Ward, Jr. (ID=27237, CIT=11)
"Treeshrews: an account of the mammalian family tupaiidae." Proc. U.S. Nat. Hist. Mus. 45:1-188.
- 1917 Kempf, E.J. (ID=2006, CIT=14)
"The social and sexual behavior of infrahuman primates, and some comparable facts in human behavior." Psychoanal. Rev. 4:127-154.
- 1922 ***Herbert McLean Evans and Joseph Abraham Long (ID=24787, CIT=16)
The Estrous Cycle in the Rat and its Associated Phenomena. Mem. Univ. Calif. 6(2):1- .
- 1923 Corner, G.W. (ID=1798, CIT=62)
"Ovulation and menstruation in *Macacus rhesus*." Contr. Embryol. Carneg. Instn. 15:73-101.
- 1923 Coventry, A.F. (ID=2072, CIT=14)
"The placenta of the guinea baboon (*Cynocephalus papio*, Desmar.)." Anta. Rec. 25:237-255.
- 1925 Pocock, R.I. (ID=25665, CIT=13)
"The external characteristics of the catarrhine monkeys and apes." Proc. Zool. Soc., Lond 1479-1579.
- 1926 Allen, E. (ID=1873, CIT=14)
"The time of ovulation in the menstrual cycle of the monkey, *Macacus rhesus*." Proc. Soc. Exp. Biol. 23:381-383.
- 1926 Collings, M.R. (ID=1934, CIT=13)
"A study of the cutaneous reddening and swelling about the genitalia of the monkey, *Macacus rhesus*." Anat. Rec. 33:271-287.
- 1926 ***Hartman, Carl G. (ID=20156, CIT=11)
"Polynuclear ova and polyovular follicles in the opossum and other mammals with special reference to the problem of fecundity." Amer. J. Anat. 37:1- .
- 1927 Allen, E. (ID=1836, CIT=70)
"The menstrual cycle of the monkey, *Macacus rhesus*: observations on normal animals, the effects of removal of the ovaries and the effects of injections of ovarian and placental extracts into the spayed animals." Contr. Embryol. Carneg. Instn. 19:1-44.
- 1927 Corner, G.W. (ID=1799, CIT=16)
"The relation between menstruation and ovulation in the monkey: its possible significance for man." J. Amer. Med. Ass. 89:1838-1840.
- 1928 Allen, E. (ID=1886, CIT=14)
"Reactions of immature monkeys to injections of ovarian hormone, *Macacus rhesus*." J. Morph. 46: 79-519.
- 1928 Allen, E. (ID=1838, CIT=15)
"Further experiments with an ovarian hormone in the ovariectomized adult monkey, *Macacus rhesus*, especially the degenerative phase of the experimental menstrual cycle." Amer. J. Anat. 42:467-487.
- 1928 Bingham, H.C. (ID=2003, CIT=20)
"Sex development in apes." Comp. Psychol. Monogr. 5(23).
- 1928 Hartman, C.G. (ID=1967, CIT=24)
"The period of gestation in the monkey, *Macacus rhesus*, first description of parturition in monkeys, size and behavior of the young." J. Mammal. 9:181-194.
- 1928 Hartman, C.G. (ID=1968, CIT=10)
"Gestation in a monkey, *Macacus rhesus*, and associated phenomena." Amer. J. Obstet. Gynec. 15:534-540.
- 1928 Joachimovitz, R. (ID=1819, CIT=17)
"Studien zu Menstruation, Ovulation, Aufbau und Pathologie des weiblichen Genitales bei Mensch und Affe (*Pithecus fascicularis mordax*)." Biol. Gen. 4:447-540.
- 1928 Miller, G.S., Jr. (ID=2009, CIT=10)
"Some elements of sexual behavior in primates and their possible influence on the beginnings of human social development." J. Mammal. 9:273-293.

- 1929 Fox, H. (ID=1963, CIT=21)
"The birth of two anthropoid apes." J. Mammal. 10:37-51.
- 1929 Schultz, A.H. (ID=2553, CIT=10)
"The technique of measuring the outer body of human fetuses and of primates in general." Contr. Embryol. Carnegie. Instn. 20:213-257.
- 1929 Wislocki, G.B. (ID=2064, CIT=16)
"On the placentation of primates, with a consideration of the phylogeny of the placenta." Contr. Embryol. Carnegie. Instn. 20:51-80.
- 1930 Spiegel, A. (ID=1983, CIT=12)
"Beobachtungen über den Sexualzyklus, die Gravidität und die Geburt bei Javanakaken. (*Macaca irus mordax* Thomas and Wroughton [*lynceolagus* L.])." Arch. Gynaec. 142:561-591.
- 1930 Zuckerman, S. (ID=2570, CIT=48)
"The menstrual cycle of the primates--Part I--General nature and homology." Proc. Zool. Soc. Lond 691-754.
- 1931 Hartman, C.G. (ID=1994, CIT=21)
"The breeding season in monkeys, with special reference to *Pithecus Macacus rhesus*." J. Mammal. 12:129-142.
- 1931 Parkes, A.S. and S. Zuckerman (ID=1859, CIT=21)
"The menstrual cycle of the primates--Part II--Some effects of oestrin on baboons and macaques." J. Anat. 65:272-276.
- 1931 Zuckerman, S. (ID=25713, CIT=20)
"The menstrual cycle of the primates--Part III--The alleged breeding season of primates with special reference to the Chacma Baboon (*Papio porcarius*)." Proc. Zool. Soc. Lond 325- .
- 1932 Engle, E.T. (ID=1761, CIT=12)
"Uterine bleeding of the interval type in *Macacus* monkey during injections of extracts of pregnancy urine." Proc. Soc. Exp. Biol. 29:1224-1225.
- 1932 Gerard, P. (ID=2053, CIT=12)
"Etudes sur l'ovogenese et l'ontogenese chez les Lemuriens du genre *Galago*." Arch. Biol. 43:93-151.
- 1932 Hartman, C.G. (ID=1809, CIT=89)
"Studies in the reproduction of the monkey *Macacus* (*Pithecus*) *rhesus*, with special reference to menstruation and pregnancy." Contr. Embryol. Carnegie. Instn. 23:1-162.
- 1932 ***Hill, J.P. (ID=25023, CIT=36)
"The developmental history of the primates." Philosophical Transactions of the Royal Society of London, Series B 221:45-178.
- 1932 Saki, S. (ID=1760, CIT=12)
"Relation of the hypophysis and ovaries to experimentally induced bleeding in monkeys." Amer. J. Physiol. 100:8-20.
- 1932 Wislocki, G.B. (ID=2097, CIT=13)
"Placentation in the marmoset (*Oedipomidas geoffroyi*), with remarks on twinning in monkeys." Anat. Rec. 52:381-399.
- 1932 Zuckerman, S. and A.S. Parkes (ID=25720, CIT=23)
"The menstrual cycle of the primates--Part V--The cycle of the baboon." Proc. Zool. Soc. Lond 139-191.
- 1933 Hartman, C.G. (ID=1879, CIT=15)
"Pelvic (rectal) palpation of the female monkey, with special reference to the ascertainment of ovulation time." Amer. J. Obstet. Gynec. 26:600-608.
- 1933 ***Papanicolaou, George N. (ID=20198, CIT=11)
"The sexual cycle in the human female as revealed by vaginal smears." Amer. J. Anat. 52:519-616.
- 1933 Tinklepaugh, O.L. (ID=1825, CIT=21)
"Sex cycles and other cyclic phenomena in the chimpanzee during adolescence, maturity, and pregnancy." J. Morph. 54:521-547.
- 1933 Yerkes, R.M. (ID=2031, CIT=11)
"Genetic aspects of grooming, a social important primate behavior pattern." J. Soc. Psychol. 4:3-25.
- 1934 Carpenter, C.R. (ID=2299, CIT=34)
"A field study of the behavior and social relations of howling monkeys (*Alouatta palliata*)." Comp. Psychol. Monogr. 10:1-168.
- 1934 Zuckerman, S. and J.F. Fulton (ID=1947, CIT=11)
"The menstrual cycle of the primates--Part VII--The sexual skin of the chimpanzee." J. Anat. 69:38-46.
- 1935 Ball, Josephine and C.G. Hartman (ID=2001, CIT=32)
"Sexual excitability as related to the menstrual cycle in monkey." Amer. J. Obstet. Gynaec. 29:117-119.
- 1935 Carpenter, C.R. (ID=2301, CIT=20)
"Behavior of red spider monkeys in Panama." J. Mammal. 16:171-180.
- 1935 Corner, G.W. (ID=1842, CIT=11)
"Influence of the ovarian hormones, oestrin and progesterin, upon the menstrual cycle of the monkey." Amer. J. Physiol. 113:238-250.

- 1935 Davis, M.F. and C.G. Hartman (ID=1922, CIT=11)
"Changes in vaginal epithelium during pregnancy in relation to the vaginal cycle." J. Amer. Med. Ass. 104:279-285.
- 1935 Engle, E.T. and P.F. Smith (ID=1900, CIT=14)
"Some uterine effects obtained in female monkeys during continued oestrin administration, with especial reference to the cervix uteri." Anat. Rec. 61:471-483.
- 1935 Engle, E.T., P.F. Smith, and M.C. Shelesnyak (ID=1848, CIT=11)
"The role of estrin and progesterin in experimental menstruation, with especial reference to the complete ovulatory cycle in monkeys and human beings." Amer. J. Obstet. Gynec. 29:787-797.
- 1935 Fitzgerald, Alice (ID=3460, CIT=13)
"Rearing marmosets in captivity." J. Mammal. 16:181-188.
- 1935 Gillman, J. (ID=1937, CIT=10)
"The cyclical changes in the external genital organs of the baboon (*P. porcarius*)." S. Afr. J. Sci. 32:342-355.
- 1935 Hertig, A.T. (ID=2078, CIT=12)
"Angiogenesis in the early human chorion and in the primary placenta of the macaque monkey." Contr. Embryol. Carneg. Instn. 25:37-82.
- 1935 Hisaw, F.L. (ID=1902, CIT=17)
"The physiology of menstruation in *Macacus rhesus* monkeys." Amer. J. Obstet. Gynec. 29:638-659.
- 1935 ***Schultz, Adolph H. (ID=20630, CIT=11)
"Eruption and decay of the permanent teeth in primates." Amer. J. Phys. Anthrop. 19:489-581.
- 1935 Schultz, A.H. and F.E. Snyder (ID=22202, CIT=18)
"Observations on reproduction in the chimpanzee." Bull. of the Johns Hopkins Hospital 57: 193-205.
- 1935 Zuckerman, S. (ID=1991, CIT=15)
"The Aschheim-Zondek diagnosis of pregnancy in the chimpanzee." Amer. J. Physiol. 110:597-601.
- 1936 Corner, G.W., G.W. Bartelmez, and C.G. Hartman (ID=2202, CIT=17)
"On normal and aberrant corpora lutea of the rhesus monkey." Amer. J. Anat. 59:433-457.
- 1936 Daron, G.H. (ID=1898, CIT=16)
"The arterial pattern of the tunica mucosa of the uterus in *Macacus rhesus*." Amer. J. Anat. 58:349-419.
- 1936 van Dyke, H.B. and G. Ch'en (ID=1923, CIT=10)
"Observations on the biochemistry of the genital tract of the female macaque particularly during the menstrual cycle." Amer. J. Anta. 58:473-499.
- 1936 Elder, J.H. and R.M. Yerkes (ID=1801, CIT=29)
"The sexual cycle of the chimpanzee." Anat. Rec. 67:119-143.
- 1936 Yerkes, R.M. and J.H. Elder (ID=1828, CIT=14)
"The sexual and reproductive cycles of chimpanzee." Proc. Nat. Acad. Sci. 22:276-283.
- 1936 Wislocki, G.B. (ID=2234, CIT=15)
"The external genitalia of the simian primates." Hum. Biol. 8:309-347.
- 1936 Yerkes, R.M. and J.H. Elder (ID=1829, CIT=20)
"Oestrus, receptivity, and mating in chimpanzee." Comp. Psychol. Monogr. 13(5):39.
- 1937 Hamlett, G.W.D. (ID=1964, CIT=14)
"Positive Friedman tests in the pregnant rhesus monkey, *Macaca mulatta*." Amer. J. Physiol. 118:664-668.
- 1937 ***Hosman, Harland (ID=22533, CIT=20)
"Comparative morphogenesis of the fetal membranes and accessory uterine structures." Contr. Embryol. Carneg. Instn. 26:129-246.
- 1937 Schultz, A.H. (ID=2146, CIT=12)
"Fetal growth and development of the rhesus monkey." Contr. Embryol. Carneg. Instn. 26:71-97.
- 1937 Zuckerman, S. (ID=25705, CIT=13)
"The duration and phases of the menstrual cycle in primates." Proc. Zool. Soc. Lond 315-325.
- 1938 Elder, J.H. (ID=1876, CIT=13)
"The time of ovulation in chimpanzees." Yale J. Biol. Med. 10:347-364.
- 1938 Wislocki, G.B. and G.L. Streeter (ID=2090, CIT=47)
"On the placentation of the macaque (*Macaca mulatta*), from the time of implantation until the formation of the definitive placenta." Contr. Embryol. Carneg. Instn. 27:1-66.
- 1939 Dempsey, E.W. (ID=2393, CIT=13)
"The reproductive cycle of New World monkeys." Amer. J. Anat. 64:381-405.
- 1939 Elder, J.H. and J.M. Bruhn (ID=2306, CIT=14)
"Use of the Friedman test for pregnancy with chimpanzees." Yale J. Biol. and Med. 12:155-160.
- 1939 Hartman, Carl G. (ID=22957, CIT=13)
"Studies on reproduction in the monkey and their bearing on gynecology and anthropology." Endocrinology 25:670-682.

DRAFT: NOT TO BE QUOTED WITHOUT PERMISSION

- 1939 Wislocki, George B. (ID=2297, CIT=15)
"Observations on twinning in marmosets." Am. J. Anat. 64:445-483.
- 1939 Yerkes, R.M. (ID=2303, CIT=10)
"Sexual behavior in the chimpanzee." Human Biol. 11:78-111.
- 1939 Yerkes, R.M. (ID=2304, CIT=10)
"Social dominance and sexual status in the chimpanzee." Quart. Rev. Biol. 14:115-136.
- 1940 Carpenter, C.R. (ID=22392, CIT=17)
"A field study of Siam of the behavior and social relations of the Gibbon." Comp. Psychol. Monogr. 16:1-212.
- 1940 Lowther, F. de L. (ID=1501, CIT=19)
"A study of the activities of a pair of Galago senegalensis moholi in captivity, including the birth and postnatal development of twins." Zoologica 25:433-462.
- 1940 Markee, J.E. (ID=1429, CIT=18)
"Menstruation in intraocular endometrial transplants in the rhesus monkey." Contr. Embryol. Carneg. Instn. 28:219-308.
- 1940 Marker, R.E. and C.G. Hartman (ID=1363, CIT=12)
"Assays of urine from rhesus monkeys for pregnanediol and other steroids." J. Biol. Chem. 133:529-537.
- 1941 Dorfman, R.I. and G. van Wagenen (ID=1400, CIT=16)
"The sex hormone excretion of adult female and pregnant monkeys." Surg. Gynec. Obstet. 73:545-548.
- 1941 Hartman, C.F. and G. W. Corner (ID=1243, CIT=10)
"The first maturation division of the macaque ovum." Contr. Embryol. Carneg. Instn. 29:1-6.
- 1941 Heuser, C.H., and G.L. Streeter (ID=1283, CIT=37)
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