Digitized by the Internet Archive
in 2009 with funding from
Ontario Council of University Libraries

http://www.archive.org/details/anatomicalrecord02bard

THE ANATOMICAL RECORD

EDITORIAL BOARD

IRVING HARDESTY
University of California

G. CARL HUBER
University of Michigan

CLARENCE M. JACKSON
University of Missouri

HORACE JAYNE
The Wistar Institute

THOMAS G. LEE
University of Minnesota

FREDERICK T. LEWIS
Howard University

WARREN H. LEWIS
Johns Hopkins University

CHARLES F. W. McCLURE
Princeton University

FLORENCE R. SABIN
Johns Hopkins University

GEORGE L. STREETER
University of Michigan

VOLUME II

1908

PHILADELPHIA
THE WISTAR INSTITUTE OF ANATOMY AND BIOLOGY

QL
801
A45
v. 2
Cop. 3

CONTENTS OF VOL. II.

NOS. 1 AND 2—MAY, 1908.

BOOK REVIEWS.

NOTES.

NO. 3—JUNE, 1908.

INDEX TO VOL. II.

THE ANATOMICAL RECORD

Vol. II. MAY, 1908. Nos. 1 and 2

SYMPOSIUM ON THE DEVELOPMENT AND STRUCTURE OF THE LYMPHATIC SYSTEM.*

I.

The Anatomy and Development of the Jugular Lymph Sacs in the Domestic Cat (Felis Domestica).

BY

GEORGE S. HUNTINGTON AND CHARLES F. W. McCLURE.

From the Anatomical Laboratory of Columbia University and the Biological Laboratory of Princeton University.

With 17 Figures.

Prior to the meeting in 1907 the writers made an extensive study of the development of the veins of the cat in order to explain from an embryological standpoint the large series of venous abnormalities which had been collected by them in the preceding years. In the course of this investigation they were impressed by the circumstance that the main lymphatic channels not only developed in close relation to the veins, but also observed, as did Lewis in the rabbit, that many of the embryonic veins appeared to be actually replaced by lymphatics in the later stages of development. A marked reciprocal relationship also appeared to exist between certain embryonic venous channels undergoing atrophy and the developing lymphatics, in the sense that as these venous channels gradually atrophied spaces were formed outside their intima which, subsequently, through fusion and growth, invaded the territory, wholly or in part, formerly occupied by the veins. On account of this reciprocal relationship between veins and lymphatics the writers[1] advanced the view, at the meeting in 1907, that the main lymphatic channels of the cat begin as extra-intimal spaces along the course of

* The following nine papers were read at the twenty-third session of the Association of American Anatomists, Chicago, January 1, 2 and 3, 1908.

[1] American Journal of Anatomy, Vol. VI, 1907.

embryonic veins and that these spaces were not to be confounded with the mesenchymal spaces of Sala,[2] since they develop in and, after becoming confluent with each other, take up, wholly or in part, the territory formerly occupied by the veins. The sinistral position assumed in the adult by the main lymphatic drainage canal, the thoracic duct, was therefore attributed by the writers to the circumstance that the embryonic veins of the left side undergo a more extensive atrophy than those of the right.

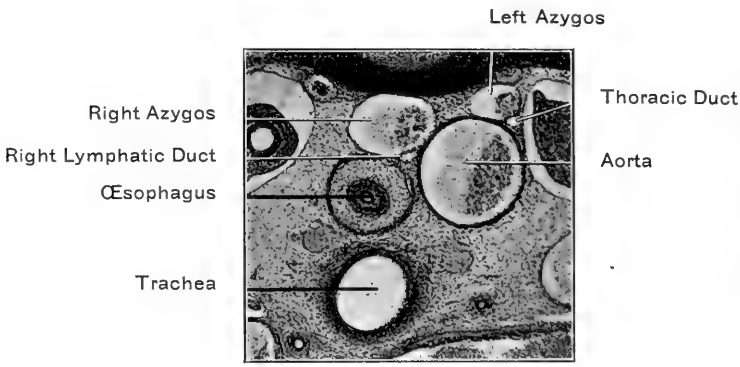


FIG. 1

Two of the many examples which might be cited in favor of the reciprocal relationship which exists between the developing lymphatics and embryonic veins which are undergoing atrophy are the relations which the right lymphatic and thoracic ducts bear to the thoracic azygos (supracardinal)[3] veins during the different stages of development, as well as the history of the partial atrophy of the postrenal division of the left supracardinal vein and its replacement by a lymphatic.

Fig. 1 represents a section taken through the anterior thoracic region of a 16 mm. cat embryo in which both azygos veins are of large

[2]Richerche n. lab. di anat. norm. d. r. Univ. di Roma, Vol. VII, 1900.

[3]Huntington and McClure, Amer. Jour. of Anat., Vol. VI, 1907. "A bilateral and originally symmetrical venous channel develops dorso-medial to the primitive postcardinal vein by longitudinal anastomoses between somatic postcardinal tributaries. This secondary vein channel forms what we have termed the supracardinal system of veins. It extends from the level at which the posterior limb veins open into the postcardinals to a point cephalad where it joins that portion of the postcardinals which alone persists to form the anterior end of the adult Azygos. Between these levels the supracardinal veins enter into the definite organization of both the adult post-cava in its

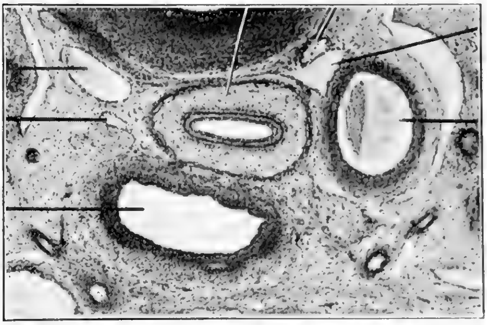


FIG. 2

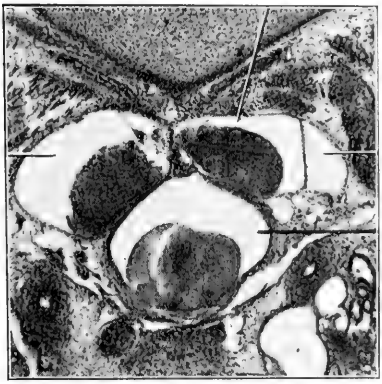


FIG. 3

size and in which the right lymphatic and thoracic ducts are small and lie in close contact with, but outside the intima of the veins. In a more advanced embryo (25 mm., Fig. 2), in a section taken through

postrenal division and of the Azygos in its lumbar and part of its thoracic segments, entirely replacing in these districts the primitive postcardinal veins. It is important to note that in our interpretation the supracardinal veins are not in any sense merely synonyms for the dorsal limb of the peri-ureteric ring described by Hochstetter and others as surmised in the discussion following the presentation of our paper, but comprise a continuous and morphologically uniform system of longitudinal vein channels contributing, as above outlined, to the establishment of the adult condition in both the post caval and in the azygos areas."

the same region, the left azygos vein is much smaller than the right, since it has already undergone atrophy in correlation with the establishment of a permanent right-sided azygos termination. In comparing these two stages it is seen that the thoracic duct is much larger than the right lymphatic duct in the 25 mm. embryo and that it actually

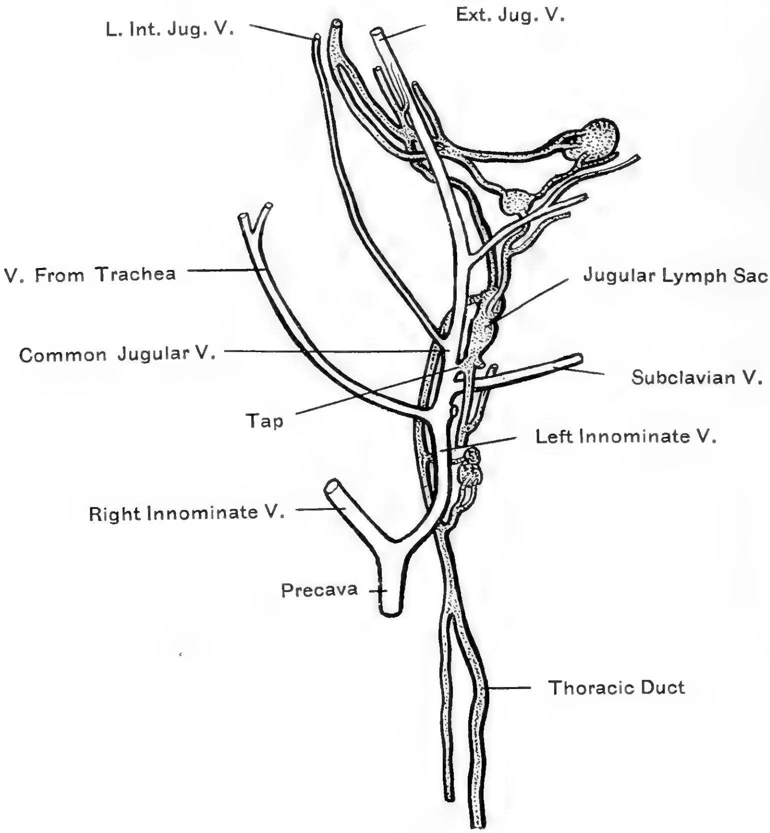


FIG. 4

encroaches upon the space formerly occupied by the now almost atrophied left azygos vein, although it still retains the same extra-intimal position with respect to the vein as in the 16 mm. embryo.

In correlation with the atrophy of the ureteric ring portion of the left supracardinal vein, since the vein of the right side, for the most part, persists as the postrenal division of the adult postcava, well defined and clear-cut spaces are frequently met with which occupy a part of the territory formerly occupied by the vein, but which are completely separated from the latter by a partition. These spaces, which are very prominent in a 35 mm. embryo (Fig. 3), are without doubt lymphatic in character, since they are continuous forward with the thoracic duct.

Although we were and are still convinced that the principle of replacement of certain embryonic venous channels by lymphatics is cor-

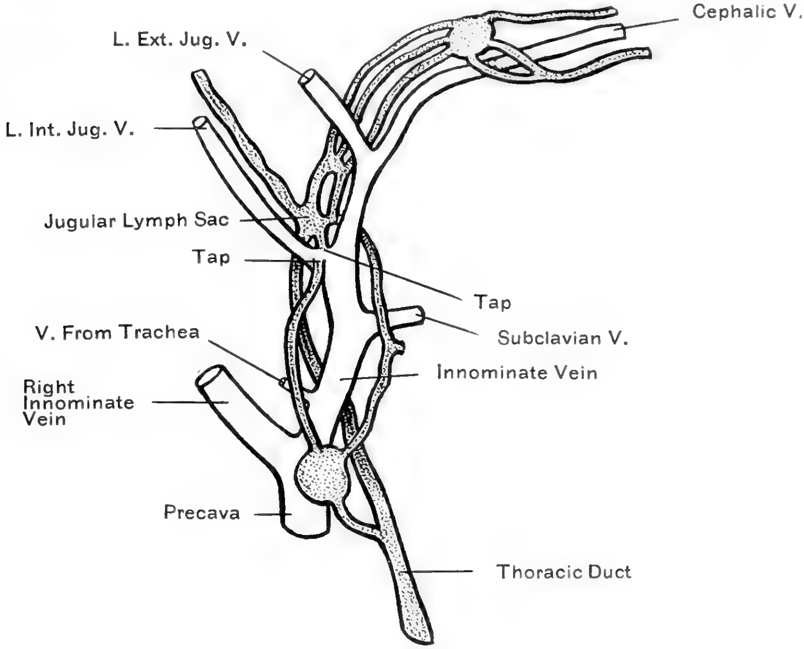


FIG. 5

rect, we were not prepared at the time of the meeting of 1907 to show conclusively that in some cases this replacement may not have been of a secondary character and that these extra-intimal spaces may not have been derived primarily from the veins. Since this meeting, however, we have made a detailed investigation of the development of the jugular lymph sacs of the cat and, so far as these elements of the lymphatic system are concerned, have proved conclusively, to our own satisfaction, that they are derived from the veins. On the other hand, as far as our observations extend, we have been unable to find any valid evidence, in the sense in which the jugular lymph sacs are developed, regarding the venous origin of the lymph spaces and lymph vessels which are formed independently of the jugular lymph sacs and, since a proper interpretation of these spaces and vessels gives the keynote to the correct ontogenetic conception of the lymphatic system as a whole, it may be fairly stated that their genesis requires a most careful investigation.

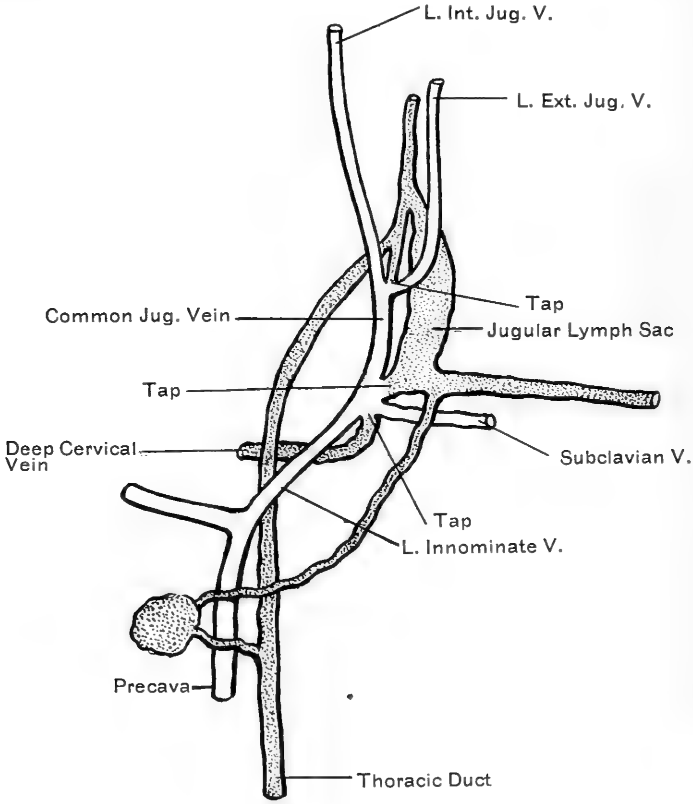


FIG. 6

3. The thoracic duct, in common with anterior end of the jugular lymph sac, may open into the veins at the point of confluence of the external and internal jugulars and, in addition to this, the posterior end of the lymph sac may also open into the veins at the common jugulo-subclavian junction, as in 1. In this case the subclavian vein may also receive an independent lymphatic vessel from the deep cervical region (Fig. 6).

Erratum: The paragraph at the bottom of page 6: "3. The thoracic duct, etc.," should follow the paragraph on page 7, beginning: "2. The lymph sac may be rudimentary."

The Lymphatico-Venous Connections in the Adult Cat.

The thoracic duct of the adult cat has been described by Reighard and Jennings[4] as opening into the left external jugular vein at its junction with the subclavian. An examination of a number of adult cats has shown us that considerable variation may exist on the left side regarding the connection between the venous and lymphatic systems, as follows:

1. The thoracic duct may open into the anterior end of the jugular lymph sac, while the latter opens into the common jugular vein at its point of confluence with the subclavian (Fig. 4).

2. The lymph sac may be rudimentary and, after receiving the thoracic duct, open into the veins at the point of confluence of the external and internal jugulars. A lymph vessel from the thymus region may also open into the veins at the same point. The external and internal jugular veins are in this case about subequal in size (Fig. 5).

The Development of the Jugular Lymph Sacs in the Cat. (Anterior Lymph Hearts of Sabin.)

So far as known to the writers, Sabin[5] and Lewis[6] are the only investigators who have thus far studied the development of the jugular lymph sacs in mammals.

In all of the papers thus far published by Sabin she maintains that the principle involved in the development of the mammalian lymphatic system (pig) is that of continuous centrifugal growth of lymphatic ducts from four primary venous centers which bud off from the veins in the neck and inguinal regions. The anterior pair of buds constitute the anlages of the jugular lymph sacs or hearts, and in her estimation these sacs retain from the beginning their primary connections with the veins.

Lewis, who studied the development of the lymphatics in the rabbit, states that they arise not by four but by several venous outgrowths which become detached from the venous system and, after uniting with one another to form a continuous system, acquire new and permanent openings into the veins near the subclavian termination. Although

[4]Anatomy of the Cat (p. 331).
[5]American Jour. of Anat., Vol. I, 1902; Vol. III, 1904; Vol. IV, 1904.
[6]American Jour. of Anat., Vol. V, 1905.

Lewis did not describe in detail the actual derivation of the venous outgrowths which enter into the formation of the jugular lymph sacs, he is undoubtedly correct in principle and should receive full credit for his careful observations.

The present investigation is based upon the study of serial sections and a very complete series of wax reconstructions of the venous and lymphatic systems made after the method of Born. A complete series of these reconstructions was exhibited at the meeting held at Chicago in 1908.

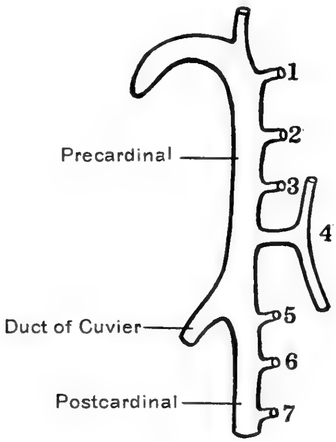


FIG. 7

Figs. 7 to 13, inclusive, are a series of semi-diagrammatic figures which illustrate the development of the jugular lymph sac of the left side, but answer as well for the sac of the opposite side, since it is developed in exactly the same manner. The stippled area indicated on the figures (Figs. 7 to 11, inclusive) represents the portion of the venous system which is subsequently split off from the main venous channels and which becomes transformed, through growth and fusion and after the evacuation of its blood contents, into the definite jugular lymph sacs.

It may be stated at the beginning that the lymph sacs present a remarkable variation as regards the details of their development, not only in different embryos of the same stage, but even upon opposite sides of the same embryo. It will therefore be necessary in this brief outline to give a more or less composite description of the conditions which may prevail at any given stage rather than those which invariably exist.

The primary principle underlying the development of the jugular lymph sacs in the cat is the separation of parallel venous channels from the embryonic veins by a process of fenestration, and the subsequent conversion of these channels into the definite lymph sacs by a process of growth and fusion.

In a 5-6 mm. embryo the process of fenestration is, as a rule, not yet evident (Fig. 7). Four fairly constant tributaries open into the dorsomedial surface of the precardinal (1 to 4) which are serially continuous with the segmentally arranged tributaries which open into the dorsomedial surface of the postcardinal vein.

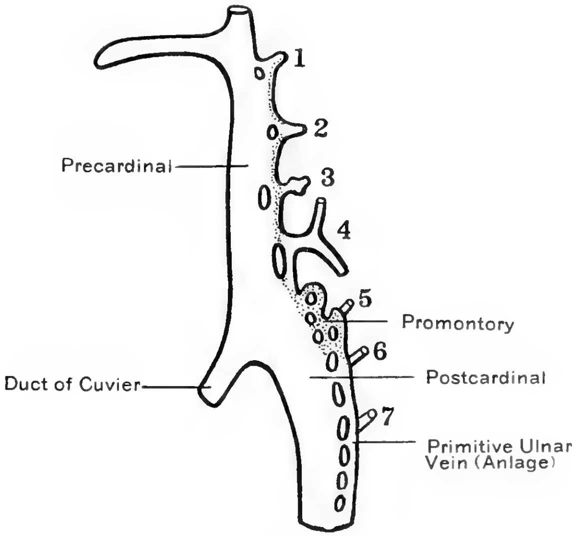


FIG. 8

In a 6.5 mm. embryo the process of fenestration is usually well advanced (Fig. 8). The fenestræ have formed along the dorsolateral surface of the postcardinal vein and are continuous forward with a similar series formed along the precardinal. The portion of the postcardinal vein involved in this process of fenestration is raised into a well-defined ridge which now projects slightly forward, in the region of the duct of Cuvier, over the precardinal vein. It is from this anterior projection of the postcardinal vein, which may be termed the "jugular promontory," that the anlages of the jugular lymph sacs are, for the most part, developed. The process of fenestration which extends along the postcardinal vein, including the promontory, does not, at this or at any subsequent stage, involve the segmentally arranged tributaries which open into the postcardinal. This is not always the case, however, with the precardinal tributaries. The fourth precardinal tributary (4, Fig. 8) may become separated from the precardinal by a process of fenestration and subsequently open into the promontory, where it forms the first of the well defined segmentally arranged series of postcardinal tributaries (Fig. 9). The remaining three tributaries of the precardinal may or may not be involved in the process of fenestration. In the former case, as represented in Figs. 9 and 10, they subsequently enter into the formation of the jugular lymph sacs, while in the latter case they apparently do not. Being connected with the anterior segment of the precardinal which may (Fig. 5) or may not be (Fig. 4) transformed into a vein of importance in the adult, the fate of the precardinal tributaries is correspondingly uncertain. The anlage of the

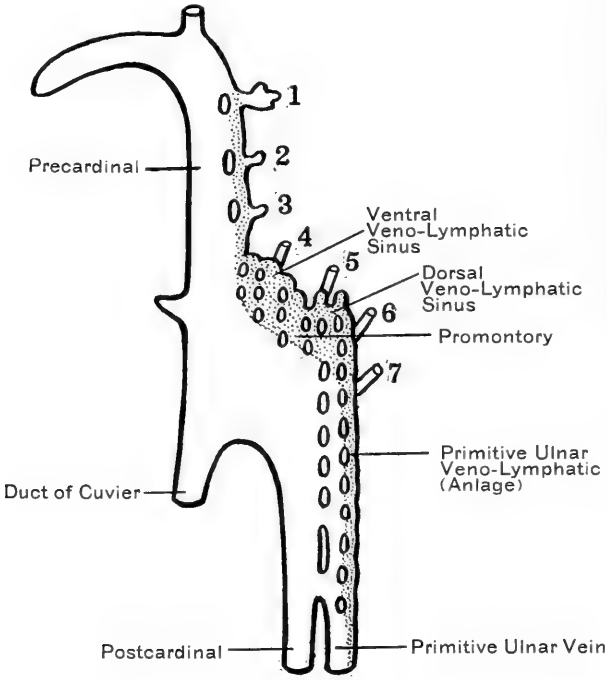


FIG. 9

primitive ulnar vein is already established in the 6.5 mm. embryo, but has not yet split off from the main postcardinal channel.

In a 7 mm. embryo (Fig. 9) the promontory has increased in size and the process of fenestration correspondingly more extensively developed than in the preceding stage. The two projections which extend forward from the promontory over the precardinal constitute, respect-

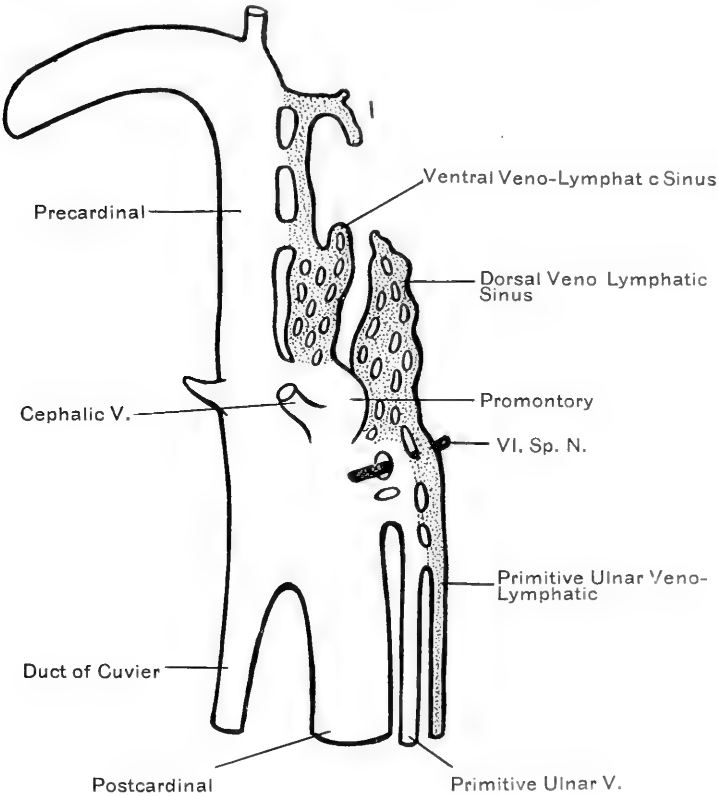


FIG. 10

ively, the dorsal and ventral divisions of the *veno-lymphatic sinuses,* a term which we have applied, for descriptive purposes, to all of the venous derivatives which subsequently enter into the formation of the definite lymph sacs, before they get rid of their blood and become separated from the main venous channels. The fourth segmental tributary of the precardinal has given up its connection with the latter vein and now forms the most anterior or first segmental tributary of the postcardinal vein, as already described in connection with the 6.5 mm. embryo. The primitive ulnar vein has already begun to split off from the postcardinal vein, from behind forward, as a result of a confluence between the fenestræ which were formed between it and the main channel of the postcardinal vein. A new vessel which will subsequently be involved in the lymphatic system is also beginning to be split off from the primitive ulnar vein by a similar process of fenestration (anlage of the primitive ulnar lymphatic, Figs. 9, 10, 11, 12 and 13).

In an 8.5 embryo (Fig. 10) the dorsal and ventral divisions of the veno-lymphatic sinuses extend for some distance in front of the promontory and are distinctly separated from each other. This separation has probably been brought about as the result of a confluence between the fenestræ in the promontory. The dorsal division of the veno-lymphatic sinus now opens into the dorsolateral surface of the promontory in common with the primitive ulnar vein by means of a single and much constricted opening. The primitive ulnar vein has, for the most part, been split off from the postcardinal except in the region of the promontory, where two fenestræ are still retained, through one of which the sixth spinal nerve passes. The primitive ulnar veno-lymphatic sinus has also undergone a partial separation from the primitive ulnar vein, but still retains its connections in front with the postcardinal vein, as well as with the dorsal veno-lymphatic sinus. The ventral veno-lymphatic sinus may connect directly with the face of the promontory by means of a broad opening as in Fig. 10, or, by means of a much constricted opening, with the lateral surface of the promontory, contiguous to the latter's point of confluence with the cephalic vein. This ventral sinus may also connect anteriorly with the venous elements which have been split off from the precardinal vein.

The 10.5 mm. embryo (Fig. 11) is distinguished from that of the preceding stage, chiefly by the circumstance that the dorsal veno-lymphatic sinus has grown forward, dorsal to the precardinal vein, where it frequently makes a secondary connection with the venous system by anastomosing with one of the dorsal tributaries of the precardinal vein. This secondary connection with the precardinal vein often becomes much enlarged and, when such is the case, the sinus may give up its primary conection with the promontory. The ventral veno-lymphatic sinus now fuses with the dorsal sinus caudally, but no longer opens into the precardinal vein. It still retains, however, a narrow connection with the lateral surface of the promontory contiguous to the point where the latter receives the cephalic vein. The ventral veno-lymphatic sinus, although quite variable in form, is more or less sac-like at this stage and lies upon the lateral as well as upon the dorsal surface of the precardinal vein. The primitive ulnar vein and its veno-lymphatic

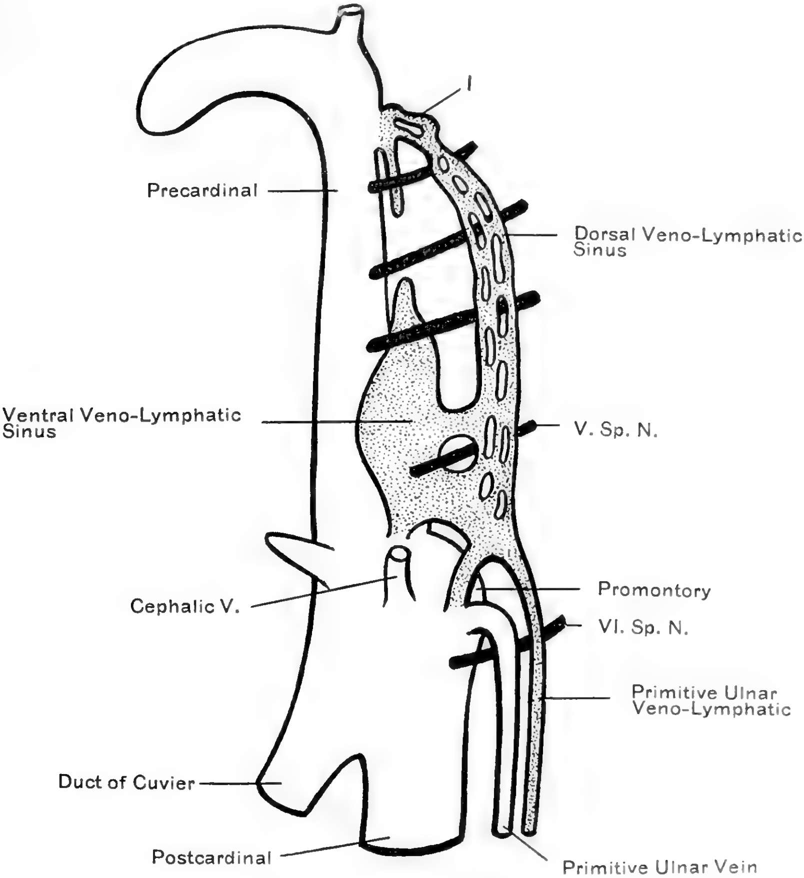


FIG. 11

derivative are entirely separated from each other. The former opens into the dorsolateral surface of the promontory, while the latter is directly continuous with the dorsal division of the veno-lymphatic sinus.

The relations which the nerves bear to the veno-lymphatic sinuses in the 10.5 mm. embryo (Fig. 11) are worthy of mention, since essentially

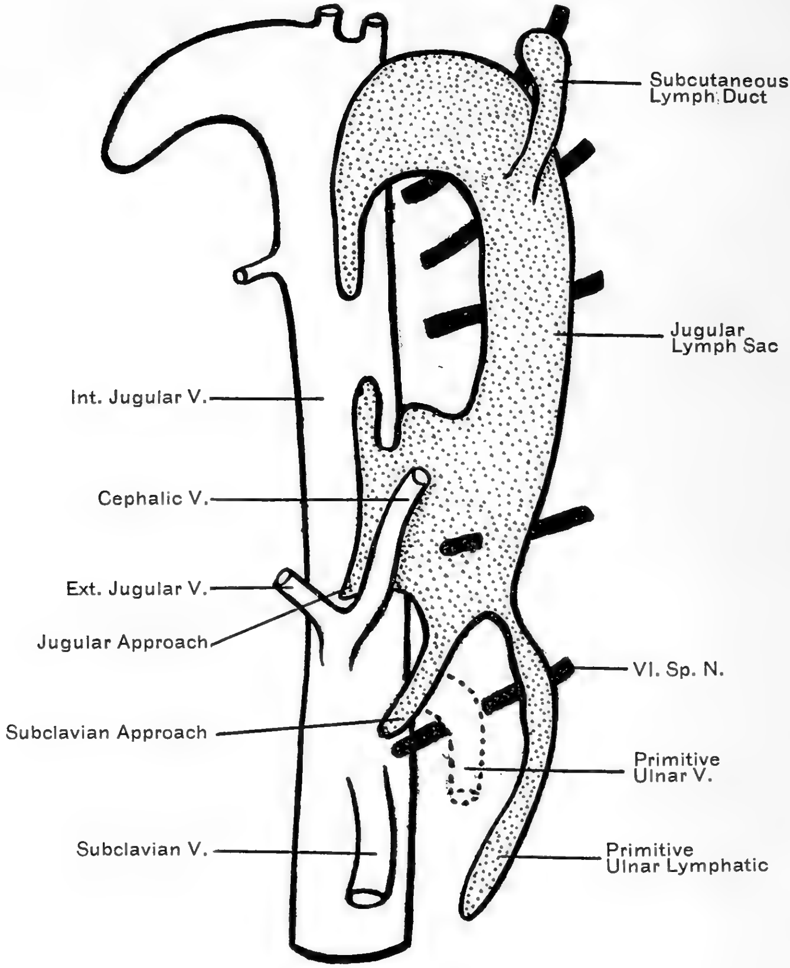


FIG. 12

the same relations are maintained in later stages after the veno-lymphatic sinuses have been converted into the definite jugular lymph sacs. The second, third and fourth spinal nerves pass laterad between the two veno-lymphatic sinuses, while the fifth may either penetrate the dorsal sinus or, as represented in Fig. 11, may pass through a foramen formed between the two.

The subsequent development of the veno-lymphatic sinuses, in stages more advanced than that last described, consists, as far as we can deter-

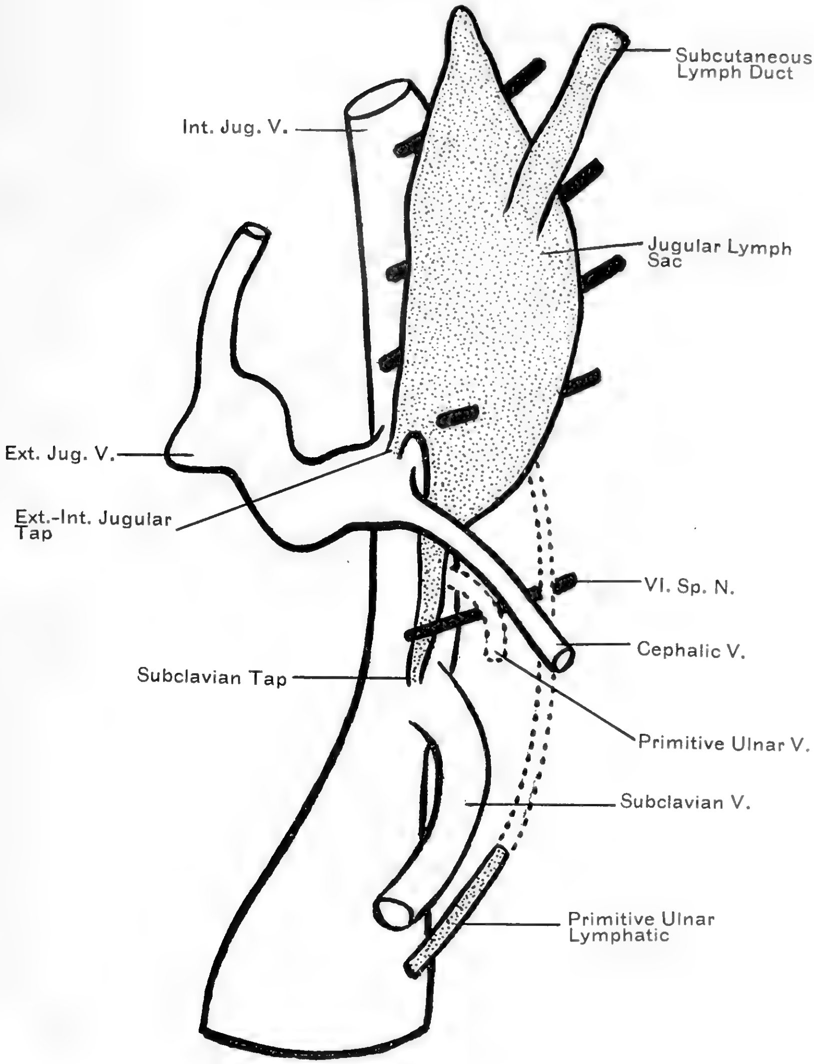


FIG. 13

mine, of a further fusion between them to form a single sac, of an evacuation of their blood contents and, finally, of their complete separation from the venous system. When these changes have taken place, one can speak of these sacs thus formed as belonging to the definite lymphatic organization, although, practically, the only distinction that can be made in early stages (10.5 mm. embryo) between the veno-lymphatic sinuses and the definite lymphatic sac, is that one contains blood corpuscles and functions as a vein, while the other does not.

The evacuation of the blood from the veno-lymphatic sinuses appears to take place at a time when the embryos measure between 10.5 and 11.5 mm. in length. The process of evacuation is very rapid and the veno-lymphatics of the left side usually lose their blood before those of the right.

In a 10.7 mm.[7] embryo, which is represented by Fig. 12, the evacuation process has taken place and a complete separation apparently established between the veins and, what may now be termed, the jugular lymph sac. The jugular lymph sac is also quite compact in form and possesses a complicated multilocular structure. Also, although at this stage there is no observable connection between the lymph sac and the veins, the sac sends out two processes which approach and almost reach the two points at which the lymph sac often connects with the veins in the adult (Fig. 6).

These two points appear to correspond, respectively, to those at which at an earlier stage the dorsal and ventral veno-lymphatic sinuses opened into the jugular promontory (compare Fig. 12 with Figs. 10, 11 and 13) and, in view of this relation, it may be regarded as still open to question whether the lymph sac ever separates from the veins at these two primary points of connection except in those cases in which only one connection is destined to persist in the adult (Figs. 4 and 5). If a continuity exists throughout development, it is evident from our observations that the character of the connection in the 10.7 and 11 mm. embryos differs widely from that in the earlier and later stages in which its appearance is typical, unmistakable and most easily identified.

A number of other important changes have taken place in the 10.7 mm. embryo. The promontory has entirely disappeared, probably in correlation with an elongation of the vein in this region. The primitive ulnar vein has also given up its primary point of connection with the venous system and the primitive ulnar lymphatic which was derived

[7]The reconstruction from which Fig. 12 was drawn was made of an embryo belonging to the Harvard Embryological Collection (Series 474, 10.7 mm. embryo), and we take this opportunity of thanking Professor Minot for his courtesy in placing this as well as several other series of embryos at our disposal.

from the primitive ulnar vein can be traced from the jugular lymph sac into the fore-limb, where it follows the course of the veins. The subcutaneous lymph duct, which is extensively developed in older embryos, now opens laterally into the jugular lymph sac.

In the 16 mm. embryo (Fig. 13), in which, so far as the jugular lymph sac is concerned, the adult condition has practically been reached, the sac has become, through growth and fusion, still more compact and sac-like than in the preceding stages. It now connects (secondarily?) with the venous system usually at two points, as is frequently the case in the adult (Fig. 6), namely, at the junction of the external and internal jugular veins and at the subclavio-common jugular junction. Each opening into the venous system is guarded by a typically con-

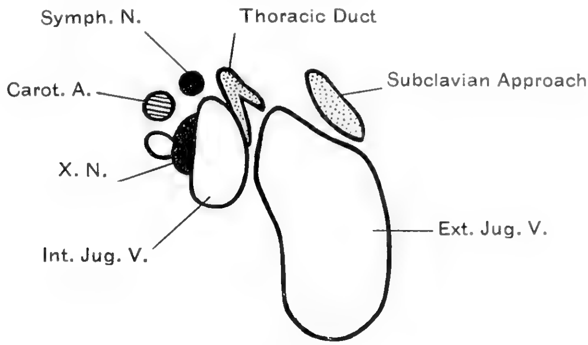


FIG. 14

structed ring valve, the character of which is illustrated by a series of camera drawings which were made of the region just preceding, as well as through the external-internal jugular tap in a 16 mm. embryo (Fig. 14, Section 234; Figs. 15, Section 237; Fig. 16, Section 240, and Fig. 17, Section 241).

Finally, with slight differences due to fusion as well as to a further expansion of the jugular lymph sac, the spinal nerves retain the same relations to the sac as in the 10.7 mm. embryo (Fig. 12). The primitive ulnar lymphatic appears to have given up its connection with the jugular lymph sac in the 16 mm. embryo, but can still be followed in the fore-limb, where it may possibly be retained in the adult as a functional vessel, although we have not been able to determine definitely that such is the case.

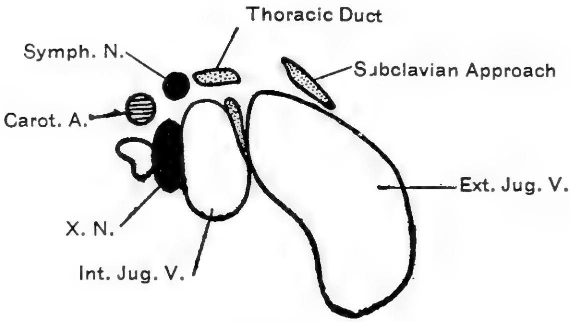


FIG. 15

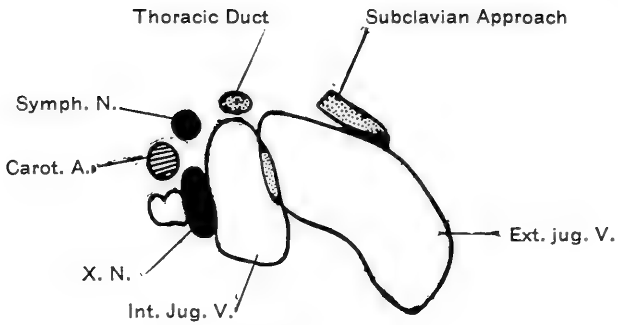


FIG. 16

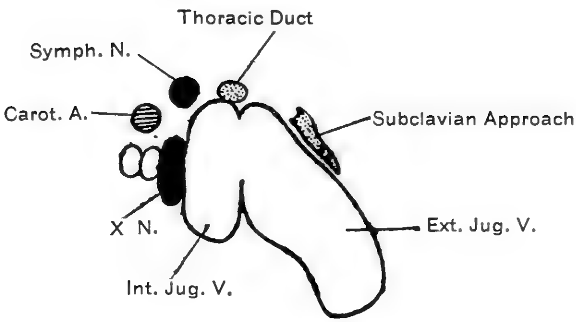


FIG. 17

II.

The Genetic Interpretation of the Development of the Mammalian Lymphatic System.

BY

GEORGE S. HUNTINGTON

From the Anatomical Laboratory of Columbia University.

With Ten Figures.

Modern investigations of the development of the mammalian lymphatic system have led different observers to agree on certain main facts, while in other important details these researches have produced more or less radically divergent views as to the primary derivation of the main lymphatic vessels of the adult.

The chief contributions to this subject in recent years have been made by Sabin,[1] of Johns Hopkins University; by Lewis,[2] of Harvard University, and by McClure, of Princeton University, and myself jointly.[3] These papers deal with lymphatic development in the mammalian embryo, Sabin working on the pig, Lewis chiefly on rabbits, Huntington and McClure on the cat.

Of contributions which have appeared within the decade dealing with the development of the lymphatic system in vertebrates other than mammalia, the important paper of Sala[4] is to be especially noted, in which he describes the development of the lymphatic hearts and the

[1]Florence R. Sabin. "On the Origin of the Lymphatic System from the Veins, and the Development of the Lymph Hearts and Thoracic Duct in the Pig," Am. Jour. of Anat., Vol. I. 1902, pp. 367-389; "On the Development of the Superficial Lymphatics in the Skin of the Pig," Am. Jour. of Anat., Vol. III, 1904, pp. 183-195; "The Development of the Lymphatic Nodes in the Pig and their Relation to the Lymph Hearts," Am. Jour. of Anat., Vol. IV, 1905, pp. 355-389.

[2]Frederick T. Lewis. "The Development of the Lymphatic System in Rabbits," Am. Jour. of Anat., Vol. V, 1905, pp. 95-111.

[3]George H. Huntington and C. F. W. McClure. "The Development of the Main Lymph Channels of the Cat in their Relations to the Venous System," Am. Jour. of Anat., Vol. VI, 1907. Abstract in ANAT. RECORD, Vol. I, pp. 36-41.

[4]Luigi Sala. "Ricerche fatte nel Laboratorio di Anatomia Normale della R. Università di Roma, Vol. VII, pp. 263-269, April, 1900.

thoracic ducts in the chick embryo. The main views regarding the general question of mammalian lymphatic development expressed by these writers may be summarized as follows:

1. Continuous centrifugal growth of the lymphatic system from a number of outgrowths or "buds," derived directly from the venous system and retaining from the beginning their primary connection with the veins. (Sabin.)

Professor Sabin regards the entire lymphatic system as arising from four (or more[5]) primary centers which arise as "out-buds" from the embryonal veins of the cervical and inguinal regions, pervade the entire body by a process of continuous growth toward the periphery, deriving their intimal lining from the venous endothelium, with which they remain in uninterrupted connection, and following the course of the blood channels, which precede them in invading new territory.

The anterior pair of buds form the jugular lymph sacs or anterior or cervical "lymph hearts." They retain from the beginning their primary connections with the veins, and these serve as the permanent portals of entry of the adult lymphatic into the venous system. Sabin's "posterior buds" or "posterior lymph hearts" must in later stages give up their connection with the veins of the inguinal region, since such connections no longer appear in the adult mammal.

2. Direct transformation of certain embryonal veins into permanent lymphatic channels. (Lewis.)

F. T. Lewis has supported the view that the lymphatic system is directly derived from the embryonal veins, multiple detached elements of the latter becoming confluent and establishing the permanent systemic lymphatics, which then make secondary connections with the permanent venous channels. This hypothesis regards the entire adult lymphatic system as directly derived from the embryonal venous channels, certain veins or portions thereof being directly transformed into definite lymphatic vessels.

3. McClure, of Princeton, and the writer jointly advanced the view, at the twenty-second session of the Association of American Anatomists, New York City, 1907, that the main systemic lymphatic trunks arise as independent spaces, situated without the intimal lining of the bilateral symmetrical redundant embryonal venous channels, and that

[5]Recent discussion during Lymphatic Symposium of Twenty-third Session Assoc. Am. Anat., Chicago, January 1-3, 1908. This number of the ANATOMICAL RECORD, page 46.

these spaces, forming by confluence the permanent chief lymphatic vessels of the adult, subsequently effect a secondary connection with the definite venous system. Our observations were made exclusively on embryos of the domestic cat and in close connection with a preceding exhaustive study of the development of the systemic veins in this form and of the venous variations encountered in a large series of adult animals. These studies revealed the correlations existing, both ontogenetically and in the adult, in the venous and lymphatic organization, and the mutual interdependence of these two vascular systems,[6] since embryonal venous channels, undergoing atrophy, afford the greater opportunity for the development of lymphatic trunks, which encroach on the territory formerly occupied exclusively by the embryonal veins of the earlier stages, or even entirely replace the latter. The developmental shifting of the primitive redundant embryonal venous system from the original bilateral symmetrical type to the dextro-venous condition of the adult, through the establishment of the innominate, azygos and iliac cross anastomoses, favors the sinistral development of the main lymphatic channels, which replace the atrophied left segments of the primitive bilateral symmetrical venous system of the earlier embryonal stages.

4. Sala's thorough work on the development of the lymphatic hearts and thoracic ducts in the chick, which will be analyzed more in detail presently, establishes in this bird the embryonal existence of a pair of posterior lymph hearts, developed directly from the lateral branches of the first five coccygeal veins. These lymph hearts subsequently make secondary connections with the general lymphatics of the body, formed by the confluence of independently developed spaces, "excavated in the mesenchyme." The lymphatic system, thus constituted from a double anlage, makes anteriorly secondary connections with the precaval veins, while the posterior lymph hearts retrograde shortly after the period of incubation is completed and disappear entirely during the first thirty or forty days of free life.

[6]G. S. Huntington and C. F. W. McClure. "Development of Postcava and Tributaries in the Domestic Cat," Am. Jour. of Anat., Vol. VI, No. 3, April 1, 1907, abstract, Anat. Record, Vol. I, p. 29; "The Interpretation of Variations of the Postcava and Tributaries of the Adult Cat, based on their Development," Am. Jour. of Anat., Vol. VI, No. 3, April 1, 1907, abstract, Anat. Record, Vol. I, p. 33. William Darrach, "Variations of the Postcava and its Tributaries in 605 examples of the Domestic Cat," Am. Jour. of Anat., Vol. VI, No. 3, April 1, 1907, abstract, Anat. Record, Vol. I, p. 30.

It is manifest that the attention of investigators of the development of the lymphatic system has been attracted to the following three general elements, and that they have assigned different relative values to these in their interpretations of the genesis of the lymphatic system as a whole:

1. Lymphatic elements directly derived from the embryonal venous system. In their full development these organs function as the contractile lymph hearts of the lower vertebrates, while they are represented in the higher forms by temporary embryonal and highly modified adult homologous structures.

2. The development of the main systemic lymphatic vessels, by confluence of multiple separate anlages, either directly derived from the embryonal veins or formed independently of the latter, but closely associated with the redundant embryonal venous channels.

3. The development and structure of the adult connections between the venous and the lymphatic system.

Of these factors the second is the most important, *i. e.,* the development of the isolated spaces which by subsequent union form the main lymphatic channels, whether they arise as independent formations or are to be regarded as being directly derived from the venous system. Their existence contradicts the assumption of a continuous growth of the lymphatics from venous centers toward the periphery, as assumed in Sabin's conception of lymphatic development.

The existence of a direct venous derivative in the development of the mammalian lymphatic system, as the cervical or jugular lymph sac or "anterior" lymph heart, may be regarded as firmly established. The development of this structure in the embryos of the domestic cat, as determined in detail by McClure and myself, is described in a separate communication in this issue of the Record. I regard the jugular sacs and the terminal parts of some of their main tributary components (as the proximal end of the thoracic duct) as representing in the basic plan of the entire lymphatic system a segment interposed between the definite adult venous system and the main systemic lymphatics, developed by confluences of lymphatic spaces, associated with embryonal veins. These spaces form the keynote in the correct interpretation of vertebrate lymphatic development. Sala regards them as "excavations in the mesenchyme," and in the district which he assigns to the avian thoracic ducts, as the result of canalization of originally solid cords of modified præ-aortic mesenchymal tissue.

Lewis inclines to consider them in general as detached and isolated portions of the venous system, but is somewhat indefinite in assigning to them a distinct genetic history and in deriving them directly from the venous channels, as primary veins which are subsequently directly transferred bodily to the lymphatic system.

The writer, as outlined in the preliminary communication published last year, believes that these spaces are formed along the embryonal veins, without their intimal lining, and that they are largely determined in their development by the atrophy of certain of the original embryonal venous pathways which they secondarily replace.

If in the final adult organization the systematic lymphatic channels, formed by fusion of the discrete extra-venous spaces, communicate with the general venous system, it can only be accomplished by the interpolation of the jugular lymph sacs, they constituting a link, which in the mammal unites two genetically separate sets of vascular channels at definite and—within normal limits of variation—constant points.

It is evident that any interpretation of lymphatic development in the mammal must be based not only upon careful observations of the ontogeny of the lymphatic system in any one individual form, but upon the phylogenetic history of the lymphatic system as a whole, and upon the adult conditions encountered in mammals, as well as in vertebrates lower in the zoological scale.

If the hypothesis above outlined in reference to the genetic interpretation of the development of the lymphatic system and its association with the venous system in the mammalian embryo is true, then all known facts, both of phylogenetic and ontogenetic development of the lymphatic system, should conform strictly to the morphological demands made by the same. It is the purpose of this communication to bring together—as far as possible—the observations and facts which form the basis of this conception of mammalian lymphatic development, without considering the details of structure, which are reserved for a subsequent and more complete publication.

We can arrange the subject matter under the following headings:

I. Summary of observations on the development of the jugular lymph sacs and the general lymphatic system in embryos of Felis domestica.

II. Phylogeny of the lymph hearts and of homologous structures in the vertebrate series.

III. Ontogeny of the mammalian jugular lymph sacs as compared with the embryonal avian lymph hearts described by Sala, and general comparison of avian and mammalian lymphatic development.

1. Summary of Observation on the Development of the Jugular Lymph Sacs and of the General Lymphatic System in Embryos of Felis Domestica.

1. *The jugular lymph sacs* in the embryo of the cat are direct derivatives from the early redundant embryonal venous pathways of the pre- and post-cardinal regions, adjacent to and including their point of confluence to form the duct of Cuvier.

They subsequently—voiding their early blood contents—become, as far as it has been possible to accurately determine, for a time entirely separated from the venous channels from which they arose in the manner described in detail in another communication. Subsequently they form secondary connections with the venous system, at definite points, and with the general systemic lymphatic vessels.

2. *The independently formed isolated spaces, which develop along the course of the embryonal veins, and which, becoming confluent, constitute the anlages of the main systematic lymphatic channels.*

In the present state of our knowledge regarding the development of the mammalian lymphatic system, the appearance of these isolated spaces constitutes one of the most important phases of the entire problem. These spaces, developing along the course of the principal venous channels, become later confluent with each other to form the principal systemic lymphatic channels, which gain their permanent entrance into the venous system through secondary connections established with the jugular lymph sacs or lymph hearts.

Three main possibilities suggest themselves in reference to the genesis of these spaces:

A. Either they are detached and evacuated portions of the primitive embryonal venous system, which, after losing their blood contents, became confluent to form larger spaces. In other words, they represent multiple rudimentary lymph heart formations, developed in the same manner, directly from the venous system, as the jugular lymph sacs.

B. Or those spaces are formed independently outside the lumen of the embryonal veins, in the sense previously defined.

C. Or, lastly, there is a combination of these two processes, namely, lymph heart formation at a number of points along the course of embryonal veins (mesenteric, inguinal, etc.), in addition to the main jugular lymph sac, with the formation of intervening lymphatic channels resulting from the confluence of independently formed spaces.

Against the first hypothesis is the uniform character and appearance of these spaces in their relation to the embryonal venous channels, and the fact that up to the present definite and constant connections between these spaces and the vascular system have not been demonstrated. Also that they are uniformly and from their earliest inception empty and void of blood contents, entirely differing in their structure and their relations to the venous system from the early veno-lymphatic stages of the jugular lymph sac elements.

In favor of the first and of the third hypothesis is the phylogenetic history of multiple lymph heart derivatives from the embryonal venous system.

As far as I have been able to accurately determine by careful study of numerous serial sections and plastic reconstructions of the embryo of the cat in the important stages, the general systemic lymphatic vessels, as distinguished from the jugular lymph sacs, arise, not by direct transformation of veins, but by the formation of spaces lying outside the intimal lining of the veins, which spaces, becoming confluent, form the general lymphatic channels of the body. They are closely correlated to the main and secondary venous channels, but independent of the same, except in as far as abandoned and atrophied embryonal venous pathways afford to the lymphatic vessels the opportunity for more extensive development, and permit them to secondarily occupy the area of the shrinking vein.

I have been unable to obtain any evidence that the lymphatic spaces, developing along the course of the principal embryonal venous channels, outside the jugular lymph sac area, have been directly derived from the veins with which they are so closely associated. Nor have I been able to establish at any point direct and indisputable connections, primary or secondary, between these spaces and the embryonic veins which they accompany. The peripheral general lymphatic channels appear to be developed by confluence of spaces independent of the venous system, althought closely associated with the same. The histological picture presented by them differs radically from that of the jugular veno-lymphatic derivatives. They begin as minute extra-venous vacuoles, closely applied to the surface of the veins which they accompany. They enlarge as the lumen of the vein diminishes. They become confluent with each other, but they never, from their first inception, contain red blood cells, nor do they, as far as I have been able to ascertain in numerous carefully studied series of excellent preservation and fixation, communicate with the blood channels. In the present state of our knowledge of the genetic history of these spaces, I believe we are obliged to consider them as developing independently of the venous system, in the sense that they are not direct derivatives from the embryonal veins, but lymph spaces formed outside of the lumen of the venous channels.

3. Finally, after the establishment of connections between the jugular lymph sacs (venous in origin) and the general systemic lymphatic vessels (developed along the embryonal veins by confluence of extra-vascular spaces), the combined and now continuous and definite lymphatic system establishes, in the mammalian embryo, its permanent points of entry into the venous system.

I am convinced that the definite adult connections of the venous and lymphatic systems are secondarily developed, although they occur normally at definite points, which, in the embryo of the cat, correspond to two of the primitive connections of the jugular lymph sac with the embryonal venous channels. These points are:

A. The angle of confluence of the common jugular vein, *i. e.,* of the combined trunk of the external jugular and cephalic veins with the internal jugular vein (cephalic lymphatico-venous tap, corresponding to the primitive junction of the ventral division of the veno-lymphatic sinus with the precardinal vein at its junction with the jugular promontory).[7]

B. Jugulo-subclavian angle (caudal lymphatico-venous tap, corresponding to the primitive junction of the dorsal division of the veno-lymphatic sinus with the jugular promontory at the entrance of the primitive ulnar vein).[7]

The steps by which this irruption of the completed lymphatic system into the definitely organized venous system of the mammal is accomplished are so regular, so typical in their development and present such constant and consistent pictures that, once recognized, they stamp the final lymphatico-venous connection as a secondary process, marking the establishment of permanent adult conditions.

We have, therefore, in order to accentuate the intermediate position of the jugular lymph sacs, described their initial organization as constituting the *veno-lymphatic stage* in the upbuilding of the entire lymphatic system.

[7]For details and explanation of descriptive terms cf. joint paper of McClure and writer on the Development of the Jugular Lymph Sac in this number of the Record, p. 1.

The conception of the development of this system in the mammal, which has impressed itself on me as combining all definitely ascertained facts into a logical and congruent whole, may be summed up as follows:

1. Development of the veno-lymphatic sinuses and the resulting jugular lymph hearts directly from a definite portion of the pre- and post-cardinal veins.

2. Evacuation of the blood contents of the veno-lymphatic sinuses through certain of their primitive connections into the permanent venous channels.

3. Subsequent complete separation of the voided veno-lymphatic sinuses from the veins which gave origin to them.

4. Development of extra-venous spaces along the course of the main embryonal veins, and confluence of these spaces to establish the systemic lymphatic channels subsequently destined to form secondary connections with the jugular lymph sacs.

5. Secondary connection of the two elements entering into the composition of the definite lymphatic system, viz: the detached and emptied veno-lymphatic sacs or anterior lymph hearts, originally derived from the veins, and the general systemic lymphatic channels, formed from the beginning independently of the veins, but closely correlated to them.

6. Final entrance of the completed lymphatic system, thus formed from a double anlage, into the permanent venous system by the formation of the typical secondary connections, with their characteristic wedge-shaped entrance and annular valves.

There are two points which deserve mention in outlining this genetic interpretation of mammalian lymphatic development:

1. It is quite possible, in fact probable, that in the mammal, in addition to the more fully developed jugular lymph sac, or "anterior lymph heart," other more rudimentary direct venous derivatives of the lymphatic system occur further caudad, possessing exactly the same significance and to be interpreted as incomplete lymph heart formations, which may or may not be multiple. Phylogenetically this would be expected, although from the evidence at present available these structures appear to be much more reduced and rudimentary than the anterior or jugular lymph sacs. They are incomplete in the sense that in the mammal, after complete organization of the venous and lymphatic systems has been accomplished, they no longer serve, as do the jugular lymph sacs, as portals of definite lymphatico-venous connections. Thus Baetjer's mesenteric sac and Sabin's caudal lymph heart

may very well represent in the general mammalian plan reduced and rudimentary lymph heart formations of direct venous origin, as will be more fully considered presently in dealing with the phylogenetic aspect of lymph heart development. At present it is sufficient to point out that the interpretation of mammalian lymphatic development given above admits of the ontogenetic appearance of multiple direct venous derivatives of the primitive lymphatic system, representing incomplete lymphatic heart elements, only differing from the more highly developed anterior or jugular lymph sacs or lymph hearts in that they do not persist as permanent links between the lymphatic and venous systems of the adult, as do the homologous and more complete jugular structures.

2. The question of peripheral lymphatic growth is not involved in formulating the basic ground plan of development of the lymphatic system. When that system is once established and has acquired structural fixity, further growth of the lymphatic channels will be by continuous peripheral extension, entirely homologous to the similar enlargement of blood vascular areas, whether occurring normally during development or pathologically after normal growth is completed.

II. Phylogeny of the Lymph Hearts and of Homologous Structures in the Vertebrate Series.

The vertebrate lymphatic system, both in its phylogeny and in its embryonal development, reveals a compound character, the two component elements being the *lymphatic hearts* and the general *systemic lymphatic vessels.* Phylogenetically the most striking character is found in the gradual numerical reduction, degeneration and ultimate almost complete elimination of the lymphatic hearts, correlated, in Mammalia, with high development of the systemic lymphatic vessels.

The lymph hearts of the fishes are apparently represented by the lymphatic sinuses found on each side in the scapular region, in direct communication with the venous system and receiving the lymphatic vessels of the head and body. They appear to constitute early phylogenetic types of lymph heart formation, before the walls have developed striped muscular tissue.

In some forms (Silurus, Anguilla) rhythmically contractile lymph hearts develop in the caudal region.

The lymph hearts reach their highest development in the Amphibia, with striated muscular fibers forming part of the walls.

In the Urodeles as many as 14-20 of these organs exist on either side of the trunk and tail at the junction of the dorsal and ventral trunk musculature. A lymphatic sinus included in the walls of the Truncus arteriosus of these forms has been described as a "central lymph heart."

In Anura the number of lymph hearts is reduced to two pairs, cephalic and caudal, the former placed between the transverse processes of the third and fourth vertebra, the latter between the urostyle and pelvis.

From this point on the Sauropsid branch, including reptiles and birds, appears to have specialized on the posterior or caudal organ to the practical exclusion of the anterior or cephalic lymph heart, except in as far as rudiments of this structure may be represented in the anterior or jugular lymphatico-venous connections in these vertebrate classes.

In Reptilia only the posterior of the two pairs is retained in the adult organization, situated at the junction of trunk and tail, on the vertebral transverse processes or on the ribs of this region.

The posterior lymph hearts appear during the embryonal period in birds at the boundary between the sacral and coccygeal vertebræ, partly covered by the M. coccygeus dorsalis, and in open communication with the coccygeal and pelvic veins. In the chick they are evidently functionally active during the period of incubation. They undergo rapid degeneration after free life is established and subsequently (30-40 days) disappear entirely.

In some other avian species they persist in a more or less modified condition in adult life.

In some forms they appear well developed; in still others they present themselves as rudimentary organs, forming simple vesicular dilatations; in still others, as in the chick and in all Gallinaceæ, they appear to be uniformly wanting in the adult.

In birds the anterior lymph heart apparently no longer develops completely. From the account given by Sala it appears, however, extremely probable that in a rudimentary form it unites the precaval veins with the independently established systemic lymphatic channels (cf. *infra*).

In Mammalia, on the other hand, in contradistinction to the posterior Sauropsid type, lymphatic heart development is centred, at least chiefly, in the anterior region. The early embryonal veno-lymphatic sinuses and the subsequent jugular lymph sacs must from their ontogenetic history be homologized with the more completely developed lymph hearts of the lower vertebrates, although they are highly modified, relatively much reduced, and no longer develop muscular fibers as a constituent of their walls.

Professor Sabin has described an anterior cervical and posterior inguinal organ in pig embryos.

At the twenty-third session of the Association of American Anatomists, held in Chicago, January 1, 2 and 3, 1908, W. A. Baetjer, of Johns Hopkins University, presented, through Sabin, a paper "On the Origin of the Mesenteric Sac and its Relation to the Thoracic Duct,"[8] the details of which are at this writing not yet published. Presumably this mesenteric lymph sac represents the anlage of the mammalian receptaculum chyli.

In the studies made jointly by McClure and myself on cat embryos we have traced the development of the anterior or jugular lymph sac in detail. In the cat, as far as our observations extend, no correspondent formation occurs in the posterior end of the embryo, although certain stages in the veno-lymphatic development caudad of the omphalomesenteric artery and the subcardinal cross anastomosis strongly suggest foreshortened and rudimentary ontogenetic processes, homologous to those observed in the more complete development of the jugular lymph sacs. More detailed investigations and carefully executed plastic reconstructions are needed to clear up this question, but, as previously stated, multiple rudimentary lymph heart formations may be expected in the mammalian embryo as being in line with the phylogenetic history of these organs. If they exist, as seems probable, they no longer function as ports of entry of the lymphatic into the venous system. As far as present evidence goes, they become, when once detached from the venous system, incorporated in the general lymphatic system.

Reviewing the facts at present established, it is fair to state that the lymph hearts in their highest development (amphibia, reptiles and during incubation in birds) are derived primarily from the venous system, retain their connections with the same and receive the systemic lymphatic trunks of the body.

No matter what their number or situation may be in individual vertebrate forms, they are closed sacs, with striped muscular tissue entering into the composition of their walls, interposed between the general systemic lymphatic trunks and the permanent venous system. They thus occupy the position of intermediate elements, originally venous in derivation, but specially modified and transferred to the

[8]This number of the Anatomical Record, page 55.

lymphatic system, their original points of connection with the venous system constituting permanent portals of lymphatico-venous entry in amphibia and reptiles, and functioning as such during the embryonal period in birds. They evidently act as contractile reservoirs, receiving the centripetal flow of lymph from the general systemic and peripheral lymphatics. By virtue of their muscular contractility they are able to empty the lymphatic fluid accumulated in their cavity into the venous system through the original avenues of connection with the same, the direction of the flow being apparently regulated by definite valve formation in the interior of the sacs and the connecting vessels.

As a secondary function it is possible that they may promote the centripetal flow of lymph from the periphery toward the lymphatico-venous confluence by a pumping or suction action.

On the other hand, the anterior lymph hearts of Mammalia, the jugular or cervical lymph sacs, while no longer contractile organs, develop directly from the pre- and post-cardinal venous confluence, and subsequently, after receiving the terminals of the general lymphatic system, form, by secondary connection, the link of communication between the lymphatics and the permanent veins.

Regarded, therefore, from the general standpoint, the lymphatic hearts and the systemic lymphatic vessels present throughout the entire vertebrate series a uniform and consistent structural picture, whose main features may be summarized as follows:

1. *Lymphatic Hearts.*—They develop directly from embryonal venous channels.

They are always placed at the points of communication between the lymphatic and the venous systems, interposed between the two and communicating with both.

In the lower vertebrate classes these organs develop contractile walls, are multiple, and maintain numerous points of connection with the venous system throughout adult life (some Fishes, Urodeles). In ascending the zoological scale they become reduced numerically to two pairs, cephalic and caudal (Anures). Progressive phylogenetic development (Reptilia) shows reduction of the anterior or cephalic pair, while the posterior organs persist and retain throughout adult life their original structural character and function as true lymph hearts.

In birds the reptilian type appears ontogenetically as the caudal lymph heart, well developed and evidently functionally active during the period of incubation, but lost in most forms in the adult condition.

It is quite probable that a reduced and rudimentary anterior lymph heart forms in birds the uniting link between the venous and lymphatic system (cf. infra analysis of Sala's description of anterior lymphatico-præcaval junction).

In Mammalia finally the progressive development of the general systemic lymphatic system is correlated to the reduction and almost complete elimination of the posterior lymph hearts (inguinal, mesenteric) which may appear during certain ontogenetic stages, as incomplete structures, but are not retained as final and definite lymphatico-venous adult connections. The anterior lymph hearts, on the other hand, modified in structure as the jugular or cervical lymph sacs, develop more completely and serve as the links of secondary connection between the lymphatic and the venous system.

2. *The General Systemic Lymphatic Channels.*—These develop either as direct derivatives of the embryonal venous system (Lewis) or as spaces formed independently of the veins, although closely associated with them in the sense previously defined (Huntington).

They establish secondary connections with the lymphatic hearts or their reduced mammalian homologues, the jugular lymph sacs, and through these organs form their permanent connection with the venous system. In lower vertebrate types, where the lymph hearts are numerous, the general systemic lymphatics are more simply organized and less extensively developed as a continuous system. With the reduction of the lymph hearts in ascending the zoological scale the systemic lymphatic system assumes a more and more important position and overshadows in extent and complexity the primitive multiple lymph heart formation.

3. In the higher forms the latter is reduced, but of necessity retained, in at least one of its primordial districts, as affording the portal of lymphatico-venous connection.

The single or double lymphatico-venous entry of the mammal thus stands in contrast with the multiple connections of the Urodele amphibian, but is correlated to the same by the difference in the type of development exhibited by the two primary components of the lymphatic system, viz: the lymph hearts and the systemic lymph channels.

4. The lymphatico-venous junction trends phylogenetically toward the confluence of the main embryonal venous channels, viz: the Cuvierian junction of the pre- and post-cardinal veins. Thus, in the avian lymphatic organization, in spite of the high ontogenetic development of

the posterior lymph heart, the definite adult lymphatico-venous connection is established with the precaval veins. In the mammal the corresponding lymph heart, as the jugular or cervical lymph sac, constitutes the only permanent link or links of communication in the adult between the lymphatic and venous systems. The multiple lymphatic hearts of the lower types have in the higher forms either disappeared altogether or have, after an evanescent ontogenetic existence, become incorporated in the general systemic lymphatic apparatus. Thus the lymphatic hearts, from the beginning of the phylogenetic series up to the highest vertebrate types, occupy, no matter how modified in form or structure, or how much reduced numerically—a constant, consistent and uniform position—as elements, directly derived from the embryonal venous channels, interposed between the system of the general lymphatics and that of the permanent veins, destined to receive the same.

These lymph heart links, joining the two great correlated divisions of the compound veno-lymphatic vascular system, may be multiple, as in the lower vertebrate types, or reduced to a single pair, as in higher forms. Their morphological position and genetic significance remain precisely the same under all modifications encountered in the entire zoological series.

III. Ontogeny of the Mammalian Jugular Lymph Sacs as Compared with the Embryonal Avian Lymph Hearts Described by Sala, and General Comparison of Avian and Mammalian Lymphatic Development.

In defining the fundamental common ground plan of vertebrate lymphatic organization, as illustrated by the comparative study of avian and mammalian development, the two distinct component elements must be sharply differentiated in their mutual relation and in their connection with the venous system.

1. *The Lymphatic Hearts.*—These, as well as their rudimentary representatives in the higher forms, are direct derivatives from the venous system. A limited number of lateral tributaries of the main venous trunks in the jugular region (mammalian embryo) and in the iliac region (avian embryo) specialize by dilatation and confluence. In the mammal, in addition, a considerable segment of the pre- and postcardinal veins, adjacent to their Cuvierian confluence, becomes separated by fenestration from the proper venous channels, and, together

with the fused and dilated dorsal tributaries involved in the process, forms a capacious sac or bag, the jugular or cervical lymph sac. In the embryo of the chick a corresponding structure develops from the pelvic and coccygeal veins, becomes invested by a layer of striped muscular fibers and functions during the period of incubation as a contractile lymph heart, corresponding to the adult organs of reptiles and amphibians. In the chick, according to Sala's researches, the development of the lymphatic heart is restricted to the posterior region of the embryo. Derived from the lateral branches of the first five coccygeal veins, the lymph heart passes through a definite ontogenetic cycle, including the development of a sheath of striped muscular tissue, but is lost shortly after completion of incubation, and is not carried, at least in its original form, into the adult lymphatic organization of the bird.

The lymphatic heart development of the chick may be schematically represented in Figs. 1-5, based on Sala's description and the plates accompanying his publication.

The sacral and coccygeal veins of the chick are laid down in the first hours of the seventh day of incubation, a dorsal and a lateral branch of each segment uniting into a common trunk which opens into the caudal end of the post-cardinal vein. The lateral branches of the first five coccygeal veins of each side develop the lymphatic hearts. These veins are from the beginning larger than the succeeding veins of the same series not involved in the lymphatic heart formation. In the mesenchyme surrounding these lateral branches of the proximal five coccygeal veins "little spaces or fissures develop in direct connection with the veins." To quote Sala's words, "One would in fact say that these fissures are only simple dilatations and ramifications of the veins themselves."

These spaces are at first few and of irregular form, "arranged segmentally, in a linear series, parallel to the vertebral column, corresponding to the point of penetration of each venous branch into the intermuscular segment" (Fig. 1).

Later (Fig. 2) these spaces enlarge and fuse with each other, the remnants of their walls appearing as more or less complete internal septa or diaphragmata, producing a "system of cavities, very irregular in form and dimensions, intercommunicating, and connected at the same time with the lateral branches of the first five coccygeal veins." The mesenchyme surrounding this system of cavities becomes gradually denser, differentiating from the adjacent indifferent mesenchyme. In the second half of the eighth day the walls of the primitive lymph hearts are still composed exclusively of lengthened mesenchymal cells, without trace of muscular fiber. The cells directly enclosing the cavities have flattened and have transformed themselves into endothelial cells, while the more peripheral cells of the walls are elongated and have extensively fused with each other.

"These cavities excavated in the heart are very irregular in form and dimensions, divided incompletely one from the other by means of diaphragmata or trabeculæ, with perforations here and there, and also composed of memsenchymal cells fused together." "The cavity as a whole may be at this stage compared to a sponge with large and small holes. Contrary to Budge, I have observed that the cavities at this time often contain red globules of blood, and sometimes appear quite filled with them."

Muscular fibers first appear in the surrounding mesenchymal wall of the lymph heart cavity during the second half of the ninth day, scattered irregularly at first, subsequently forming a continuous stratum embracing the entire sac, for the most part in a circular manner (Fig. 4).

The lymph heart obtains its greatest development between the fourteenth and fifteenth day. The fusion of the individual cavities has continued until at this time the diaphragmata or trabeculæ in the interior have become much reduced in number, so that the lymphatic hearts appear as single cavities, 1.5 to 2 mm. in diameter.

"The formation of the lymph hearts . . . shows us the close connection which these organs assume with the coccygeal veins. From their first appearance the cavities around which the mesenchymal cells condense and which precede the formation of the real heart, are in the last analysis nothing but terminal dilatations of the veins themselves, which have gradually grown in volume and fused together. This communication between the lymphatic hearts and the coccygeal veins, which appears so early, is maintained (in part) throughout the whole duration of the embryonic period, and also for that small space of adult life in which these organs persist."

As the development of the lymph hearts (Fig. 4) proceeds they lose their connection with the first and the last of the series of the five proximal coccygeal veins, the intermediate three veins (second, third and fourth of the original series) remaining and "leaving the heart in large apertures excavated in its walls, to correspond with which, from the twelfth day, the intimal surface of the sac forms a more or less manifest projection, sometimes circular, *i. e.,* continuing around the aperture, at other times limited to a portion of the circumference of the aperture itself, and which corresponds probably to the valvular formation noted by Budge."

2. *Systemic Lymphatic System.*—The lymph hearts make secondary connections with the general lymphatic system relatively late, toward the end of the tenth day, one, or more rarely two, lymphatic vessels uniting the hearts with "the lymphatic spaces which have formed in great numbers around the two hypogastric veins and their median anastomotic branch" (Figs. 4 and 5).

"These spaces appear in the last hours of the ninth day, forming fissures, not very large at first and of irregular form, excavated in the mesenchyme which immediately surrounds the above mentioned venous vessels."

This picture af avian lymphatic development furnished by Sala's observations gives the following salient points:

1. Formation of lymph hearts as the direct products of dilatation, modification and fusion of certain embryonal venous tributaries (Figs. 1, 2, 3).

2. Reduction in number of the primitive connections of the lymph hearts with the venous system (Fig. 4).

3. Development of the general systemic lymphatic vessels, as the result of fusion and confluence of independently formed perivenous mesenchymal spaces (Figs. 4 and 5).

4. Establishment of secondary connections between the lymph hearts and the independently formed general lymphatic system (Fig. 5).

5. Soon after the completion of incubation regression and ultimate disappearance of the lymph hearts as specialized parts of the general lymphatic system.

Comparison of Sala's Observations with the Results Obtained in a Detailed Study of the Development of the Jugular Lymph Sacs in the Embryo of the Cat, and Correlation of the Homologous Parts of the Lymphatic System in Avian and Mammalian Embryos.

(Figs. 1-5 compared with Figs. 6-10.)

In the cat the development of the jugular lymph sacs represents the regressional embryonic appearance of the anterior lymph heart of lower vertebrates. This value was assigned to the structures by Sabin in her earlier publication,[8] and questioned later by Lewis,[9] by reason of the absence of muscular elements in the walls of the sac. As soon, however, as the finer details in the development of the sacs were established by McClure and the writer, a comparison of the results obtained with Sala's full and accurate account of avian lymph heart development dispels all doubt as to the intrinsic character of these structures in the mammalian embryo, and puts them in line, as rudimentary representatives, with the series of more fully developed lymphatic hearts in other vertebrate classes.

Dilatation and fusion of certain precardinal tributaries (Fig. 6, 1-3 or 4), together with the separation by fenestration and confluence of a secondary channel from the dorsal segments of the pre- and post-cardinal veins adjacent to and including their junction at the duct of Cuvier (blue area in Figs. 6 and 7), yields a product, the jugular lymph sac, constructed on the same principles as the coccygeal lymph heart of the chick in early stages (Figs. 1 and 2), but never attaining the degree of development in which *striped muscular fibers* appear in its walls. The lymph sacs of the earlier mammalian stages, after confluence and fusion of the component elements (Fig. 8), show their compound nature, and the multiple interior partitions and septa betray their origin from a number of fused and confluent venous spaces, reproducing exactly the earlier avian condition described by Sala (Figs. 2 and 3).

The resulting mammalian lymph heart presents at the height of its development (Fig. 7) the appearance of a capacious sac or sinus, directly derived from the venous system, lined by an endothelium continuous with the intimal lining of the true venous channels.

In the early stages the veno-lymphatic sinus is in free communication with the pre- and post-cardinal veins by the openings of some or all of the original dorsal tributaries involved in its formation (Figs. 6, 1, 2, 3, and at times part or the whole of 4) and by secondary openings which, during the separation by fenestration from the primitive venous pathways, the dorso-lateral portions of these channels, involved in the formation of the lymph sac, have retained with the parent vein, as the persistent intervals between the fenestral spaces, which, with the more complete detachment of the veno-lymphatic sinus, become drawn out

[8] *Loc. cit.*
[9] *Loc. cit.*, p. 110.

into secondary channels, connecting the jugular lymph sac with the permanent veins. Thus in the early stages, up to 10 mm. embryos, the veno-lymphatic sinus, which precedes the appearance of the true lymph heart, is in free and open communication with the venous system by a number of connections (Fig. 7), just as the corresponding structure is for a much longer period in the avian embryo (cf. Figs. 2 and 3).

In the cat embryo the following observations were made:

Series 31. Embryo 5-6 mm. Left side. 13 communicating channels between the rudimentary veno-lymphatic sinus and the permanent veins.

Series 3. Embryo 7 mm. Left side. 9 communications.

Series 106. Embryo 9 mm. Left. 13 communications.

Series 113. Embryo 10 mm. Left side. 14 communications.

These early multiple connections of the sinus with the true veins are subsequently greatly reduced in number (Fig. 8), just as in the chick the original five lymph heart veins are reduced to three by the loss of the heart's connection with the first and fifth coccygeal veins (Fig. 4).

In the mammal this process of secondary separation of the lymph hearts or jugular lymph sacs from the venous channels which primarily gave origin to them, is carried much further than in the avian embryo. In the cat two of these connections are usually retained for some time after the remainder have been lost, one with the precardinal where the vessel receives the combined trunk formed by the cephalic and external jugular veins (cephalic primitive tap, Fig. 8), the other further caudad, originally in post-cardinal territory, at the terminal of the primitive ulnar vein, becoming subsequently, after establishment of the subclavian vein, located at the angle of confluence of this vessel with the main jugular trunk (caudal primitive tap, Fig. 8).

Up to this point the general developmental processes in bird and mammal have been along practically parallel lines. The fact that striped muscular development does not occur in the walls of the mammalian lymph sac, but does so in the chick, suggests, as Budge has pointed out, that in the latter the posterior lymph hearts may be of functional value during the embryonal period in the lymphatic circulation. In the mammalian embryo they do not appear to have this value, but they are retained in a more rudimentary form and adapted to the complicated establishment of the secondary and final connections established between the definitely organized lymphatic and the permanent venous system.

The jugular lymph sac of the cat represents, therefore, at this stage a sac still filled with blood and still in communication with the venous system at one or more points, the multiple early veno-lymphatic connections having undergone considerable numerical reduction (Fig. 8). The structure corresponds, in all essential ontogenetic characters, to the conditions described by Sala for the development of the lymph heart of the chick.

From this point on the organ in mammals enters a new developmental phase, not represented, as far as definite knowledge based on actual observations is available, in the lower vertebrate classes. It is exceedingly probable, however, that further careful researches will determine the existence of a more rudimentary anterior lymph heart or jugular lymph sac in avian and reptilian embryos, and that the final entry of the lymphatic system into the præcaval veins is, in the bird, established through the intervention of this structure, on the same general plan as exists in mammals.

In the embryo of the cat the lymphatic sac becomes much more completely separated from the venous system and very rapidly evacuates its blood contents into the latter through one or more of the primitive channels of communication. This "tap of evacuation" appears to enlarge at this time, and the process of emptying the veno-lymphatic sinus of its blood proceeds with great rapidity.

As soon at this is accomplished the "tap of evacuation" also closes and becomes detached from the venous channels, so that the sinus now forms a closed empty sac, completely separated from the venous system from which it arose, the jugular lymph sac proper, as contradistinguished against the earlier veno-lymphatic sinus or anterior lymph heart (Fig. 9).

It is somewhat difficult to interpret this feature in the development of the mammalian lymph sac, since the permanent normal connections of the lymphatic and the venous system take place at the identical points occupied in the preceding stage by the primitive veno-lymphatic taps which are the last to close in the temporary separation of the lymphatic sac from the venous system. The picture afforded by the proper stages (10.7 mm. to 12 mm.) is, however, so constant and the observations so numerous, that it seems necessary to accept this separation as occurring normally and constantly. This closed sac then forms two sets of secondary connections:

(*a*) With the general system of independently formed perivenous lymphatic vessels (Fig. 9).

(*b*) With the venous system, re-entering the same by the establishment of a complicated secondary opening, guarded by a circular valve.

These secondary lymphatico-venous connections are, in the cat, made normally at two points, the angle of confluence of the internal jugular with the combined trunk of external jugular and cephalic veins (cephalic secondary tap) and at jugulo-subclavian angle (caudal secondary tap), corresponding to the points at which in the earlier stages the primitive direct connection between the veno-lymphatic sinus and the true veins were longest retained (taps of evacuation, Fig. 10). The failure in any individual to establish one or the other of these typical connections leads to the adult variations of single lymphatico-venous tap described in another paper, while the early multiple connections of the lymphatic sinus with the venous system open up a wide range of more aberrant variants, on the assumption that any of these may abnormally replace the two typical taps of evacuation and subsequently serve as the portals of definite secondary lymphatico-venous entry.

The relative size of the jugular lymph hearts or lymph sacs diminishes after the final venous connection is established, and in the later embryonal stages and in the adult they appear as rudimentary structures at the site of the veno-lymphatic entrance. In the early stages the mammalian and avian embryos agree in the development of homologous parts of the lymphatic system, the jugular lymph sac of the former corresponding to the coccygeal lymph heart of the latter. They also agree in the development of the general systemic lymphatics by confluence of independently formed spaces, and in the secondary connection between the resulting lymphatic channels and the lymph heart or its mammalian representative, the jugular lymph sac. The bird, however, retains the more fully developed contractile lymph heart unchanged until the end of incubation and for a short period after adult conditions are established, the organ then undergoing rapid degeneration and elimination. In the mammal the corresponding anterior structure is never functionally contractile, and probably never acts as a "lymph heart." It is, however, developed in a modified form and incorporated in the final secondary connection established between the lymphatic and the venous system. The adult connection of the lymphatic system with the præcaval veins in birds is likewise a secondary formation. It is quite probable that in its establishment an extremely modified and reduced anterior lymphatic heart is interpolated, as in the mammal, between the venous and the lymphatic systems, in the service of this secondary and final connection. Sala's account in this particular is not very full or conclusive, and the subject deserves careful revision in the light of the facts ascertained in the developmental history of the mammalian jugular lymph sacs.

Sala, after describing the structures which he considers the avian thoracic ducts as being formed by the confluence of excavated spaces in "cords" of modified mesenchymal tissue, says:

"In embryos of eight days . . . in that portion of its course in which the cord stands in a medial relation to the superior vena cava, betwen the latter and the arch of the corresponding Ductus Botalli, the cavities are numerous and some come into contact with the wall of the vena cava, but *at this period there does not yet exist any communication between the vein and those cavities which are hollowing themselves out in the cord.*"

And further, in describing the next stage, embryo of eight days and eighteen hours:

"In the part in which the cord is in contact with the medial wall of the vena cava superior the numerous cavities excavated in it are extended up to contact with the vein; in fact, I do not exclude the possibility of some of them being in communication with the vein itself, although I have not succeeded in fully demonstrating this connection for this period, which communication, nevertheless, is already evident at the completion of the ninth day, as we shall see."

Speaking of the first appearance of the anlages of his "cords," he states that the first traces of these structures appear somewhat later than the lymphatic hearts, *i. e.,* in the second half of the eighth day. Before this time, in embryos of seven days and six hours, in the region where the thoracic ducts are to be formed, no trace of such formation can be found. He then goes on to say:

"In the mesenchyme which surrounds the thoracic aorta and the large arterial vessels which open into this (Botallian ducts), as also in the mesenchyme which limits mesially the superior vena cava, there exist, it is true, numerous spaces or cavities, clothed with endothelium, and more or less large, of irregular form, which perhaps correspond to the lymphatic cavities of the first circulation of Budge, *but none of these communicate with the superior vena cava.*"

At the middle of the eighth day, in the same mesenchyme, in addition to these spaces, are found here and there small areas in which the mesenchyme cells "present themselves much nearer to each other, so as to form little accumulations or lumps, which contrast clearly with the rest of the mesenchyma. Highly magnified, these accumulations appear to consist in large part of elements offering all the characteristics of young connective tissue cells of roundish form, with no projections and a large and intensely colorable nucleus. Some are in a state of karyokinesis. In the midst of these elements appear *red blood globules in larger or smaller quantities.*" These accumulations are especially developed in the mesenchyma on the medial aspect of the superior vena cava "in correspondence with the point in which it receives the outlet of the jugular and subclavian veins."

We seem to have here, couched in different language, a description which corresponds in all essential points to the homologous stages in the mammalian embryo, up to the period of the establishment of the permanent connections between the evacuated veno-lymphatic sinus and the venous system.

The early avian period, with blood contents in the aggregated "lumps" and mesenchymal spaces, seems to point to a direct venous derivative as forming part of the bird's lymphatic organization, quite corresponding to the early veno-lymphatic stages of the mammalian jugular lymph sac. Sala's account does not give a clear insight into the genetic relation of these structures to the embryonal veins, but the fact that they at one time contain blood cells suggests their direct connection with and derivation from embryonal venous pathways.

They subsequently lose their blood contents, enlarge, become confluent, approach the permanent venous channels, and finally establish a secondary connection with them. Thus Sala's account represents in every essential detail a foreshortened and abbreviated review of the genetic processes governing the development of the jugular lymph sac of the mammalian embryo.

It should also be remembered in this connection that the terminal segment of the mammalian thoracic duct is apparently a veno-lymphatic derivative in the sense defined, making subsequent secondary connections with the independently formed extra-venous portions of the canal in the supra-cardinal venous area, just as Sala's "excavated cords" tap the independently developed lymphatic spaces around the cœlio-mesenteric artery of the bird.

If this suggestion as to the essentially identical processes of jugular lymph heart development in avian and mammalian embryos should prove true on careful revision of the lymphatic ontogeny of the chick, then the phylogenetic lymph heart record would read as follows:

FISHES: Rudimentary.

AMPHIBIA: Fully developed.

UROdeles: Multiple (14-20).

ANURES: Number reduced to two pairs, *cephalic* and *caudal lymph hearts.*

REPTILES: *Caudal heart* retained in adult.

BIRDS: *Caudal heart* developed ontogenetically, apparently of functional value during the embryonal period. Disappears shortly after adult conditions are established, except in certain forms. *Cephalic heart* rudimentary, involved in establishment of secondary lymphatico-venous connections.

MAMMALS: Lymph heart formation not carried to point of contractility.
Caudal heart rudimentary. Details of its development from venous system not yet established completely.
Cephalic heart, as the modified jugular lymph sac, establishes the definite secondary lymphatico-venous connections.

EXPLANATION OF FIGURES.

In all figures the following color scheme has been used:

Systemic Veins: White.

Systemic Lymphatics, formed by confluence of perivenous spaces: Yellow.

Veno-lymphatics, components of the adult lymphatic system derived from embryonal veins, as the avian lymph heart and the mammalian jugular lymph sac: Blue.

Figs 1-5 inclusive represent schematically the development of the posterior lymph heart and its connections with the systemic lymphatics in the embryo of the chick, as published by Sala. The figures are reconstructed in schema from Sala's description and from the plates accompanying his paper.

Figs. 6-10 inclusive represent in schema the development of the jugular lymph sac and its connections in the embryo of Felis domestica, as determined by Huntington and McClure.

FIG. 1. Early stage in development of the chick's posterior lymph heart. Dilatation of the lateral branches of the first five coccygeal veins, extending into the surrounding mesenchyme.

FIG. 2. Confluence of the five dilated venous extensions to form rudiment of the single lymph heart. Scattered muscular fibers in the condensed pericardiac mesenchyme.

FIG. 3. Further development of the lymph heart. Intracardiac septa or partitions resulting from fusion of the five originally separate venous derivatives. Cardiac muscular layer completely developed, in direct contact with endocardial endothelial lining.

Fig. 4. Lymph heart and perivenous lymphatic spaces of right side. Differentiation of cardiac wall into a superficial muscular layer and a deep layer, composed of endothelium and a supporting connective tissue stratum. Intracardiac diaphragmata disappear, the lymph heart forming a single cavity, which has lost its original connections with the lateral branches of the first and fifth coccygeal veins, but retains the connections with the three intermediate veins. Beginning formation of one or two cardiac lymphatic vessels, proceeding from the heart to the plexus of independently developed systemic lymphatic vessels surrounding the two hypogastric veins and their median cross-anastomosis.

Fig. 5. Final stage. Lymph heart and systemic lymphatic connections of left side. Lymph hearts communicate by one or two cardiac lymphatic vessels with the general systemic lymphatics, which have formed by confluence of perivenous spaces around the hypogastric veins, their median anastomosis, and their venous tributaries.

CHRONOLOGY OF LYMPHATIC DEVELOPMENT OF CHICK, AFTER SALA.

1. First outlines of posterior lymph hearts appear middle of 7th day.
2. Muscle fibers appear in cardiac walls second half of 9th day.
3. Connection of lymph heart with first and fifth coccygeal veins interrupted from 11th to 12th day.
4. Independently formed lymphatic spaces appear around hypogastric venous plexus end of 9th day.
5. Communication established between general lymphatic system and hearts end of 10th day.
6. Lymph hearts increase in size from 8th to 15th or 16th day. From 16th to 20th day lumen of cavity remains the same, the walls increasing in thickness.
7. Traces of lymph heart formation persist in young chickens up to the 30th or 35th day of free life.

Fig. 6. Embryo of Cat. Early stage in development of the veno-lymphatic sinus, preceding formation of jugular sac.

Composite schematic figure based on plastic reconstruction of the following embryos:

5-6 mm. Both sides (Princeton University Embryological Collection, Series 30).

5-6 mm. Right side (Princeton University Embryological Collection, Series 31).

6.2 mm. Left side (Columbia University Embryological Collection, Series 109).

7 mm. Left side (Princeton University Embryological Collection, Series 2).

7.25 mm. Both sides (Princeton University Embryological Collection, Series 13).

Fig. 7. Second stage. Veno-lymphatic sinus developed in three main divisions, still entirely separated from each other.

Composite schematic figure based on reconstructions of the following embryos:

7 mm. Left side. Columbia University Embryological Coll., Series 138.
8.5 mm. Both sides. Columbia University Embryological Coll., Series 102.
9 mm. Both sides. Princeton University Embryological Coll., Series 19.
9 mm. Left side. Columbia University Embryological Coll., Series 106.
10 mm. Left side. Columbia University Embryological Coll., Series 112.
10 mm. Left side. Columbia University Embryological Coll., Series 113.
10 mm. Left side. Columbia University Embryological Coll., Series 114.

Fig. 8. Third stage. Confluence of veno-lymphatic components. Reduction of early multiple connections between the veno-lymphatic sinus and the permanent veins. Evacuation of sac. Appearance of isolated independent perivenous lymphatic spaces, preceding the development of the fully formed systemic lymphatics.

Composite schematic figure based on reconstructions of the following embryos:

10.5 mm. Both sides. Columbia University Embryological Coll., Series 101.
11 mm. Both sides. Columbia University Embryological Coll., Series 77.

Fig. 9. Fourth stage. Primary lymphatic condition. Evacuated sac completely detached for a time from the veins. Junction of same with independently formed perivenous systemic lymphatic vessels.

Composite schematic figure based on reconstructions of the following embryos:

10.7 mm. Both sides. Harvard University Embryological Coll., Series 474.*
12 mm. Both sides. Columbia University Embryological Coll., Series 78.

Fig. 10. Final stage. Secondary or definite lymphatic condition. Fully formed jugular lymph sac of the later embryonic stages and of the adult. Secondary connection of the sac with the venous system and with the general systemic lymphatic vessels. Relative reduction of jugular sac.

Composite schematic figure based on reconstructions of the following embryos and on dissections of a number of adult animals:

14 mm. Left side. Princeton University Embryological Coll., Series 37.
15 mm. Left side. Princeton University Embryological Coll., Series 16.
17 mm. Left side. Princeton University Embryological Coll., Series 36.
18 mm. Both sides. Columbia University Embryological Coll., Series 88.
25 mm. Both sides. Princeton University Embryological Coll., Series 22.

*I owe the opportunity of examining this embryo to the kindness of Prof. C. S. Minot, of Harvard University.

III.

Further Evidence on the Origin of the Lymphatic Endothelium from the Endothelium of the Blood Vascular System.

BY

FLORENCE R. SABIN.

From the Anatomical Laboratory, Johns Hopkins University.

The question of the origin of the lymphatic system has now resolved itself into the question of the origin of its endothelial lining. Is the lymphatic endothelium angioblastic or does it come from the less differentiated mesenchyme cells? By the one theory the endothelium of the blood vascular system has become a specific tissue before the lymphatic system begins and is capable of giving rise to all the endothelium both of the blood vascular and of the lymphatic systems. By the other theory, the lymphatic endothelium is formed out of mesenchyme cells, just as the lining of the primitive blood islands had been formed at a much earlier stage. Thus the question is one of the specificity of tissues, and means how early does endothelium become specific.

The theory that the lymphatics arise from tissue spaces and that the lining comes from flattened-out mesenchyme cells is well expressed by Gulland. He studied sections of human and other mammalian embryos and found spaces in the connective tissue of the limb buds, and thought that these spaces gradually dilated, flowed together and formed lymphatic ducts.[1]

Budge studied the lymphatic system in chick embryos. He injected the cœlom in chicks 2½ days old and found that the fluid passed by blunt processes out to the limits of the area vasculosa, where it formed a peripheral sinus. These spaces of the area vasculosa, he thought, made a primitive lymphatic system, later supplanted by the definite lymphatic system of which he made beautiful injections along the allantoic vessels in chicks 18 days old.[2]

The most recent exponent of this theory is Sala, who has also studied the lymphatics in the chick, and finds a series of sacs along the aorta

[1]Gulland. Journal of Pathology and Bacteriology. Vol. II, 1894, p. 466.
[2]Budge. Arch. f. Anat. u. Phys., Anat. Abth., 1880 and 1887.

which he considers to be lymph hearts. From these mesenchyme spaces the thoracic duct is formed.[3]

The first link in the chain of evidence for the vascular origin of the lymphatic endothelium was the discovery by Langer in 1868 that the lymphatics in the skin of the frog grow by means of blind sprouts of endothelial cells. That is, the lymphatic capillaries grow by the same method as the vascular capillaries.[4] This method of growth was rediscovered by Ranvier in studying developing lymphatics in the skin of the embryo pig. Based upon this discovery, he suggested the hypothesis that the lymphatics grow from the veins.[5]

If this hypothesis be true, it should be possible to trace the growth of the lymphatic capillaries into the different tissues and organs. This has been done in the case of the skin, where it was shown that in embryos under 20 mm. there are no lymphatic capillaries in the skin. At about that time the lymphatics reach the skin in the neck and gradually spread over the body. Thus it is possible to mark out successive zones containing lymphatics. Along the margin of these zones the lymphatic capillaries can be seen growing out into non-lymphatic areas. The lymphatics first cover the skin as a single primary plexus in the subcutaneous tissue. Then a secondary and more superficial plexus develops from the first and from this second plexus the final capillaries enter the papillæ.

In studying vascular injections of pig embryos which are to be demonstrated at this meeting, we have noted that there are non-blood vascular areas in the skin as well as non-lymphatic areas. In the injected specimens of embryos 15 to 20 mm. long it will be seen that the deep capillaries over the central nervous system have met in the mid-dorsal line, while the superficial capillaries in the skin do not pass beyond the myotomes. Thus there is a non-vascular area of the skin dorsal to the central nervous system, which is narrow over the spinal cord and wider over the brain. In the case of the head the non-blood vascular area persists late, so that it is still present in embryos 5 to 5.5 cm. long. The skin of the head is also late in receiving its lymphatics, and at this

[3]Sala. Ricerche n. lab. di anat. norm. d. r. Univ. di Roma, Vol. VII, 1900, pp. 263-269. Reviewed in Archives Italienne de Biologie, Tome 34, 1900, p. 453.

[4]Langer. Ueber das Lymphgefäss-System des Frosches, LVIII Bd. der Sitzb. d. K. Akad. d. Wissensch., I Abth., 1868.

[5]Ranvier. Comptes Rendus, 1895 and 1896; Archiv d'Anatomie, Tome 1, 1897.

stage the lymphatic vessels which are growing up between the eye and the ear are at least 3 mm. behind the invading blood capillaries. This makes one of the best places in the body to study growing blood vessels and growing lymphatics in their relations to new territories.

The second place where the test of the invasion of lymphatics into new territories has been made is in the intestine. Dr. Heuer, whose work is to be presented at this meeting, has followed the gradual growth of the lymphatics through the mesentery to the wall of the intestine. He has followed the growth of the lymphatics by means of injections of successive stages and has shown that after entering the intestinal wall they first grow into the submucosa, making there a primary plexus. Then a secondary plexus forms beneath the mucosa and lastly the terminal lacteals grow into the villi.

In Dr. Flint's recent paper on the development of the lung he has shown that the lymphatics follow the same general law,—appearing first in the hilus of the lung and gradually invading the lung itself.[6] Thus, as far as developing lymphatics have been studied in relation to their growth in organs, they first approach each organ from without and then gradually invade its structures. Therefore, the hypothesis of the growth of the lymphatics from center to periphery, from the veins rather than to the veins, is sustained by the study of the growth of the lymphatics into the organs.

The second series of experiments in regard to the origin of the lymphatics has been the tracing of the finished lymphatics back to the earlier stages and concerns the study of the lymphatic sacs. Everyone who has worked on the lymphatic system in early stages is aware of the extreme difficulty in identifying lymphatics. There are so many structures with which they may be confused in sections that it seems as if almost the only clue with which to meet the difficulty is to start with the finished lymphatic system and trace it back to the younger stages. The finished lymphatics in the skin of the embryo are identified with great ease by means of injections; their characteristics are so well known that they cannot be mistaken. In younger stages the character of the lymphatic capillaries more closely resembles the blood vascular capillaries, so that it becomes even more necessary to have injections that will show whether the vessels in question are connected with the blood vascular system or with the lymphatics. By a great number of lymphatic injections it has been shown that the lymphatics in the skin of

[6]Flint. Amer. Jour. of Anat., Vol. VI, 1906.

the pig run either to the neck or to the groin. In the neck these vessels run either to a sac or into the group of lymph nodes into which this sac differentiates.

In studying the cervical heart, the first anlage of the lymphatic system, I was able to trace it back, first by lymphatic injections, and, where they failed, by vascular injections, to a stage where it consisted of a small sac against the jugular vein. The opening of this sac was difficult to find in sections even in later stages, where one could watch the injecting fluid pass from the lymphatic duct into the vein. In these injected specimens, however, it was possible to find the valve in sections, and they showed that the lymphatics entered the vein at a very oblique angle. Having found how the valves looked in later stages, it was possible to find them in earlier stages. I followed the origin of the lymph heart back to a stage in which it is a simple sac connected with the vein, and interpreted this as a budding out from the vein. This sac is to be found in embryo pigs about 15 mm. long. Dr. Lewis, of Harvard, approaching the subject after a careful study of the veins, was able to trace the origin of the cervical sac still further.[7] He showed that there is first a plexus of veins in the region of the sac; these veins are in free connection with the jugular vein. Then the plexus of veins is cut off from the jugular and appears full of blood, but without venous connections. Later the plexus forms a sac and rejoins the main vein. After it has joined the vein it becomes empty of its blood. This discovery of Dr. Lewis I can entirely confirm. The methods of injecting embryos have been much perfected in our laboratory, so that we have many series of sections of complete vascular injections, including embryos from 10-30 mm. in length. In one specimen of an embryo 15 mm. long, I have the symmetrical sacs in the neck filled with blood in both sides. On one side a very small amount of the ink injected into the vein has run over into the sac, showing that it has a small opening on the one side and none on the other. Thus the origin and relations of the cervical lymph heart have been traced.

Dr. Lewis discovered a similar sac in the root of the mesentery of a pig embryo 20 mm. long and identified it as a part of the lymphatic system. We were working on this mesenteric sac at the time, but had not been able to interpret it. Mr. Baetjer has traced the origin of Dr. Lewis' mesenteric sac and its relation to the thoracic duct. He

[7]Lewis, F. T. Amer. Jour. of Anat., Vol. V, 1905.

will report his work at this meeting and will show that the mesenteric sac arises from the veins of the renal anastomosis, independently of the thoracic duct; the receptaculum chyli arises as still another sac, adjacent to the azygos veins, and in an embryo 3 cm. long the mesenteric sac and the receptaculum chyli have joined and can be injected. The details of the origin of the receptaculum chyli Mr. Baetjer is not yet ready to report.

In regard to the posterior lymph sacs, I can demonstrate them in sections, but have not studied them further. Thus far it has been shown that there are six primitive sacs which form the anlage of the lymphatic system. Four of these sacs are paired, two in the neck and two in the groin, while two are unpaired, one at the root of the mesentery and the other behind the aorta forming the receptaculum chyli. All of these sacs arise independently, all have a complete lining of endothelium and the three that have been studied with care, namely, the two cervical sacs and the mesenteric sac have been shown to arise from the veins.

We must now take up the question brought up by Dr. Huntington and Dr. McClure as to whether these sacs are the first lymphatics. At our meeting last year, Dr. Huntington and Dr. McClure showed a series of models representing the development of the lymphatic system. Some of the later models showed the true cervical lymphatic sac, easily identified as the sac which I had published as the first anlage of the lymphatic system, a point which had been confirmed by Dr. Lewis. In disagreement with both Dr. Lewis and myself, these models carried the origin of the lymphatics back to much earlier stages, showing them in cat embryos 8 to 8.5 mm. long. Dr. Huntington and Dr. McClure describe oval or spindle-shaped spaces arising along the veins as the result of shrinkage and condensation of primitive redundant precardinal vein channels. These spaces they describe as situated without the intima of the veins in the peri-intimal adventitious tissue and are not to be confounded with the mesenchymal spaces of Sala, since they develop in territory formerly occupied by the veins themselves. From this it is not clear what forms the lining of these spaces; since the veins at this stage have only a lining of endothelium which rests on a connective tissue syncytium, these spaces must be lined either by endothelium or by the connective tissue, unless one imagines them as formed by a sagging of the endothelium away from the surrounding tissue so that the spaces are bounded by endothelium on the one side and the connective tissue on the other.

I have cut many new sets of serial sections of various stages of pig embryos, from 10 to 16 mm. long, and am convinced that these early lymphatics cannot be demonstrated. Spaces exist, but they are not part of the lymphatic system. In the first place, there are a very interesting series of spaces, which encircle many of the nerves and may be called peri-neural spaces. These peri-neural spaces, which were excluded from the lymphatic system in my earlier work, since they are easily injected but never connect with the lymphatic system, are large and prominent in early embryos. Inasmuch as the nerves are often close to the veins, the peri-neural spaces often touch the veins. I have many specimens showing that these peri-neural spaces are like the arachnoid from which they can be injected, and I will later show their development. They are especially large around the growing tips of the nerves and they will be demonstrated at this meeting. These peri-neural spaces are to be distinguished from lymphatics by the absence of endothelium, by the fact that they arise from the destruction of connective tissue and by their following the nerves. They have undoubtedly great physiological significance, and may supply the place of a lymphatic system to the nervous system, since it never receives true lymphatics.

Besides these peri-neural spaces, there are true rounded spacs in the mesenchyme which undoubtedly contain lymph but which are not a part of the lymphatic system. There are also veins, or blood capillaries, which are exceedingly difficult to trace in relation to other blood capillaries in uninjected specimens. Just as in adult tissues one cannot trace a capillary plexus completely without injecting it, so one meets the same difficulty in the embryonic stages. From a careful study of new sets of sections of early stages we feel that the true lymphatics cannot be demonstrated before the appearance of the lymph sacs, and therefore think that the importance of the lymph sacs as the first lymphatics is fully emphasized. It seems to me that it is now possible to define the lymphatic system as a series of vessels lined by endothelium which arise from transformed veins and eventually open into the veins. All tissue spaces bordered only by connective tissue and all the serous sacs are to be excluded from the lymphatic system morphologically. Previous to the formation of the lymph sacs, the anlage of the lymphatic system, there are no spaces which have been proved to become a part of the true lymphatic system.[8]

[8]Inasmuch as the discussion which followed the reading of the papers of the Lymphatic Symposium of 1908 will not be published, I should like to

We pass now to the third important point in connection with the origin of the lymphatic system, namely, the series of blind spaces, definitely lined with endothelium, which Dr. Lewis has pictured in a series of most careful reconstructions of the development of the lymphatics in the rabbit.[9] In a rabbit embryo of 11 mm., or 14 days, he pictures the lymphatic system as consisting simply of the cervical sac. Later, in embryos nearly 15 and 17 days old, he pictures isolated spaces along the external mammary and umbilical veins. Dr. Lewis does not picture any of these spaces in the pig of 20 mm., where the entire system consists of the cervical sac, the mesenteric sacs and the receptaculum chyli, but if the later stages of the cat and rabbit embryos show them, one should be able to find them in pig embryos older than the stage of 20 mm. Thus Dr. Lewis agrees in regarding the sacs as primitive anlagen of the lymphatic system, but disagrees in finding multiple endothelial anlagen associated with the growing system of ducts. Since these spaces are lined with a definite endothelium, they form a much more serious obstacle to the theory of growth of the lymphatics from the endothelium of the veins than the more indefinite spaces to be found in earlier embryos, and I cannot but think that if these multiple endothelial-lined isolated spaces do exist along the veins in the later stages, they would form serious evidence against the theory of the origin of the lymphatics

add one or two footnotes to my paper to bring out the points in which we now all agree and those in which there are still differences of opinion. In this paper, if I seem to lay too much emphasis on the method of the origin of the lymph sacs, it is because that was the chief point of controversy at the meeting of 1907. Since we have all come to agree that the lymph sacs arise from the veins, that they are preceded by a plexus of veins which separate from the main veins, then unite to form lymphatic sacs and subsequently join the vein again, it is clear that the most fundamental and important evidence for the venous origin of the lymphatic system still stands. We may then regard as established by the recent American work on the lymphatic system that the primary lymph sacs are derived from the veins, that their endothelial lining is derived from the venous endothelium, and that the permanent openings of the lymphatics into the veins are secondary rather than primary. In regard to the primary lymphatic sacs or hearts, in mammals, only the jugular lymph sacs and the mesenteric lymph sac have been thoroughly investigated. The posterior lymph sacs, the receptaculum chyli and probably symmetrical lymph sacs along the subclavian veins for the lymphatics following the deep vessels of the arm and the external mammary veins need further study.

[9]Lewis, *Ibid.*

from the veins. Or at least if the lymphatics, in their growth, do pick up isolated endothelial-lined spaces, we shall again be left without a clue as to the origin of the lymphatic system. These multiple anlagen would then need to be traced back to their origin before any generalization in regard to the lymphatic system could be made.

I have not had the same material as Dr. Lewis with which to test his numerous anlagen, but if they be general, one should be able to find them, whenever lymphatics are invading a new territory following the veins. I have, therefore, tested the point in the zone of the skin previously described where both invading blood vessels and invading lymphatics can be studied. The test was made in this way: The lymphatic plexus between the eye and the ear in pigs 50 to 55 mm. long was injected. Some of the injections were made complete, which can be done in this way: after withdrawing the needle the finger is laid on the plexus and gentle pressure applied until the terminal sprouts just rupture. Other injections were left purposely incomplete, and some specimens were not injected at all. Serial sections of all the specimens were made, cutting parallel to the surface of the skin, and then the specimens were studied with reference to whether there are isolated vessels in front of the growing lymphatics. The first important point is to be gained from watching the injections. It will be often seen in making an injection that large, long sprouts run out in front of the plexus; often from such a long sprout a slender side channel will suddenly shoot out and open into a large space which might easily appear isolated in sections. When this second large vessel is full a second slender channel will open up from it and carry the injection mass back to meet the main plexus. Thus it might have been injected at first from the main plexus, but the mass runs easiest into the wide channels and the very slender, collapsed vessels open up only under pressure. From these experiments one may readily expect difficulties in tracing the connections of such spaces in uninjected specimens.

The serial sections bring out three points: First, that in complete injections there are no vessels which have not received the injecting mass. Secondly, in partial injections and uninjected specimens there are endothelial-lined vessels which can be traced only with difficulty or not at all to the primary plexus. Thirdly, since some of the injecting fluid often flows out of the vessels when the needle is withdrawn, one can find vessels containing ink and which must have been injected from the plexus, and yet one cannot trace their slender connections. From this evidence we doubt if such isolated vessels really exist in front of growing lymphatics. Of the accuracy of Dr. Lewis' observations on these anlagen we have no question; they undoubtedly exist in serial sections, so we question not the observation, but the limitations of the method. If in adult tissues sections without injections are wholly inadequate to show all of the blood capillaries, it is obvious that they must fail more conspicuously with lymphatic capillaries where the walls are thinner and the channels are often excessively small and collapsed. Thus, where I have been able to put the test of injection, there are no isolated anlagen of endothelial-lined spaces preceding the growing lymphatics.[10]

Thus the reworking of the subject of the origin of the lymphatic system seems to me to have emphasized the fundamental distinction between tissue spaces in the mesenchyme and the endothelial-lined lymphatics. The first lymphatic endothelium is derived from the venous

[10] As was stated in the first footnote, we are all agreed in regard to the method of origin of the primary lymph sacs as far as they have been studied. The differences of opinion have wholly to do with the growth of the lymphatics after the lymph sacs have been formed. There are before us three possibilities; first, one suggested by the isolated endothelial lined spaces shown in Dr. Lewis' reconstructions along the course of veins near growing lymphatic zones. These might be interpreted as the formation of multiple lymph hearts from the veins. There is no theoretical objection to this interpretation, but, if I judge correctly, Dr. Lewis wisely refrains from making it definite for lack of positive evidence. My work offers some suggestion that a more adequate method than that of serial sections alone may eventually show that these isolated rings of endothelium are in reality connected with the lymphatic endothelium. The second possibility is that to the lymph sacs are added tissue spaces lined by mesenchyme and that these tissue spaces form the lymph trunks. This position seems to me wholly untenable, it means that the lymphatics first arise from venous endothelium which is growing by the method of sprouting; then the system grows by additions of a new kind of lining cell, and subsequently returns to its primitive method of growth, namely, the sprouting of endothelium. This seems to me out of harmony with the laws of growth as far as we know them. The third possibility, which seems to me the most likely to be correct, is that the lymphatics grow from the various primary lymph sacs by the sprouting of endothelium and gradually spread over the body. Wherever it has been possible to test this method it has been found to hold. I believe that it is only the difficulty of making lymphatic injections in the early stages immediately after the formation of the lymph sacs that makes this point still an open question. It can undoubtedly be settled by further studies of growing lymphatics, and these studies must be based on the crucial point, which is to find the source of all of the endothelium of the lymphatic system.

endothelium, not by a simple process of budding, but by a transforming of veins into the primitive lymphatic sacs. To recapitulate, (1) all the lymphatic vessels arise by a process of sprouting from the lymph sacs, which in turn are formed from the veins; (2) no lymphatics have been demonstrated in embryos before the lymph sacs are formed; and (3) the additional anlagen of Dr. Lewis can be injected from the lymphatic system and therefore must also arise from it. In uninjected specimens the connections cannot always be seen.

IV.

The Origin of the Mesenteric Lymph Sac in the Pig.

BY

WALTER A. BAETJER.

From the Anatomical Laboratory, Johns Hopkins University.

In the study of the origin of the lymphatic system, it has been found that there are certain primitive sacs arising in different regions which represent the earliest lymphatics. To find the origin of these sacs is, therefore, the most fundamental part in the study of the origin of the system as a whole. The cervical lymph sac or heart, which is the first to appear, has already been worked out and proven to come from the veins. In this work, which was undertaken for the purpose of tracing the development of the thoracic duct, it was subsequently found that the relation of this duct to a sac at the root of the mesentery must first be determined, inasmuch as the latter appears before there is any anlage of the receptaculum chyli.

This sac, located in the root of the mesentery between the Wolffian bodies, and just ventrad to the renal anastomosis of the subcardinal veins, was first noticed by Dr. Lewis, of Harvard, in following the transformations of the vena cava inferior in rabbits.[1]

In this paper, in the plate illustrating the vessels of the region, the lower portions of the subcardinal veins are detached from the rest, and, "though colored blue," like the veins, they are described as spaces in the mesentery, suggesting the lymph hearts of the chick. It is also stated that they may be subcardinal derivatives. In a later paper Dr. Lewis makes it more sure that these vessels are lymphatics.[2]

[1]Lewis, F. T. Amer. Jour. Anat., Vol. I, 1901-02.
[2]Lewis, F. T. Amer. Jour. Anat., Vol. V, 1906.

To trace the origin of this mesenteric sac, serial sections of pig embryos of varying stages have been cut. These embryos were first injected through the umbilical vein with India ink, so that all the blood vessels of the region, arteries, veins and capillaries were well filled. In an embryo of 16 mm. there are no vessels whatever in the region where the sac is to form, and the root of the mesentery is a homogeneous network of embryonic connective tissue. At 17 mm. a few small blood capillaries have appeared in the mesentery; their course is extremely short, running only the length of a few sections, and they arise from the renal anastomosis of the subcardinal veins. Through the stages of 18 and 19 mm. there is a gradual increase in these small mesenteric veins; they become more numerous, of definitely larger caliber, while at the same time there is an increase in their length. During this time, also, there is a beginning of the process of fusion, a process which eventually leads to the formation of the sac in later stages.

From now on, that is, from 19 to 20 mm., the changes which have hitherto been gradual become much more rapid. The blood capillaries increase in number and size and many of them fuse into channels having a close resemblance to the definite sac of later stages, but still connected with the veins, as is shown by the injection mass. This active process continues through embryos between 20 and 21 mm. when there is a definite sac with irregular margins due to the fact that the sac is formed by the coalescence of numerous capillaries. At 21 mm. there are still definite venous openings, although they are gradually being lessened. Between 22 and 23 mm. the sac becomes entirely cut off from the veins, so that it receives no injection by way of the veins. This leaves the sac for a short time entirely independent both of the veins and of the lymphatics, for the primitive receptaculum chyli forms between the stages 23 and 25 mm. The receptaculum chyli forms dorsad to the aorta adjacent to the azygos veins. Vessels from the sac grow toward the receptaculum and anastomose with branches from the receptaculum, so that by the time the embryo is 30 mm. long the mesenteric sac is freely connected with the thoracic duct and can be injected from it.

To sum up, then, the following conclusions may be noted: That the mesenteric sac begins as a mass of blood capillaries lying ventrad to the renal anastomosis of the subcardinal veins. They become fused into a sac which can first be injected from the veins; but the venous openings become gradually obliterated, making the sac entirely independent of venous or lymphatic connections. Subsequently the sac joins the receptaculum chyli and thus becomes a part of the lymphatic system. We have then, here as elsewhere, clear evidence of the genesis of the lymphatic system from the veins.

V.

The Development of the Lymphatics in the Small Intestine of the Pig.

BY

GEORGE J. HEUER, M.D.

From the Anatomical Laboratory, Johns Hopkins University.

If it be true that the lymphatics arise from the veins and grow from center to periphery, it should follow that they will gradually grow to and invade the different organs of the body, and it should be possible to trace their growth into each organ and their gradual differentiation within the organ. It was to test this point in the intestine that this work was started. The lymphatics have been traced by means of the method of injection in their growth through the mesentery into the wall of the intestine. Then the successive formation of the primary and secondary plexuses down to the ultimate capillaries has been followed. Thus the work adds one link in the chain of evidence for the venous origin of the lymphatics.

The lymphatics of the intestine were injected by way of the thoracic duct. By the time the embryo is 3 cm. long the thoracic duct is connected with the mesenteric sac, which lies ventrad to the renal anastomosis of the subcardinal veins and between the superior mesenteric arteries. The thoracic duct is injected by introducing a hypodermic needle close to the aorta, just behind or dorsad to the intercostal arteries. When care is taken not to enter the post-cardinal vein, a lymphatic injection can be obtained almost every time. Prussian blue and India ink were used for injection masses. In embryos larger than 12 cm. the intestine could not be injected from the thoracic duct on account of the intervention of the mesenteric lymph nodes. In these stages the mesenteric lymph nodes were filled with the injection mass and the fluid passed from them out to the intestine. Later on the needle was introduced directly into the wall of the intestine. The portion of the intestine studied in all cases is a loop which coils around the root of the mesentery. This loop has the shortest mesentery and hence is the easiest to inject.

In an embryo 3 cm. long an injection into the thoracic duct is difficult but not impossible to make, and shows that the injection mass runs into a sac at the root of the mesentery. In an embryo 4.3 cm. long numerous lymphatic injections show that the plexus of lymphatic ducts in the mesentery has extended in the mesentery almost to the wall of the intestine, but never into the wall. These lymphatics follow the course of the mesenteric arteries. In embryos 6, 7 and 8 cm. long the ducts have reached the wall of the intestine.

The marginal zone of the developing lymphatics, as seen in cleared total mounts of the injections of each stage, shows the blunt rounded ends characteristic of lymphatics invading new territory.

The second step in tracing the development of the intestinal lymphatics is their differentiation within the wall of the intestine. The vessels which enter the intestine, first penetrate the muscle coats and enter the submucosa. This is shown in embryos 8 to 10 cm. long. Within the submucosa the lymph trunks divide into two trunks, which encircle the intestine. In an embryo 8.7 cm. long these two vessels have anastomosed, making a series of loops in the submucosa. In the completed report these segmental loops will be discussed with reference to a lymphatic unit. These loops soon become converted into a primary plexus in the submucosa.

From this primary plexus a secondary lymphatic plexus develops in the mucous membrane at the base of the villi, and from this plexus branches enter the villi. The vessels of the villi appear in embryos from 8.7 to 9 cm. long.

The lymphatic plexus of the serosa develops late and has not appeared until the embryo is 10 cm. long. It is formed from vessels that grow from the primary ducts that enter the intestine as well as from ducts that grow outward from the submucosal plexus.

From the study of the development of the lymphatics of the intestine it is clear that the growth of these vessels is from center to periphery, and that in their differentiation the lymphatics follow the general lines of the development of the blood vessels in their segmental arrangement, in their primary distributing plexus of submucosa as well as in the development of the ultimate capillaries.

VI.

The Origin and Development of the Anterior Lymph Hearts and the Subcutaneous Lymph Sacs in the Frog.

BY

HENRY McE. KNOWER,
Johns Hopkins University.

As the writer was prevented from reading this paper before the Association of American Anatomists in Chicago, the following abstract is now presented:

1. No lymphatics can be demonstrated in palustris embryos before a stage of about 6.5 mm. (Embryos of R. virescens and R. sylvatica were also studied with results similar to those given here for R. palustris.) At this period the epidermis lies relatively close to the myotomes, with but little connective tissue between.

2. The first lymph vessels to appear are the anterior lymph hearts, as was demonstrated in embryos of this stage by the writer before the American Society of Zoologists in Philadelphia, December, 1903. It was formerly believed (Jourdain, etc.) that the posterior lymph hearts were the first to develop and that these were not formed until the time of the appearance of the hind limbs. The writer believes, as was stated in 1903, that his announcement made at that time was the first claim of as early an origin for the anterior hearts in very young embryos as described in this paper.

3. A single pair of lymph hearts is differentiated at this stage, one on either side of the body, arising from a vein opposite the fourth myotome.

4. When first found, the anterior lymph heart of each side lies over the posterior end of the elongated pronephros, and empties into the fourth intersegmental vein (*i. e.*, between the fourth and fifth myotomes) through its primary connection.

The discovery in Anura of this primary relation of the anterior pair of lymph hearts to the segmental vessels is of fundamental comparative value, in bringing this first pair to develop within the same serial homology as the posterior pairs of lymph hearts which arise later from segmental vessels at the base of the tail.

There is evidence that the anterior pair of lymph hearts may, at times, in the same species develop from a vein in an intersegment other than the particular one mentioned, instead of constantly from the same vessel; and that in different species, as virescens and palustris, this pair of hearts may arise from different segmental vessels.

The Anura may now be compared more closely with the Urodela, where the segmental series of lymph hearts is more extensive.

5. Though the early connections may be traced in older embryos, the primary segmental arrangement is later obscured by the increase in connective tissue, by the gradual growth and concentration of the pronephric sinus (*i. e.,* Ductus Cuvieri), by the distension of the dorsal coelomic cavity, and by the consequent shifting of the relations of the lymph hearts until they come to lie above the posterior portion of the pronephros, dorsally and outward from the myotomes nearer the epidermis. They hold this position in embryos from 10 to 12 mm. The heart empties into the pronephric sinus (Ductus Cuvieri) just back of the last pronephric funnel and opposite the glomerulus. It fills a corner bounded by the posterior dorsal angle of the pronephros in front, the dorsal wall of the cœlom below and the myotomes medially. The lateral nerve gives off its dorsal branch just over the lymph heart.

6. In its early stages the wall of the anterior lymph heart, outside of the endothelium, is a peculiar web-like syncytium, in which striated muscle fibrils are laid down irregularly. At about the 8 mm. stage, the fibril bundles are numerous and branch freely.

7. Since the hearts arise in an intersegment just next to the ventrolateral edges of two adjacent myotomes, the source of this striated muscle has been suspected to be in these myotomes. The endothelium of the heart wall is continuous with that of the intersegmental vessels, hence a contribution of syncytial protoplasm from the myogenic cells, which are found in this region of the myotome, to the walls of the adjacent lymph heart is evidently possible.

A number of preparations lend support to this view of the derivation of the musculature of these lymph hearts, rather than to a theory calling upon the general mesenchyme to supply this specialized type of tissue.

8. Two important trunks can be clearly defined on each side opening into the anterior lymph heart of the same side in an early embryo, 7.5 mm. to 8 mm. These trunks run parallel with the surface of the skin along the course of the lateral nerve in the connective tissue external to the segmental blood vessels. The shorter trunk runs back from the head. It enters the heart as it meets the longer one from the body, which follows the course of the lateral nerve forward over several segments, external to the segmental vessels.

The openings of these lateral lymph trunks into the lymph heart are guarded by valves, as is the opening of the heart into the vein which conveys its contents into the pronephric sinus (Ductus Cuvieri). The walls of the lateral lymph trunks are delicate endothelium, continuous with that of the lymph heart.

9. A study of successive stages shows that the subcutaneous lymph sacs arise from these primary lateral lymph trunks as a result of an extensive ramification of these vessels in the connective tissue, now much more abundant. The ramifications of the primary trunks coalesce as the partitions break down, thus producing saccular cavities beneath the skin which still retain their openings into the anterior lymph hearts.

10. The structure of the anterior lymph hearts may be best observed at an early stage, alive and in action, in embryos which have been caused to develop without a systemic heart, or with circulation partly arrested through the action of acetone-chloroform, or otherwise.[1] In such specimens an extensive œdema, which distends the tissues, renders them exceptionally transparent and makes it possible to study the course of the lymph stream through the movement of corpuscles, the action of valves, the contractions of the hearts, etc.

Conclusions.

The origin of the lymph hearts, and especially of the anterior pair, is thus shown to take place at an earlier stage of the anuran embryo than has been previously indicated for Amphibia, and at a relatively earlier stage than that described for any vertebrate; while the demonstration that the anterior lymph hearts arise from segmental veins of the trunk, brings them within the same serial homology as the posterior hearts and the more numerous segmentally arranged hearts of Urodela.

The results of Jourdain, H. Hoyer and his pupil Radwanska are modified, and the history of the lymphatic system is carried back to a much earlier stage (as already demonstrated by the author in 1903), and to a primitive condition of comparative value in reference to other vertebrates.

The mode of development here described for the anterior lymph hearts is somewhat similar to that described by Sala for the posterior pairs of the embryo chick of 7 to 8 days and later, where the hearts are also derived from branches of segmental vessels.

[1]"Effects of Early Removal of the Heart and Arrest of the Circulation on the Development of Frog Embryos." H. McE. Knower, American Journal of Anatomy, Vol. VII, No. 3, Anatomical Record, 1907, Vol. I, page 162.

The method of development of the extensive subcutaneous lymph sacs of the trunk of the frog from the ramification of at first simple tubular vessels (the lateral lymph trunks), is like that imagined by Ranvier, and recently described by G. Goldfinger for the similar sac of the posterior extremity of the frog.

VII.

The Hæmolymph Glands of the Sheep.

BY

ARTHUR W. MEYER,

Assistant Professor of Anatomy, University of Minnesota.

From a study of sheep fœtuses, of the new-born, of lambs of varying ages and of several thousand carcasses of sheep, the following conclusions regarding the development, occurrence, structure, and, secondarily, of the function of the hæmolymph nodes, seem justified.

The earliest differentiation between the *anlage* of lymphatic and hæmolymph nodes is seen in fœtuses about 9.8 cm. long. In such fœtuses the typical hæmolymph nodes can be seen, and all stages of development from these early nodes to mature nodes can be obtained by making serial sections of the tissue, in the lumbar region for example. A study of such series shows that the hæmolymph nodes arise from mesenchyme, and later become vascularized.

The hæmolymph nodes have an irregular distribution, are not constant in occurrence, and disappear with age. They may be found anywhere near the viscera from the base of the skull to the rectum, but are never found on the abdominal wall, on the diaphragm or in the inguinal or subscapular regions, in both of which places lymph glands are found. Subcutaneous nodes, so constant in bovines, were never found in sheep. No definite grouping of the hæmolymph nodes was found but a para-rectal, a lumbar or prevertebral, a thoracic or paravertebral, a mediastinal and a deep cervical group might be spoken of. In young sheep 30-40 glands is a fair estimate, though the widest differences in size and occurrence exist.

Hundreds of injections from adjacent glands, made directly upon the carcass immediately after death, supplemented by similar injections in excised tissue, and further injections of carmine gelatine and Prussian blue from the aorta and vena cava in fœtuses, lambs and young sheep, together with repeated injections of lymph glands and of the large lmphatic trunks, prove conclusively that the hæmolymph nodes of the sheep are entirely independent of the lymphatic system, and that they are not intercalated in the course of veins.

The structure of the hæmolymph nodes varies from that of a dense mass of lymphatic tissue with many or no follicles and erythrocytes to a sac of blood containing but a few remnants of lymphatic tissue. Between these extremes every transition is found. The nodes of young lambs usually contain more follicles, and quite frequently these are so closely packed that their contiguous sides are flattened. They often contain blood spaces and occasionally an artery, but, as a rule, injection masses do not penetrate them.

Other conclusions were these:

1. That the reticulum is not lined by endothelium.

2. That the circulation is an open one.

3. That the peripheral sinus and blood sinuses are not in direct connection with either the venous lacunæ of Weidenreich or with the arteries, save developmentally.

4. That the peripheral sinus and blood sinus are inconstant structures, while the venous lacunæ are always present, even if not evident, on cross section of a node.

5. That the peripheral sinus and blood sinuses often contain more reticulum and leucocytes than the venous lacunæ, and that they are not injected from the arterial or venous side unless high pressures are used.

6. That the arterioles open directly into the venous lucunæ and that the latter communicate with each other and with the veins.

7. That the relation of the vein or veins to the node is an exceedingly variable one, and is frequently merely a contact relationship.

8. That small veins occasionally join the hæmolymph nodes by penetrating the capsule near the periphery, and that these veins are afferent veins.

9. That the relation of the artery to the node is a constant one.

10. That it is easy to distinguish a hæmolymph node from a lymph node by means of injection, and that it is equally easy to distinguish a venous injection from an arterial one.

11. That the giant cells, hyaline cells (Drummond) and large phagocytic cells arise from the connective tissue and reticulum cells in both the embryonic and adult node.

12. That iron was never found and that the change in color on exposure to hydrogen sulphide, variously used, does not indicate that hæmolymph nodes contain an excess of iron.

13. That pigment is rarely found in hæmolymph nodes, but frequently in lymph nodes.

14. That the blood cells in the peripheral sinus and blood sinuses are generally well preserved, while those in the venous lacunæ are frequently degenerated.

15. That a definite hilum can seldom be recognized macroscopically.

16. That fat was never found in hæmolymph nodes, that a degeneration into fat was not observed, and that the hæmolymph nodes appear before fat appears in the fœtus.

17. That no classification into spleno- and marrow-lymph nodes is possible.

18. That "mixed" glands, *i.e.,* true hæmolymph glands, were not found.

19. That the occurrence of hæmolymph nodes has no recognizable relation to fatness, sex, pregnancy, castration, hygienic conditions, to tuberculosis or some acute bacterial infection or severe infections with Œsophagastoma columbanum, but that age has an important bearing upon the size and number, and, to some extent, upon the structure of the nodes.

20. That the hæmolymph nodes of the sheep, goat and bovines are very similar in structure.

21. That in view of these facts, the word hæmolymph as applied to these nodes in the sheep is a misnomer, and that the term hæmal node, suggested by Lewis, is to be preferred.

VIII.

Subcutaneous and Subpanicular Hæmolymph Glands.

BY

ARTHUR W. MEYER,

Assistant Professor of Anatomy, University of Minnesota.

On examination of carcasses of beeves in abattoirs a number of hæmolymph nodes can usually be found lying in the subcutaneous fat over the neck and shoulder and, more particularly, in the region directly anterior to the hip. These nodes vary in number from one to a dozen on each half of the carcass and have the same appearance as those in the lumbar prevertebral region. They vary in size from a half to one and a half centimeters, are oval or circular in outline and usually flattened laterally. In color they vary from a bluish black to a bright red or pale pink. They are usually firm, the blood cannot be expressed from them by pressure, and injections of India ink fail to reveal any lymphatic vessels. They are most numerous in young cattle and were found in fœtuses of twenty-two or more centimeters in length. In old cattle they are generally small or absent altogether.

Their structure is very similar to that of the hæmolymph nodes of sheep, and as wide variations in structure were found to exist. Such differences in structure as exist are minor even in the case of developing glands. In the latter the occurrence of giant cells is particularly noticeable, and, as in the case of developing hæmolymph nodes of the sheep, they arise from mesenchyme.

In carcasses showing evidences of generalized tuberculosis, no change in these nodes was noticeable.

No relation between the size and number of these nodes and any condition, save that of age, was observed, although such a relationship very likely exists.

IX.

Distribution of the Subcutaneous Vessels in the Tail Region of Lepisosteus.

BY

WILLIAM F. ALLEN,

From the Herzstein Marine Laboratory, Pacific Grove, Cal.

This communication is an abstract from a recent study of the subcutaneous vessels in the tail region of Lepisosteus, which was a continuation of a recent paper[1] on the "Distribution of Subcutaneous Vessels in the Head Region of the Ganoids Polyodon and Lepisosteus." It was an attempt to see what light a study of these vessels in this group would throw on the general problem as to whether these vessels in fishes were veins or lymphatics; or a common system that might function for both; or if, perchance, they might not function as veins in the lower or more generalized forms, and lymphatics in the higher or more specialized forms. In other words, to ascertain, if possible, what bearing, if any, they might have on the origin and phylogeny of the lymphatic system.

In the tail region of Lepisosteus there are four longitudinal sub-

[1]Proc. Wash. Acad. of Sci., Vol. IX, pp. 79-158, 1907.

cutaneous vessels and two profundus trunks in the hæmal canal, which collect a subcutaneous network that so far as could be determined is entirely separated from the arteries or their capillaries, and which in one way or another terminate in two caudal sinuses that discharge themselves in the caudal vein.

The two caudal sinuses are elongate reservoirs situated ventrad of the posterior end of the vertebral column. They communicate mesad with each other, dorso-cephalad with what has been designated as sinus (x), and ventro-cephalad with the caudal vein, the latter orifice being guarded by a pair of semi-lunar valves.

Posteriorly one of the caudal sinuses, more often the right, receives what has been described as the caudal trunk, which is merely a prolongation of the ventral trunk to pass through the basal canal of the caudal fin, where it runs parallel to a corresponding caudal artery and vein. From each ray it receives two branches which traverse the dorsal and ventral surfaces of the ray and collect a rather coarse network from the fin membrane. This network is not continuous with arterials from the fin ray arteries. The caudal trunk in its course from the tail to the caudal sinus follows the caudal artery, and is in fact a more profundus trunk than the caudal vein, which passes cephalad between the superficial and profundus muscles of the caudal fin.

The ventral trunk, of which the caudal is a posterior continuation, travels along the ventro-median line, just within the skin, and in passing through the basal canal of the anal fin collects paired branches from each ray, which assemble a similar network from the fin membrane to that found in the caudal fin.

Each caudal sinus receives a most important communication through its dorso-cephalic wall, which has been described as sinus (x). These sinuses, which follow along the ventro-lateral surfaces of the preceding vertebræ, collect a lateral and a longitudinal hæmal trunk, and one or the other of them, the dorsal trunk.

The dorsal subcutaneous trunk travels along the dorso-median line just below the skin, but when the dorsal fin is reached, instead of bifurcating into two circular canals at the insertion of the dorsal fin as in the Selachians and most Teleosts, it passes completely through the basal canal of the fin, and similar to the caudal trunk, assembled a pair of canals from each ray, which gathered a network, decidedly lymphatic in the character of its meshes, and which, so far as I am aware, has no connection with the arteries. When about equidistant from the posterior insertion of the dorsal and the base of the caudal fin it makes a ventral bend to cross the vertebral column, usually the right side, and culminates in the corresponding sinus (x). Differing considerably in its termination from Hopkin's description for Amiatus, where it bifurcated with each fork uniting with the lateral trunk, immediately before the latter joined the caudal sinus.

As has been pointed out, the venous supply from the dorsal fin is collected by a pair of dorsal fin ray veins from each ray. In position these veins and the corresponding arteries are nearer the surfaces of the rays than the dorsal fin ray subcutaneous canals. In the basal canal of the fin they are gathered by a dorsal fin vein, which passes through the basal canal in company with the dorsal subcutaneous trunk and the dorsal fin artery. Upon leaving this canal, the dorsal fin vein in the two specimens in which it was traced out crossed the left side of the vertebral column to terminate in the caudal vein. The distribution of this vein recalls the *vena postica* of Mayer and Parker for the Selachians, and, had it anastomosed with the dorsal subcutaneous trunk at the posterior border of the dorsal fin, we would have had a condition of affairs almost identical to that found in the Selachians.

With Lepisosteus the lateral subcutaneous trunk offers few peculiarities not found in Amiatus or the Teleosts. In the Selachians and in Polyodon they are less sinus-like than in the bony Ganoids and in the Teleosts. In Lepisosteus, as in other fishes, they collect numerous paired transverse or intermuscular branches, which assemble a rather coarse network from the connective tissue binding the skin to the myotomes. These transverse branches are undoubtedly prolonged dorsad and ventrad to anastomose with the dorsal and ventral trunks, as in Scorpœnichthys and in other fishes, but this point was not determined for a certainty in Lepisosteus. Instead of emptying directly into the caudal sinus, as in Amiatus, the lateral trunk in Lepisosteus unites with a hæmal trunk in forming sinus (x), which terminates in the caudal sinus. In a 90 mm. L. osseus series a connecting canal was found joining the right lateral trunk with the right hæmal trunk. This communication was in advance of the union of the lateral with the hæmal in forming sinus (x). It was not found on the opposite side of this series or in any of the dissections.

Two longitudinal hæmal trunks were found above the caudal vein on either side of caudal artery in the hæmal canal of Lepisosteus. They are undoubtedly homologous to what Mayer has described in the Selachians as vasa vasorum and to a similar trunk in the hæmal canal of the Teleosts. The cephalic distribution of this trunk was not traced out. No hæmal vessels were found connecting it with the ventral trunk as in the Teleosts, and, as stated above, it emptied into sinus (x).

In Lepisosteus no longitudinal neural trunk was found in the neural canal, as is the case with many Teleosts, and consequently there are no neural vessels to communicate above with the dorsal trunk.

Microscopic sections of a 90 mm. L. osseus showed the subcutaneous trunks, the caudal sinus and the caudal vein to be composed of a single layer of endothelium, surrounded by a mass of connective tissue. They contained but few corpuscles, the red predominating over the white.

No valves were found in the subcutaneous system of the tail region of Lepisosteus, save two semi-lunar valves guarding the entrance of each caudal sinus into the caudal vein.

From the above summary the subcutaneous system of Lepisosteus should fall under the head of a lymphatic system, or a separate subcutaneous venous system that has no counterpart in the arterial system and which may function both for veins and lymphatics.

In favor of the hypothesis that this system in the tail region of Lepisosteus are veins, we find from microscopic sections of a 90 mm. L. osseus that the structure of the subcutaneous vessels and the caudal vein are almost identical, and while they contain but few corpuscles, yet the red predominate.

As opposed to this supposition and in favor of the hypothesis that they are lymphatics, this study has revealed the subcutaneous system of the tail region of Lepisosteus to be entirely separate from the blood vascular system, save at the points where the caudal sinuses discharge themselves into the caudal vein. This system of vessels collects a network, which is decidedly lymphatic in the character of its meshes, is coarser than the blood capillaries, and so far as observed had no connection with the arteries. Furthermore, the peripheral regions are sufficiently supplied with veins, for most of the smaller subcutaneous vessels are accompanied by corresponding arterial and venous branches; the lateral arteries and veins supply the peripheral region of the trunk, the dorsal fin artery and vein nourish the dorsal fin, and the caudal artery and vein do the same for the caudal fin. If the subcutaneous vessels are classed as veins, it would be necessary to consider them as a distinct venous system that had no counterpart in the arterial system.

Concerning the data at hand, we are compelled to admit that the evidence is insufficient to warrant any sweeping statement as to the exact nature of this system of vessels in fishes. The little we have when considered in the light of certain recent studies on the embryology of the lymphatics in mammals supports the supposition that in more primitive Selachians certain subcutaneous vessels, probably veins, have become separated to some extent from the main venous system. According to Sappey ,in the skates, the communications of this system with the veins are quite numerous. In Mustelus and Squalus, Parker and Mayer found these points of union less abundant, but in addition to the connections of the subcutaneous vessels with the caudal vein found in the tail region of the Ganoids and Teleosts, they note that the so-called dorsal cutaneous vein anastomoses behind the dorsal fin with a profundus dorsal fin vein. Such a vein was found in Lepisosteus, but no anastomosis with the dorsal subcutaneous trunk occurred, indicating, of course, that in Lepisosteus the separation of this subcutaneous system had become more complete.

In the head region we find that the same differentiation of the subcutaneous system has gone on as we pass from the Selachians to the Ganoids and from the Ganoids to the Teleosts and Batrachians, but in this region, however, it is more masked. In an earlier paper it was pointed out that each of the branchial lymphatic trunks (nutrient branchial veins?) of Polyodon anastomosed above with the subcutaneous system and below with the inferior jugular vein; that they collected a coarse network from the branchial arches and from their filaments, which, so far as could be ascertained, had no capillary connections with the arterial system. In Lepisosteus these branchial trunks were separated into dorsal and ventral branchial lymphatic trunks (nutrient branchial veins?), which were not connected, and which drained their respective halves of the arches. Those from the ventral portion of the arch emptied into the inferior jugular, while those from the dorsal portion terminated in dorsal branchial sinuses, which were in communication with the subcutaneous system and with the jugular through the cephalic sinus. Similar dorsal branchial lymphatic sinuses were described in Scorpœnichthys[2] as being in communication with the subcutaneous system and with the jugular through the cephalic sinus. No branchial lymphatic trunks were seen emptying into them, but both dorsal and ventral nutrient branchial veins were set forth as uniting directly with the jugular and the inferior jugular veins. It would seem that the only explanation of the above complicated condition of

[2]Proc. Wash. Acad. of Sci., Vol. VIII, pp. 41-90, 1906.

affairs is that a part of the subcutaneous system found in the region of the gills has become entirely separated and reverted back to veins in the higher orders of fishes.

In the Teleosts there is a further differentiation or rather addition. Here we find that the rudimentary hæmal trunk in the hæmal canal of the Selachians and Ganoids has developed into a conspicuous trunk with numerous hæmal branches that communicate ventrad with the ventral trunk. There is also in Scorpœnichthys and in many Teleosts a large and important neural longitudinal trunk, which traverses the neural canal above the spinal cord and sends off numerous anastomosing branches to the dorsal trunk.

In conclusion it may be said that considerable anatomical data support the hypothesis that the subcutaneous vessels of the Teleosts and Batrachians, which are evidently lymphatics, have their homologue in the Selachians with a somewhat similar system, which has much the appearance of veins; while the subcutaneous system of the Ganoids is apparently a sort of intermediary, that of Polyodon, one of the cartilaginous Ganoids, leaning toward the Selachians, and that of Lepisosteus, one of the bony Ganoids, inclining towards the Teleosts and Batrachians.

BOOK REVIEWS.

"Lehrbuch der Entwicklungsgeschichte," by Dr. Robert Bonnet, Bonn. With 467 pages and 341 text-figures. Published by Paul Parey, Berlin, Germany, 1907. Price, $3.25 (*i. e.,* 13 marks).

It is unfortunate that the term anatomy should have become limited in its application to the gross structure of the human body, the proper relations of human anatomy to the broader field of animal morphology being thereby obscured, not a little to its detriment as a scientific study. It will also be unfortunate if, in the course of time, the term embryology should come to denote merely human or even vertebrate embryology, a possibility suggested by the title of Professor Bonnet's volume, which, notwithstanding its title, is avowedly primarily an exposition of the phenomena of human embryology. The possible danger is, however, at present very remote, human embryology being yet in too many of our medical schools but a more or less ornamental appendix to the curriculum. And yet it is undeniable that a proper understanding of adult anatomy is practically impossible without a knowledge of embryology, and it will be well for our anatomical instruction when it becomes clearly understood by both teachers and students that human embryology is not something apart and distinct from human anatomy, but is, as His has expressed it in his classic monograph, merely the "Anatomie menschlicher Embryonen."

Professor Bonnet's volume is another attempt to place in the hands of students a clear and concise account of human embryology, and it may be said at once that so far as these qualities are concerned the book is a success. But the subject is treated from the standpoint of the embryologist rather than from that of the anatomist, and the volume is intended as an introduction to the study of anatomy rather than as a book which the student will find convenient to have continually at hand while he is studying adult structure. It is, however, something more than a treatise on human embryology, for the author has drawn largely upon his knowledge of the embryology of the domestic animals, on which subject he is an authority, and, as he states in the preface, the book may well be regarded as a second, revised and enlarged edition of his *Grundriss der Embryologie der Haussäugetiere.*

These two particulars indicate both what is best and what is faulty in the book. That portion which treats of the early stages of development is excellent throughout, the account of the fetal membranes and placenta being especially clear and thorough, for throughout it the author, by including in his description the various modifications found in the lower mammals, is able to present a more complete and significant description of the fetal adnexæ than would have been possible if the human structures had alone been considered. Of especial interest, too, is the account of the various modifications observable in different vertebrates in the development of the endoderm, the differentiation of the protendoderm and a yolk-endoderm in the Amphibia leading up to the conditions, obscure in themselves, which obtain in the mammals.

But when the second half of the volume, that treating of organogeny, is reached, one meets with a certain amount of disappointment. For the most part the clearness and conciseness of treatment are maintained, but the correlation of the embryonic conditions with adult structure is not always sufficiently brought out, the embryological viewpoint, rather than the anatomical, prevailing in this portion of the book, as it naturally did in the earlier portions. In connection with certain organs, too, the account presented is altogether insufficient. Thus, as to the lymphatics, we are told that "Ueber die erste Anlage der Lymphgefässe selbst ist nichts bekannt;" in the treatment of the peripheral nervous system we learn nothing of the distinction between lateral and median motor nerves and consequently nothing of the important doctrine of nerve components; the account of the development of the sympathetic system is limited to fourteen lines; and throughout a somewhat greater attention to histogenesis would have added much to the value of the book.

But, after all, these limitations depend for the most part upon the viewpoint which the author has selected, and accepting that, Professor Bonnet has given us within a convenient compass a useful and edifying outline of the phenomena of development in the higher vertebrates. The illustrations, which are numerous and in many instances original, are well chosen and admirably reproduced, and there is an excellent index. A serious defect, however, is found in the complete absence of all references to current literature. In the presentation of a subject which is growing so rapidly as embryology and in which so many points must be stated more or less dogmatically, although in reality they are still *sub judice*, it is certainly not sufficient to confine all literature references to an allusion in the preface to Hertwig's Handbuch and the various volumes of the Ergebnisse.

J. P. McMurrich.

"Comparative Anatomy of Vertebrates," adapted from the German of Dr. R. Wiedersheim, by W. N. Parker. Third edition, founded on the sixth German. The Macmillan Company, 1907. $3.75 net.

A new English edition of Wiedersheim's standard work has been needed for some years and will be welcomed everywhere. The third edition is not a new book; on the contrary, it is a careful revision of the second English edition based on the sixth German edition. New material is usually interpolated in the old text, but certain sections, notably those upon the skin, skull, meninges, lymphatic system and the adrenals, have been largely rewritten and improved. The book is slightly larger than the second edition and contains considerably more material, greater compactness having been secured by the use of smaller type for the extensive bibliography.

The bibliography is a very useful feature of the work, but page references and both date and volume should have been given. Unfortunately, references to the bibliography have not been given in the text, and sometimes the results of research have not been incorporated, even when they are found in the German edition.

Some seventy new illustrations have been added, including several half-tones of sections of the skin and a number of colored figures from Gaupp's article on the skull in Hertwig's Handbuch der Entwickelungslehre. Occasionally the terminology of the text differs from that used in explaining an accompanying figure, or even fails to mention the facts which a figure is intended to illustrate.

The opportunity to use the Basle Nomenclature and to apply its principles to comparative anatomy has been neglected. The terminology of the English edition, unlike the German, is not consistent; for example, the translator first uses the term *fenestra ovalis,* but later *fenestra vestibuli.*

At the beginning of the volume we encounter such embryological diagrams as are found in nearly all "anatomies" and which are denounced for their coarseness and inaccuracy by all embryologists. In Fig. 1, "Das unbefruchtete tierische Ei" is represented simply by three nearly concentric circles which the translator well calls a diagram.

The account of the integument has been much improved, notably by the addition of figures from actual sections. The chapter dealing with the skeleton contains a new account of the skull based upon Gaupp's work. The section on the episternum has been omitted.

In the treatment of the nervous system the theory of nerve components has not been considered. Very little is said of fiber tracts; the *nervus terminalis* and the paraphysis are relegated to footnotes. The respiratory organs are satisfactorily treated, and the new figures, particularly the diagrams of the structure of the avian and mammalian lungs, are very helpful. The cœlom is given a very brief treatment in a separate section.

The description of the veins could be greatly improved by taking advantage of well-known embryological studies. A part of the vein described as the posterior cardinal vein in Selachians is identical with a part of that named the posterior vena cava in the Amphibia. The corresponding vessels of Protopterus are named the posterior cava on the right and posterior cardinal on the left. The section on the lymphatic system, having only one figure and three pages of text, is too brief. Even the short statement of the differences between hæmolymph and lymph glands included in the German edition has been omitted in the translation.

The addition of a large amount of new matter, together with the careful selection of material, has largely increased the value of the book without increasing its size and cost beyond the limits of class-room use. This work is of proven value and, in this edition, it will doubtless continue to maintain its unique position as the most valuable college textbook of comparative anatomy.

Leonard W. Williams.

"Handbuch der topographischen Anatomie zum Gebrauch für Aerzte," by Dr. Fr. Merkel, Professor of Anatomy in Göttingen. Bd. I (Kopf), 1885-1890; Bd. II (Hals, Brust und Bauch), 1899; Bd. III (Becken und Extremitäten), 1907.

The appearance of the third volume of Merkel's Topographic Anatomy marks the completion of what is in most respects the best work that has yet appeared dealing with this phase of anatomy. It is now over twenty years since this work was begun. During this time, Merkel has made extensive original investigation of the topographic anatomy in the various regions of the body, and this has enabled him to give the work a stamp of originality rarely seen in a work so comprehensive in scope and so exhaustive in details. At the same time, the views of other investigators in this field have received full consideration, the detailed references to the literature forming one of the most distinctive and valuable characteristics of the work. The illustrations, which form a noteworthy feature, are abundant and well chosen. A semi-diagrammatic style has been adopted, by which the complicated topographic relations are represented with unusual clearness. Wood-cuts (with conventional colors) are employed chiefly, though half-tones have been used with good effect in the last volume. Particular attention has been paid to the surface form observed in the living body in various postures. The BNA system of nomenclature is used (with few exceptions) in the last two volumes. At the end of the third volume is placed a convenient index to the entire work.

Another interesting feature, which is of great theoretical and practical importance, is the emphasis laid upon topographic variations. Wherever possible, these have been classified according to their dependence upon physiological conditions, race, sex and age. Especial attention has been paid to developmental topography, beginning with the earliest embryonal stages. As was first clearly recognized by the late Professor His, it is along this line that we may expect the most important advances in our knowledge of topographic anatomy. Only by a study of the developmental relations can we hope to learn the conditions determining the positions assumed by the various organs; and only when these conditions are known can we hope to understand fully the variations found in the adult body. The scientific basis of topographic anatomy should interest many anatomists who are inclined to turn this subject over to the clinicians.

Merkel's work contains so much that is of unusual merit that it seems invidious to point out what little might be criticised. There is, however, apparently an unnecessary duplication of figures, especially in the first volume. In this volume no less than twenty-two figures appear twice, and three of them even three times. In the case of the illustrations of cross-sections through the body, it would be better to adopt some uniform mode of orientation, preferably dorsal-upward. A few typographical errors appear, chiefly in the lettering of the figures. This was noted in Bd. I, Figs. 181, 182 (corrected in footnote on p. 582), 262; Bd. II, Figs. 49, 53, 77 (3 cm. instead of 30 cm.); Bd. III, Fig. 57. It is unnecessary to state the corrections, as they are obvious except where mentioned. In Bd. II, p. 357, the average weight of the female heart is doubtless intended for 247.7 g. instead of 147.7 g. In Bd. III, p. 6, the reference "Fig. 14" should be "Fig. 15;" and on p. 21, "Darmfortsatz" should of course be "Dornfortsatz."

The cyclopedic character of Merkel's Topographic Anatomy makes it an invaluable work of reference, not only for the anatomist, but also for the practitioner, for whom indeed it was primarily designed. This applies to the general practitioner, and also to those interested only in special regions, such as the pelvis or sense organs. The student just beginning the study of anatomy will not find this work of much service, as the first dissection is necessarily restricted chiefly to an analytical study of the various organs of the body. A synthetic study of the more complicated topographic relations existing in the intact body is at this time next to impossible. In view of the great practical importance of this subject, however, many schools offer an advanced course in topographic anatomy, particularly of the head and trunk, based upon a study of sections, topographic preparations, models, etc. If in connection with such a course the student had access to Merkel's work for reference, he would find it of great value throughout his future clinical work and practice. An English translation of this work would be very desirable.

C. M. Jackson.

"Manual of Practical Anatomy," by D. J. Cunningham, Edinburgh, Scotland. Fourth edition, 1907. Vols. I and II, with 1221 pages and 473 illustrations. Published by William Wood & Co., New York. Price per volume, $2.50.

The fourth edition of Professor Cunningham's excellent Manual of Practical Anatomy has recently appeared. Some parts of the text have been revised and over 40 new illustrations have been added. In addition a few figures have been improved by the addition of color. The new illustrations have been well selected. Over half of them have been added to the chapters on the extremities—parts which were not very fully illustrated in the third edition. The two new figures of the pleural chambers (Figs. 6 and 7, Vol. II) are good.

Professor Cunningham has a clear, attractive style, which adds interest even to the dullest topics. His descriptions are uniformly complete and concise. Every subject is fully treated in the right place. The instructor's task is vastly easier with this dissecting guide than with books which merely list the structures to be found. In my judgment Cunningham's Manual fulfils the purposes of a dissecting guide for medical students better than any other on the market. For advanced students Barker's Laboratory Manual is better, but it does not give enough assistance for a student making his first dissection.

It is to be deeply regretted, however, that Professor Cunningham has not adopted the BNA nomenclature in his new edition. It is true that the BNA terms are given in parentheses the first time the name of a structure is used, when their English equivalents are essentially different from the old terms; but this does not seem to help the student toward using the BNA terms. It is very difficult to get students to use the BNA terms when the old terms are given preference in their dissecting guide. As regards terminology, the plan recommended by Professor Barker and adopted in the American edition of Morris' Anatomy seems excellent. It consists in the use of the English equivalent of the BNA term. The old term might be put in parentheses until the new term has become thoroughly established. This gives more satisfaction on the whole than the use of the Latin words directly, inasmuch as the Latin terms are rather clumsy for the average medical student. The fact that the majority of medical students are not sufficiently well grounded in Latin to be sure of the pronunciation of long Latin names, makes them still more unwilling to use the BNA terms. On the other hand, the English equivalents are readily mastered and will come into general use as soon as the text-books adopt them.

In various parts of the text directions for procedure are given which apply only to the rapid dissection of the body necessitated by English law. In America, as a rule, two or three semesters rather than two weeks are devoted to the dissection of a body. The edition would be better for American schools if these directions had been adjusted to the American plan of dissection or else omitted altogether.

E. T. Bell.

"Manual of Anatomy, Systematic and Practical, including Embryology," by A. M. Buchanan. Vol. I and II, 1539 pages and 625 illustrations, bound in English linen buckram with flexible covers. $2.75 per volume. W. T. Keener & Co., Chicago, 1907.

The author of this combined manual and text-book states with commendable frankness that his purpose was "to furnish students with a complete treatise on the subject written entirely by himself" and that throughout the work he "has kept constantly in view the examinational requirements of students, for whom this work is especially intended."

These words leave the reviewer to infer that the volumes were not intended for students other than those in the author's own country. But this consideration, and the fact that they may answer satisfactorily all the examinational requirements of British students, cannot shield them from criticism upon their merits. The author's first aim is a pardonable one, regarding the validity of which courtesy imposes silence. The second aim, however, helps to classify these volumes in the minds of anatomists.

The text is clearly written, but is too condensed to answer the requirements of a text-book of systematic anatomy. The subject of osteology is well presented and the supplementary matter embodied in this part of the text is good. The embryological notes are usually adequate, but occasionally convey too little information to be of any use save to students having a thorough knowledge of the subject.

Throughout the text the author shows an historical bias which is manifested partly in the retention of obsolete terms—mostly proper names—which are often printed in bold type instead of being omitted or, at least, placed in parentheses. Among these may be mentioned: Haversian gland, page 464; Abernethy's fascia, page 730; glandulæ concatenatæ, page 987; Merkel's cave, page 1000; triangle of Lesser, page 1054; ducts of Walter, page 1060; membrane of Bruch, page 1389; pouch of Prussak, page 1420; pouches of Troeltsch, page 1420, etc. This historical attitude is further shown in the relegation of the BNA to the appendix of the second volume; in the entire lack of evidences showing that recent important contributions to anatomical literature have been consulted; and in the insistence throughout the second volume on the existence of stomata in serous membranes through which serous cavities are said to be in open communication with the "lymph canalicular system," together with the representation of these stomata. Both fasciæ and the lymphatic system are treated in a rather stepmotherly way in the text, and as regards the latter in the illustrations also. The illustrations are numerous and artistic enough to answer the requirements of a combined text-book and manual, perhaps. Among unsatisfactory illustrations the following may be mentioned: Figs. 85, 86, lymph glands in 221, 241, 242, 486, 488, 575, 521 and 1108. The illustrations of arterial anastomoses after Tiedemann are excellent. There is a judicious use of colors, and the selected illustrations from well known sources are numerous, well chosen and among the best.

The directions for the dissector are given after the descriptive text or grouped, as at the end of volume two. They are explicit and generally permit of an orderly exposure of a region. Being printed in small type, it is questionable, however, whether students could readily find the directions desired on so crowded a page. The urethral catheter which obtrudes itself in some of the illustrations, receives first consideration in the directions for dissection of the male and female perineum. It is not quite clear to the reviewer why partiality is shown to this instrument. The trocar, plessimeter, trephine, hypodermic needle, cyclometer, rectal tube, endoscope and various specula suggest further posibilities in this direction!

As a piece of bookmaking these volumes are wholly satisfactory. They are of convenient size, the type is good and differential, and the binding especially suited for laboratory use. Typographical errors, which are few, are found on the following pages: 40, 455, 754, 1071.

We have in these volumes, then, a quiz-compend style of book which may appeal to some students who are preparing for licensure tests, but which, as a text-book of anatomy, can in no way be compared with the best text-books of the present day. As a manual we should also judge it similarly.

A. W. Meyer.

NOTES.

We have received the following announcement of a Course in Embryology at the Marine Biological Laboratory of Woods Holl, Mass., to be given during the coming summer:

"A course in embryology will be given at the Marine Biological Laboratory this summer, that will deal with the development of the fish and of such members of the Hydrozoa, Annelida, Mollusca, Echinodermata, Crustacea, and Tunicata as best show the typical larvæ of the groups. Attention will also be given to the organization of eggs and the changes that accompany their development, and to reasons for the modifications of structure and habits of larvæ of related forms.

"The advantage of seeing organisms develop from eggs into complicated animals, over seeing a few preserved specimens that illustrate particular stages of development, cannot be overestimated. The abundance of material at Woods Holl, and the fact that it is alive and can be watched during development, makes it possible to offer a course that supplements the ordinary college course, but that cannot be duplicated in any inland laboratory.

"The course is designed to meet the needs of all who desire to gain insight into embryological problems, but it is intended to serve also as a basis for those who desire to begin independent investigations. While the course as planned will be orderly in its arrangement and will lead to definite ends, it is expected that students will exercise much individual freedom in their work. Every opportunity will be given those prepared to do so, to begin the investigation of special problems. Advice on methods of technique, such as on the collection, preservation and study of material, methods of staining, imbedding, sectioning, mounting, etc., will be given whenever needed.

"It is expected that many of the lectures that accompany the laboratory work will be given by persons who have specially investigated the subjects under consideration.

"The course in Zoology at the Marine Biological Laboratory, or *its equivalent,* is a prerequisite for admission to this course. Students desiring further information or wishing to register for the course, should correspond with Gilman A. Drew, University of Maine, Orono, Maine. It is desirable to know in advance whether each student can bring a good compound microscope, with condenser and nose piece, a dissecting microscope, microtome knife (and microtome if it is the intention to do much section cutting), dissecting instruments, camera lucida and drawing materials. It is difficult or impossible to obtain many of these articles at Woods Holl.

"The fees for the course is $50, payable in advance. Instruction will be given during four weeks in July and two weeks in August."

THE ANATOMICAL RECORD

Vol. II. JUNE, 1908. No. 3

The Columella Auris in Amphibia.

BY

B. F. KINGSBURY AND H. D. REED.

From the Anatomical Laboratory, Cornell University, Ithaca, N. Y.

With Seven Figures.

The following is a preliminary communication of the results obtained by us in a study of the relations and connections of the sound-transmitting apparatus in certain American Urodeles.

Since it is in the class Amphibia that a sound-transmitting apparatus first appears, a knowledge of the relations here is of double value,—in aiding the interpretation of homologies in the lower forms (fishes), and in contributing toward the solution of the difficult questions surrounding the significance of the reptilian columella and the auditory ossicles of the Mammalia. Furthermore, the function of the Amphibian columella is unknown, and as a preliminary to experimental work its relations in a large series of forms were ascertained.

Gaupp[1] has already called attention to the apparently different relation that the columella has to other structures in Urodeles, which led him to believe that there were two different connections of this element found in these forms, and later[2] he restated this opinion. Drüner[3] has

[1]Gaupp, E. Onotogenese und Phylogenese des Schallleitenden Apparates bei den Wirbeltieren. Merkel u. Bonnet: Ergebnisse der Anat. u. Entw., Bd. VIII, 1898-1899.

[2]Gaupp, E. Die Entwicklung des Kopfskelettes. Hertwig's Handbuch der Entwickelungslehre der Wirbeltiere, Bd. III, p. 696.

[3]Drüner, L. Studien zur Anatomie der Zungenbein-, Kiemenbogen- und Kehlkopf-Muskeln der Urodelen, I. Teil, Zool. Jahrb., Abt. f. Anat. u. Ont. d. Tiere, Bd. XV, H. 3, 1901.

likewise expressed this interpretation. This opinion was based especially upon the statements of Huxley,[4] Wiedersheim,[5] Parker[6] and Hasse.[7] Thus Huxley described in Necturus a "suspensorial stapedial ligament" under the facial nerve. Wiedersheim gives as the universal condition that a connection between the operculum and quadrate existed below the facial nerve. Hasse, on the other hand, in Siredon described the nerve as under the columella, while Parker in the large number of forms studied by him apparently found both connections, although it is sometimes difficult to determine what relation he wished to imply.

In 1903 one of us[8] described in detail the early development of the columella in Necturus and there called attention to the fact that almost from its first appearance it was connected with the squamosum (Paraquadratum of Gaupp) by a cord of cells where later was established a strong ligamentous connection. Believing that the early and primary connection of the columella with the squamosum was of fundamental morphologic importance, we have undertaken to ascertain the connections and development of the columella in a large number of representative Urodeles.

The forms studied are: Necturus maculosus, Proteus anguineus, Amphiuma means, Ambystoma (Amblystoma) punctatum, Hemidactylum scutatum, Plethodon cinereus erythronotus, Gyrinophilus porphyriticus, Spelerpes bilineatus, Diemictylus viridescens. To these we propose to add: Siren, Cryptobranchus, Chondrotus, Autodax, Manculus, Salamandra, Triton. It is recognized that the relations of the columella to other structures in many of these forms have been described by earlier workers, but it was thought that re-examination by serial sections and models would give us a better basis for interpretation.

[4]Huxley, T. H. On the Structure of the skull and of the Heart of Menobranchus lateralis. Proc. Zool. Soc., 1874.

[5]Wiedersheim, R. Das Kopfskelett der Urodelen. Morphol. Jahrb., 1877.

[6]Parker, W. K. On the Structure and Development of the Skull in the Urodelous Amphibia, Part I, Trans. Philo. Soc., Vol. CLXVII, Part 2, 1877. On the Morphology of the Skull in the Amphibia Urodela, Trans. Linn. Soc., Series 2, Vol. II, Pt. 3, 1882. On the Structure and Development of the Skull in Urodeles, Trans. Zool. Soc., Vol. XI, Pt. 6, 1882.

[7]Hasse, C. Ueber den Bau des Gehörorgans von Siredon pisciformis und über der vergleichenden Anatomie des Kiefersuspensoriums, Anatom. Studien, herausg. von C. Hasse, Vol. I, 1872.

[8]Kingsbury, B. F. Columella Auris and Nervus Facialis in the Urodela. Jour. Comp. Neurol., Vol. XIII, pp. 313-334.

As a result of this work, we have found that in Necturus, Ambystoma, Hemidactylum, Plethodon, Gyrinophilus, Spelerpes and Desmognathus the columella is connected with the squamosum. This connection arises very early in Necturus, Amphiuma, Ambystoma, Plethodon, Spelerpes and Desmognathus. Early stages of the others have not been examined. A very large number of stages of Ambystoma punctatum[9] from the early embryo through the larval, transforming and adult periods have been examined. A brief statement of the development and relations of the columella auris in this form will be given, since we have made it the basis of comparison.

The columella first appears in embryos from 4-6 mm. long at a time soon after the chondrification of the ear capsule. It is developed as a separate nodule of cartilage resting on the membrane of the fenestra vestibuli and connected with the squamosum by a dense tissue rich in cells, under and close to the jugular vein. It apparently develops outside the ear capsule. This result, which is different from that gained by Stöhr in 1888 in Siredon, is nevertheless in agreement with the development of the columella in Necturus as described by Platt.[10]

During the larval period the cephalic end of the columella becomes fused with the fenestra vestibuli. The connection with the squamosal persists and becomes a very strongly developed tissue which appears to be fibro-cartilage (Figs. 1 and 2, lc.). The relation of the ligamentum squamoso-columellare to the carotid artery and jugular vein is that found in all forms; *i. e.,* above the former and below the latter (Fig. 3, lc. and vj.). In all forms examined the facial nerve passes below the ligament except in Necturus and Proteus, where one branch, r. jugularis, passes above it.

We wish to emphasize the fact that in Ambystoma we encounter the same early established relations of the ligamentum squamoso-columellare as in Necturus, and in spite of the somewhat different relations of the facial nerve in the latter we believe that the connections are homologous.

[9]Through the courtesy of Professor S. H. Gage, who placed at our disposal the excellent series of larval Ambystoma in the collection of the Department of Histology, we were enabled to make complete our series of stages in this form, for which we wish to express our appreciation.

[10]Platt, Julia B. The development of the cartilaginous skull and of the branchial and hyoglossal musculature in Necturus. Morph. Jahrb., Bd. XXV, Heft 3, 1897.

At transformation very remarkable changes occur, which appeal to us as profoundly significant in interpreting the homologies of the sound-transmitting apparatus. These changes are:

(*a*) An extension of the fenestra vestibuli backwards.

(*b*) Largely, at least, from the walls of the ear capsule a new operculum is formed. This new structure is joined to the lips of the fenestra all round. In the cephalic part the connection is formed by membrane, while in the caudal part there is more or less continuity between the cartilage of the ear capsule and that of the new operculum. Furthermore, in the cephalic part the lips of the fenestra include the operculum (Fig. 7, p. and op.).

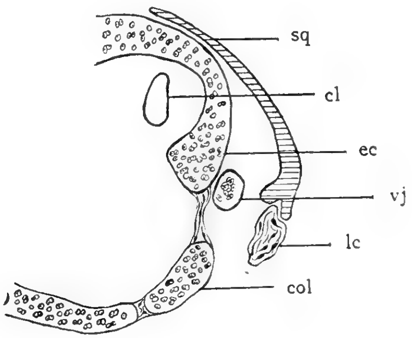


Fig. 1.—Ambystoma punctatum, mature larva 48 mm. long; sq., squamosum; cl., canalis lateralis; ec., ear capsule; vj., vena jugularis; lc., ligamentum squamoso-columellare; col., columella.

(*c*) The columella becomes more firmly united and finally incorporated with the ear capsule.

(*d*) The connection of the columella with the squamosal persists and shifts so as to include the quadrate (Figs. 4-6, sq., col., lc. and q.). There is thus formed a fourth connection of the quadrate with the cranium (Fig. 6, q.).

(*e*) The formation of a bulla-like structure extending backwards (Fig. 7, p.).

(*f*) The establishment of a muscular connection between the operculum and the supraclavicle. This is the m. opercularis described by

Gaupp[11] and Iwanzoff.[12] It is interesting to note at this point that the occurrence of this muscle or its attachment to the sound-transmitting apparatus is not found in such forms as Necturus, Proteus, larval Ambystoma, etc., in which there is a squamoso-columellar connection.

The "bulla-like structure" mentioned above is composed entirely of an outpocketing of the ear capsule, the cavity of which is occupied by an extension of the cavum perilymphaticum. For purposes of the present paper we will speak of this as the perilymphatic prominence,—in accordance with its external form. In the latero-ventral wall of the perilymphatic prominence is a foramen which for the present we desig-

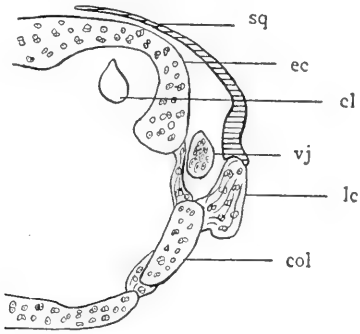


FIG. 2.—Ambystoma punctatum, mature larva, 48 mm. long; section farther caudad: sq., squamosum; cl., canalis lateralis; ec., ear capsule; vj., vena jugularis; lc., ligamentum squamoso-columellare; col., columella.

nate the secondary vestibular foramen in order that we may not confuse it with the primary foramen, of which it is doubtless an extension. This foramen is closed by the above mentioned operculum. This is an entirely new development caudad and ventrad of the columella.

The changes which come about in the sound-transmitting apparatus of Ambystoma at transformation show many striking resemblances to the development of the plectrum and operculum in the frog as described in the excellent monograph by Gaupp. A summarized statement of his results as there given is as follows:

[11]Gaupp, E. Beiträge sur Morphologie des Schädels, I. Primordialcranium und Kieferbogen von Rana fusca. Morphol. Arb., herausgegeben v. G. Schwalbe, Bd. 2, 1893.

[12]Iwanzoff, N. Zur Anatomie der Knöchelchen des Mittel-Ohres d. Amphibien u. Reptilien. Anat. Anz., Bd. IX, 1894.

(*a*) The operculum is developed out of the ear capsule with which it is connected at its caudal end.

(*b*) The columella develops as an independent structure occupying a place cephalad of the operculum and becoming fused with the cephalic margin of the fenestra vestibuli.

(*c*) A part of the crista parotica with which the processus superior columellæ is connected develops from the quadrate.

(*d*) A muscle extending from the supraclavicle has its cephalic insertion upon the operculum (m. opercularis).

From the development in Ambystoma, as well as in the frog, it would appear that there are two distinct structures,—an operculum formed out of the ear capsule, at least in part, and a columella arising independently. This was the original view of Gaupp. We will have occasion to refer to it later in a discussion of the nomenclature of the parts here involved.

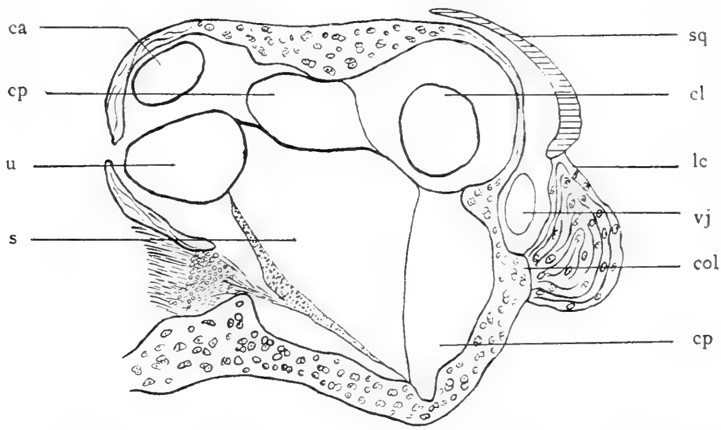


FIG. 3.—Ambystoma punctatum transforming period: ca., canalis anterior; cp., cavum perilymphaticum; u., utriculus; s., sacculus; sq., squamosum; cl., canalis lateralis; lc., ligamentum squamoso-columellare; vj., vena jugularis; col., columella.

That there are two distinct parts that have been variously spoken of as operculum and columella interchangeably is rendered very plausible by a comparison of the relations in other Amphibia.

In Ambystoma, Gyrinophilus and Diemictylus in the adult forms the perilymphatic prominence is well developed, containing, as has been said, an extension of the cavum perilymphaticum, the middle of the prominence being about opposite the origin of the ductus perilymphaticus. During the larval period in Gyrinophilus the columella has intimate connection with the squamosum, which in this form, as in Spelerpes, Plethodon, Hemidactylum and Desmognathus, is affected by a process of either bone or cartilage, conveniently termed by Gaupp the stylus columellæ. In the adult Gyrinophilus, however, the columella by its stylus becomes more closely connected with the quadrate, as in

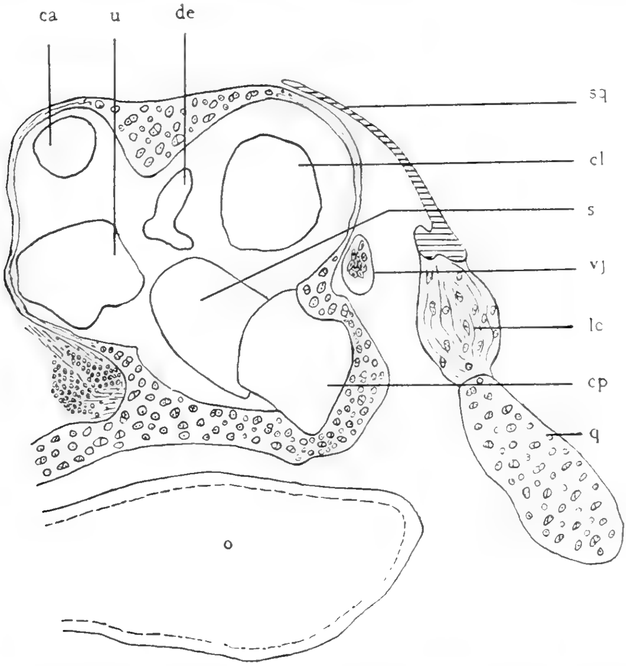


Fig. 4.—Ambystoma punctatum, transformation period; section farther cephalad; ca., canalis anterior; u. utriculus; de., ductus endolymphaticus; sq., squamosum; cl., canalis lateralis; s., sacculus; vj., vena jugularis; lc., ligamentum squamoso-columellare; cp., cavum perilymphaticum; q., quadratum; o., oral cavity.

Ambystoma, although the association is not as intimate as in that form. We are not as yet prepared to state definitely the difference between the larval and adult Gyrinophilus respecting the quadrate and squamosal connections, or what portion of the sound-transmitting apparatus (operculum) of the adult is formed by the columella.

The same peculiar disposition of the operculum, perilymphatic prominence and opercular muscle that is found in the adult Ambystoma and Gyrinophilus occurs also in the transformed Diemictylus. In this last form, although larvæ 19 and 37 mm. in length were examined as well as land forms (which are intermediate between the larva and the adult) and adults, no such squamosal connection of the columella as

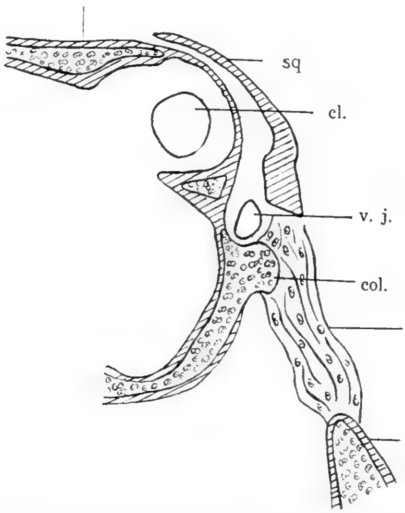


FIG. 5. Ambystoma punctatum, adult 64 mm. long; ec., ear capsule; sq., squamosum; cl., canalis lateralis; vj., vena jugularis; col., columella; lc., ligamentum squamoso-columellare; p., quadratum.

occur in larval Ambystoma, Necturus, etc., was found. No connection between the plate that fills the fenestra vestibuli (operculum), the squamosum and quadrate exists in any of the stages examined by us. In this respect Diemictylus seems to agree with the other members of the family of the Salamandridæ, judging from the works of Parker, Wiedersheim, Stöhr,[13] Fuchs[14] and others. In none of the salamanders examined by them did they find any bony, cartilaginous or ligamentous

[13]Stöhr, F. Zur Entwickelungsgeschichte des Urodelenschädels. Zeitschr. f. Wiss. Zool., Vol. XXXIII, 1879.

[14]Fuchs, H. Ueber die Entwicklung des Operculums der Urodelen und des Distelidiums ("Columella auris") einiger Reptilien. Anat. Anz., Ergänzungsheft z. Vol. XXX, 1907, pp. 8-34.

connection between the opercular apparatus and the squamosum and quadrate. Accepting, as we feel we must, the view that we have to deal here in Amphibia with two structures, it is highly probable that in these closely allied and highly specialized forms the structure designated. by us as columella, which is connected with the squamosum, does not come to development or at least disappears early in larval life, either completely or through incorporation with the operculum.

The connection of the columella with the quadrate is not a primary,

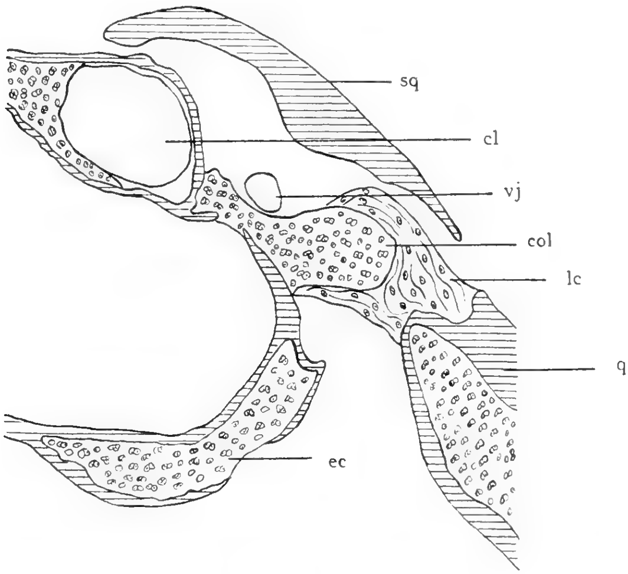


FIG. 6.—Ambystoma punctatum, small adult 100 mm. long; section farther cephalad; sq., squamosum; cl., canalis lateralis; vj., vena jugularis; col., columella; lc., ligamentum squamoso-columellare; q., quadratum; ec., ear capsule.

but a secondary one. This is the connection of the columella with other skeletal structures that is repeatedly emphasized in literature,—a connection with the quadrate. Thus in Amphiuma the stylus columellæ is very intimately connected with a backward-extending process of the quadrate cartilage, the same being true apparently in other forms. In Spelerpes and Desmognathus, larvæ and adult, we find a series of forms in which the conditions in Amphiuma are approached. Likewise in Ambystoma at transformation a close connection is developed between the columella and the quadrate which is absent in the larvæ.

There occur then two connections of the columella with the suspensorium of the lower jaw, one with the squamosum, which is itself closely connected with the quadrate, and one with the quadrate directly, the first being the primary connection both in ontogeny and, we believe, in phylogeny. The view advanced by Gaupp and Drüner that there are two connections of the columella with the quadrate, one above the facial nerve and another below it, has been mentioned at the beginning of this

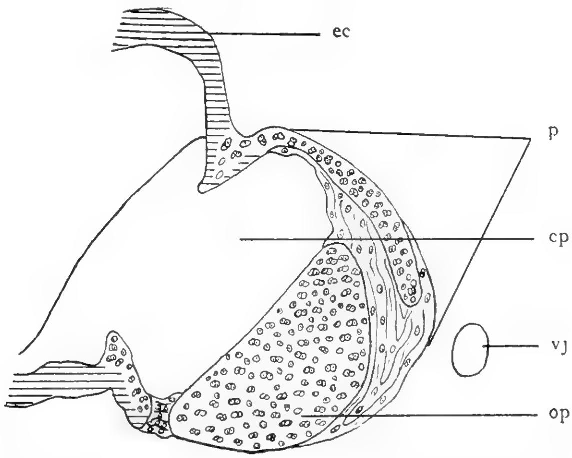


FIG. 7.—Ambystoma punctatum, small adult 100 mm. long; section through caudal part of the operculum: ec., ear capsule; p., perilymphatic prominence; cp., cavum perilymphaticum; vj., vena jugularis; op., operculum.

article. This view is apparently due primarily to the description by Huxley of a connection between the columella and quadrate cartilage in Necturus, above which the facial nerve passes. As it is recognized that this description is erroneous, it is evident that two distinct types of connections of this kind do not exist. In no form known to us does the facial nerve pass above the columellar-squamosal connection with the exception of Necturus and Proteus, in which forms the relations have already been described. In these two forms, as has been previously described by us and others, all the facial nerve passes ventral to (below) the connection in question except the jugular branch, which passes dorsal to (above) it. Since the facial nerve in different forms has often different relations to neighboring structures, as has been pointed out by Drüner and Kingsbury, this different relation in the Proteidæ and in the other Urodeles does not seem to us to offer an obstacle to the homology of the squamosal columellar connection in these forms with that found in the others. We do not desire to enter further into a discussion of this question here.

As to the homologies of the columella and operculum, we wish here to state merely our belief that the development of the columella independently of the ear capsule as described in Necturus and Ambystoma, together with the very early connection with the bone which we regard as squamosum supports the view of its homology with the hyomandibular-symplectic of fishes, and that the element which we have designated as operculum, as distinguished from the columella, seems to arise from a differentiated portion of the ear capsule itself.

The question of nomenclature of the parts involved needs a word of comment. Gaupp in the frog described the columella and operculum as distinct structures. He has since modified his use of the terms to fit the change of view with regard to homologies and has employed the term columella as a name for the sound-transmitting apparatus of Amphibia, composed in Anura of an operculum and plectron, in Urodela of an operculum and stylus columellæ. In view of the relations described above, it would seem necessary to recognize, in the Urodeles at least, two distinct structures, which may be termed respectively columella and operculum, the first arising independently and connected primarily with the squamosum and in some forms secondarily with the quadrate cartilage, the second, the operculum, having no such connection and developed largely at least out of the ear capsule.

Professor Prenant's Theory of the Nature of the Granule Cells of Paneth.

BY

R. R. BENSLEY,
University of Chicago.

In a recent short article on the "Cells of Paneth in the Glands of Lieberkühn of Man," Professor Prenant ('07) has advanced a new theory as to their nature. Prenant's material was fixed in Bouin's fluid and in Flemming's fluid, and was stained by his ferric hæmatoxylin-eosin-vert lumière method or by iron hæmatoxylin with counter staining in eosin or Van Gieson. He describes the results as follows: "La comparaison de cette substance répandue dans les cellules de Paneth avec le mucus contenu dans les cellules muqueuses calciformes de la glande est très instructive. Cette matière offre exactement la même coloration verte, elective et caractéristique dans le procédé que j'emploie, que le mucus lui-meme; elle est donc de nature mucoïde. Mais par l'eosine et par Van Gieson, elle prend une teinte différente de celle de ce mucus; au lieu que celui-ci se colore en jaunâtre, elle prend une couleur orangée ou rose; elle est donc un mucus, mais différent de celui que sécrètent les cellules muqueuses calciformes." Prenant, therefore, like Bizzozero regards the cells of Paneth as mucous cells, but as specific elements different from the goblet cells, not as young goblet cells.

Coming from such a distinguished source, the new theory is entitled to the most careful consideration from histologists engaged in the investigation of glandular problems. Accordingly, I have taken this opportunity to repeat and extend the observations of Klein ('06), with a view of determining whether or not any confirmatory evidence can be elicited in support of Prenant's theory by the use of the more generally recognized methods of studying and staining mucus.

One of the important differences between sero-albuminous and mucous cells, to which particular attention has been directed by Erik Müller ('98), is the difference in the appearance of the granules of the secretion-antecedent (mucigen, zymogen, etc.) in the fresh cell examined in an indifferent medium. Under these conditions the mucigen granules are distinguished by their low refractive power, so that only under the most favorable conditions and with the best immersion lenses, can they be studied. The granules of typical zymogenic cells, such, for example, as the chief cells of the fundus glands, or the pancreatic cells, are highly refractive and conspicuous and easily defined by dry lenses of medium power. Examining fresh sections of the intestinal mucous membrane of the guinea pig mounted in guinea pig serum, the goblet cells are seen to contain a mass of coarse granules of low refractive index resembling closely those which may be observed in the mucous cells of the submaxillary gland of the dog. The Paneth cells contain highly refractive granules resembling the zymogen granules of the pancreas, stomach and parotid gland. Exactly the same results are obtained by examining the intestinal mucous membrane of the opossum and the rat in blood serum. Accordingly, on the basis of fresh appearance, the Paneth cells resemble the zymotic gland cells and differ from mucous cells.

The specificity of the cells of Paneth as opposed to the goblet cells is indicated by Klein's observation, which I can confirm, that, in the opossum's duodenum, Paneth cells occur on the surface of the villi, the intestinal glands here being not true glands, but reproductive cell-foci, as in the Batrachia, where goblet cells, Paneth cells and cylindrical cells are all recruited by mitosis.

Klein has also demonstrated the presence in the bases of the Paneth cells of the guinea pig of a basal zone similar to the basal zone of the cells of the pancreas, containing basophile material (prozymogen, ergastoplasma) arranged in the form of basal filaments or as a diffuse basophile substance infiltrating the basal cytoplasma. This important point of similarity between the Paneth cells and zymogenic cells, which I have also confirmed, should not be overlooked.

Like Klein, I have in my recent experiments obtained uniformly negative results in attempts to stain the Paneth cells in man, opossum, guinea pig and rat, with the valuable stains for mucus introduced by P. Mayer, mucicarmine and muchæmatein, although the content of the goblet cells stains with great ease in these solutions. Equally unsuccessful have I been in attempts to stain the Paneth cell granules with the stronger mucicarmine and muchæmatein solutions used by me in the study of the glands of Brünner. The metachromatic reaction with toludine blue, thionin, safranin and cresylechtviolett has been uniformly positive for the content of the goblet cells and negative for the content of Paneth cells.

Furthermore, a multitude of staining reactions can be obtained which serve to differentiate the secretion-content of the Paneth cells from that of the goblet cells. It will suffice to mention a few of these. In iron hæmatoxylin the Paneth granules stain black, if the fixation is complete, mucigen colorless. In neutral orange-gentian violet the Paneth granules stain intensely violet, mucigen colorless. In neutral safranin-acid violet the Paneth granules stain intensely violet, mucigen granules in the goblet cells metachromatically yellow.

In view of the different appearances presented by Paneth cells and mucous cells in the fresh condition, of the many staining reactions in which the Paneth cells react differently from the goblet cells but similar to zymogenic cells, of the negative results of staining Paneth cells with the special mucous staining solutions enumerated above, it is difficult to avoid the conclusion that, in interpreting the results obtained in staining sections of human intestine by his ferric hæmatoxylin-eosin-vert lumière method, Prenant has failed to consider the alternative deduction which may be drawn from his results, namely, that his method is not specific for mucin, and has not given due weight to the many important considerations which are opposed to his theory.

It will be noted that in referring to the result obtained in staining the Paneth granules with iron hæmatoxylin I have stated that they stain black if well fixed. The reservation is necessary, because, in less successful fixations the appearances described by Prenant and previously by Nicolas ('91) are obtained in great number, that is to say, the black stain is confined to a central or peripheral granule inclosed in the larger granule, or a crescent-shaped mass at the edge takes the stain, the remainder of the granule decolorising completely in the iron alum solution or showing a slight yellowish color. Similar appearances have been described and beautifully figured by Fleischer ('04) in preparations of the lacrimal gland of the ox, where he claims to have seen them in the fresh gland. These results are of much importance because they indicate clearly a twofold chemical nature in the granules of these cells, whether a result of the progressive transformation of the siderophilous substance of the granule into a later product of the secretion, or of a twofold secretory activity of the cell. I am not convinced, however, that these appearances represent an organization of the zymogen granule which exists in the living cell. Attempts to determine this question by examination of the living cells in native blood serum are not decisive, because the granules of the Paneth cells in fresh preparations are not exactly spherical, but, on the contrary, exhibit an angular outline resulting from mutual compression. In these granules occasionally a crescent may be seen at the margin of the granule, or a dark band may be seen running over the surface of the granule, or a minute granule of more refractive power may be seen in the midst of the larger granule. I am of the opinion, however, that all these appearances are due to the existence of compression ridges on the surface of the granule and not to an internal organization of it. In the guinea pig the crescents and minute granules are so abundant in preparations fixed in aqueous bichloride that it is almost impossible to find a perfect granule. In preparations fixed in my alcohol-bichromate-bichloride solution they are also present in large numbers, but less frequently than in the aqueous bichloride preparations. In preparations fixed in a mixture of equal parts of alcoholic sublimate and Kopsch's fluid nearly all the granules present the appearance seen in the fresh cell, and only a few of the crescents are to be seen. Accordingly, I think that these appearances are to be given a chemical interpretation rather than an architectural one.

With regard to the narrow darkly staining cells which Prenant and Nicolas regard as the terminal phases of secretion, they occur very rarely in my preparations of the intestinal glands of man and of the animals mentioned above. Where they do occur the nucleus shows evidences of karyolysis, as has been noted also by Nicolas. Hence, I regard these cells as elements which have completed their cytomorphosis and which are about to disappear from the epithelium.

REFERENCES.

Fleischer, B. Beiträge zur Histologie der Thränendrüse, etc. Anat. Hefte, Wiesb., 1904, Abth. 1, Bd. 26, S. 103-66.

Klein, S., On the Nature of the Granule Cells of Paneth in the Intestinal Glands of Mammals. Am. J. Anat., Balt., 1906, Vol. V, p. 315-30.

Müller, E., Drüsenstudien, I. Die seröse Speicheldrüsen. Arch. f. Anat. u. Physiol., Anat. Abth., Leipz., 1896, S. 305-23.

——Drüsenstudien, 2, Ztschr. f. Wissensch. Zool., Bd. 64, 1898, S. 624-47.

Nicholas, A., Recherches sur l'épithélium de l'interstin grele. Internat. Monatschr. f. Anat. u. Physiol., Leipz., 1891, Vol. VIII, pp. 1-62.

Prenant, A., Sur les "Cellules de Paneth" dans les Glandes de Lieberkühn de l'homme. Comptes rendus hebdomadaires des Séances de la Société de Biologie, T. 62, Paris, 1907, pp. 1125-28.

Report on a Curious Variation in the Insertion of the Rhomboideus Major in a Negro.

BY

C. F. BOOKWALTER,

From the Anatomical Laboratory of the Johns Hopkins University.

In the dissection of an adult male negro a variation was noted in the mode of attachment of the rhomboideus major to the base of the

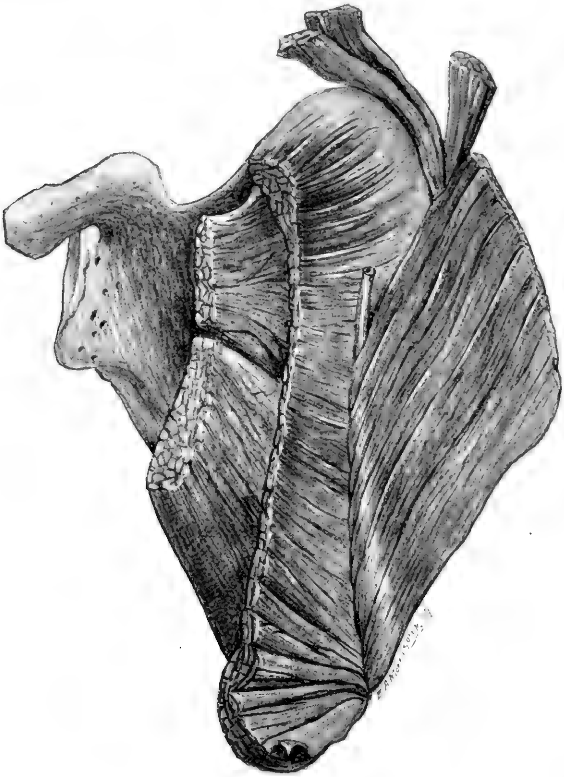


FIG. 1.—The scapula with the layers of muscles on its ventral side showing the attachment of the rhomboideus major muscle. The vessel near the turn of the muscle is the posterior scapular artery.

scapula. The variation was present on both right and left sides of the body, and consisted in an underlapping of the bone by the muscle.

Fig. 1 represents a dissection of the right side viewed from in front, showing the amount of underlapping of the muscle. At about the middle of the line of attachment the extent of underlapping amounted to about two centimeters. The direction of the muscle fasciculi as seen at this stage of the dissection is well shown in the illustration. Viewed from behind the muscle and its relations were of normal appearance.

Fig. 2.—The bundles of the rhomboideus major muscle have been separated.

Fig. 2 shows a portion of the muscle separated from its attachment to the scapula and turned back. The fascia, into which the serratus anterior is inserted, is exposed; the underlapping portion of the rhomboideus major is rather firmly attached to the fascia, and it was necessary to use a knife in separating it. Upon separating the muscle fasciculi it was seen that those forming the ventral part of the muscle, after underlapping the scapula, turn and end at the border of the bone. As the separation of the fasciculi is carried towards the angle of the scapula it is seen that they successively underlap less and less. Those fasciculi forming the dorsal part of the muscles have a straight course and are inserted at the border of the scapula in the usual way, while on the ventral side there is this curious underlapping.

I have been unable to find in the literature any variation similar to the one here recorded. The origin fluctuates and its insertion has a tendency to accumulate at the angle of the scapula. In fact, a considerable portion of its attachment is often as a tendinous arch on the dorsal border of the scapula. The variation here described is just the opposite, the muscle being turned under and returns upon itself to the border of the scapula. In many respects it reminds one of the arrangement of the bundles of the pectoralis major muscle as described by W. H. Lewis[1] and pictured by Spalteholz[2] in the last edition of his Atlas.

As the muscle was symmetrical and equally well attached on both sides, it must be viewed as an anomaly which was inherited and not acquired after birth. As we have excessive development elsewhere, so we may have an excessive length of the muscle bundles, which as a result turn upon themselves, as they are found in this specimen.

[1]Lewis, Johns Hopkins Hospital Bulletin, XII, 1901.
[2]Spalteholz, Handatlas, etc., 1906, Fig. 309.

ABSTRACTS.*

VERTEBRAL REGIONAL DETERMINATION IN YOUNG HUMAN EMBRYOS. By CHARLES RUSSELL BARDEEN. *University of Wisconsin.*

In 1904 I published a study of numerical vertebral variation in the human adult and embryo (Anat. Anz., XXV. p. 498). In this article I took exception to the views advanced by Rosenberg in 1876 (Morph. Jahrb.) that in young human embryos the sacrum is composed of a more distal set of vertebræ than it is in the adult, and that during embryonic development there is a reduction in the number of thoracic or rib-bearing vertebræ.

Rosenberg has recently (Morph. Jahrb., XXXVI, p. 609, 1907) criticised my paper on two grounds:

1. That some of the data used in the statistical tables are incorrect, inaccurate or without sufficient basis.

2. That the data used are incorrectly interpreted.

In support of the first criticism that data used in the table are inaccurate or inadequate, Rosenberg goes into a careful study of the embryos tabulated from his article of 1876 and of the embryos described by Hagen and by Peterson. He finds only two of his embryos correctly described by me and that the embryos of Hagen and Peterson are not described by these authors with sufficient detail to merit their inclusion in a statistical table.

Neither Rosenberg nor the other authors mentioned gave specific detailed accounts of the vertebral columns of the embryos studied. Rosenberg took up each of the regions of the vertebral column in turn and used various embryos to illustrate each region. The data concerning each embryo had to be gathered from the somewhat involved account which he gave concerning the different regions of the spinal column and from his figures. In deducing that Rosenberg's Embryo V^1 had a "normal" vertebral column I undoubtedly, as Rosenberg says in his recent article, had no sufficient data. The other inaccuracies which he attributes to me are due rather to interpretation from a point of view different from that of Rosenberg than to a mistake concerning the data which he furnished. It was, however, a mistake to attribute 5 instead of 6 coccygeal vertebræ to Embryos IV^3 and III^1.

*Abstracts of some of the papers read at the meeting of the Association of American Anatomists, Chicago, January 1, 2 and 3, 1908.

In utilizing the somewhat incomplete data of Hagen and Peterson I probably should have called more attention to the incompleteness of these data. Lack of better material led to their inclusion in the table.

The chief difference between the views maintained by Rosenberg and those which I have advanced comes from the interpretation which we give to embryonic data. Rosenberg would apply to embryos the ordinary criteria which are applied to the adult osseous skeleton in determining the cervico-thoracic, thoraco-lumbar, lumbo-sacral, and sacro-coccygeal boundaries, while to me it seems evident that the special features characteristic of the embryo must be taken into account. Rosenberg thinks that it is incorrect to call a vertebra a lumbar vertebra unless its cartilaginous or osseous costal element is intimately fused with the transverse process, and that it is incorrect to call a vertebra a sacral vertebra unless its cartilaginous or osseous costal element is intimately fused laterally into the lateral sacral plate. Thus, likewise, a vertebra is not a true cervical vertebra unless its costal element is intimately fused with the transverse process.

My studies of the development of the vertebral column have led me to the conclusion that there are separate centers of chondrification for the costal elements of each of the vertebra, from the first cervical to, and sometimes possibly including, the first coccygeal. In connection with the more distal coccygeal vertebra apparently no cartilaginous costal elements develop. I do not, however, agree with Rosenberg that progressive ontogenetic regional alteration is to be deduced from the independent origin of cartilaginous costal elements in connection with vertebræ to which these elements are firmly fused in the adult.

Let us take up briefly the development of the costal elements in the vertebræ in each of the regions of the spinal column.

1. *Cervical Region.*—The cervical region becomes distinct from the thoracic in the fifth week, at a period when centers of chondrification in the vertebræ are about to appear. The two regions are rendered distinct from one another by the rapid extension of the blastemal costal processes of the thoracic vertebræ into the thoracic wall (Fig. 1B). Th blastmal processes of the seventh cervical vertebra extend outwards further than those of the other cervical vertebræ, but there is less difference in length between the costal processes of the seventh cervical vertebra and those of the other cervical vertebræ than between those of the seventh cervical vertebra and those of the first thoracic. The great difference in length between the costal processes of the seventh

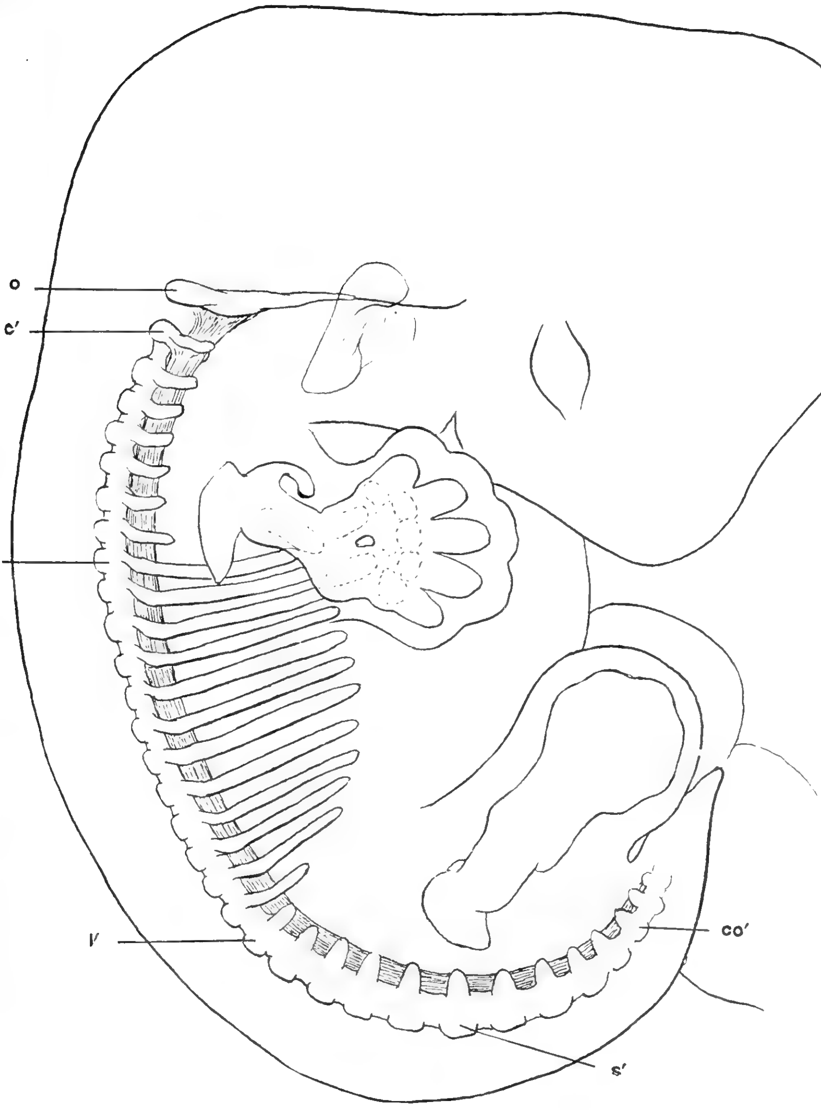


Fig. 1b.

Diagram of the skeleton of an embryo 11 mm. long and about five weeks old.

o, occipital plate.
c, first cervical vertebra.
t′, first thoracic vertebra.
l′, first lumbar vertebra.
s′, first sacral vertebra.
co′, first coccygeal vertebra.

cervical vertebra and those of the first thoracic is clearly indicated in the figures of Charlotte Müller. (Morph. Jahrb., 1906.)

In the costal process of the seventh cervical vertebra a center of chondrification is formed at the period when similar centers appear in the ribs. For this reason it may be correct to speak of the regular appearance of a pair of cartilaginous cervical ribs. I believe, however, that it would be more correct to speak of the costal elements of the seventh cervical vertebra as being more rib-like than those of the other cervical vertebræ rather than as true ribs. Normally they do not extend much beyond the transverse processes. The centers of chondrification for the costal elements of the other cervical vertebræ appear much later than those of the seventh cervical vertebra (usually not until the embryo has reached a length of from 16-18 mm.), and they fuse earlier with the transverse processes.

During the period of ossification, according to Leboucq, 1896, the ventral limb of the transverse process in most of the cervical vertebræ is ossified by ingrowth at one end from the pedicle, at the other from the tip of the transverse process. In the seventh cervical vertebra frequently, in the sixth occasionally, and in the fifth, second and fourth rarely, there arise during the second to the fifth months separate centers of ossification for the costal elements. According to Mall (Am. Journ. Anat., 1906), it is not certain that separate centers of ossification for the costal elements of the seventh cervical vertebra in the embryo are very much more frequent than cervical ribs in the adult. Undoubtedly cervical ribs are more common than one is led to believe from statistical studies of vertebral variation.

The presence of a more or less rib-like costal element in young human embryos would doubtless make it difficult or impossible to compare the relative frequency of "cervical ribs" in the adult and embryo. It would not be easy to determine how great a development of the costal element in the embryo would be necessary in order to make it comparable with a free cervical rib in the adult.

2. *Lumbar Region.*—This region becomes clearly marked off from the thoracic in the fifth week of embryonic development by the rapid growth which takes place at this time in the blastemal costal processes of the thoracic vertebræ. (See Fig. 1B.) This is shown not only in the embryos which I have studied, but also in those figured by Charlotte Müller, 1906. Slightly later it becomes distinguishable from the sacral region by fusion of the blastemal cartilaginous costal processes of the

latter to form a lateral sacral plate, the proximal part of which becomes united to the blastemal ilium (Bardeen, Am. Journ. Anat., 1905, Figs. 5 and 6). In the lumbar vertebræ it seems probable that there are separate centers of chondrification for each of the costal elements. These appear later than the centers for the ribs in the thoracic region

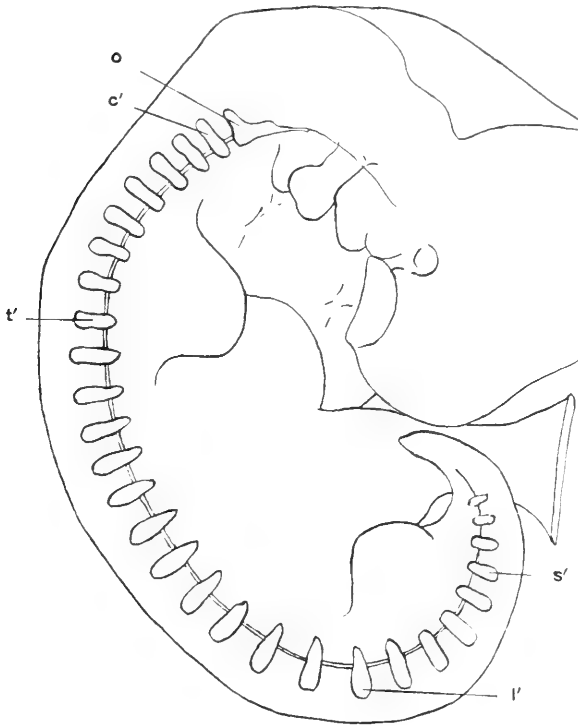


FIG. 1A.

Diagram of the vertebral column of an embryo 7½ mm. long and about four weeks old.

o, occipital plate.
c, first occipital scleromere.
t′, first thoracic scleromere.
s′, first sacral scleromere.
l¹, first lumbar scleromere.

and they very quickly fuse with the cartilaginous transverse processes. Usually they bear no close resemblance to the true ribs (see figures by Charlotte Müller, 1906). The centers for the costal elements of the first one or two lumbar vertebræ may appear a little earlier and fuse a little later with the transverse processes than those of the other lumbar vertebræ, but they are not, it seems to me, to be classed as ribs and the vertebræ to which they belong classed as thoracic or thoraco-lumbar, unless they bear so strong a morphological resemblance to the ribs as to seem to come in series with these. This normally is not the case. There is usually a sharp change of form from the twelfth thoracic rib to the costal element of the first lumbar vertebra. As a rule there are no separate centers of ossification for the costal elements of the lumbar vertebræ. In twenty embryos less than one hundred days old studied by Mall (American Journal of Anatomy, 1906), in which the other ribs were present, there were no centers of ossification for the twelfth rib in eight instances. In no instance was there a separate center of ossification for a thirteenth (first lumbar) rib. In two instances there were separate centers of ossification for a cervical rib.

There is, it seems to me, no evidence of an ontogenetic reduction of the distal portion of the thoracic region.

Sacral Region.—This region becomes distinct during the sixth week owing to the fusion of the distal ends of the blastemal costal processes to form a lateral sacral plate. Separate chondrogenous centers for the costal elements frequently, if not constantly, arise, but they quickly fuse at he base with the cartilaginous transverse processes of the neural arches. Laterally the cartilaginous costal processes become united to one another within the blastemal lateral sacral plate. The processes of the first three sacral vertebræ usually become thus united before the third is joined by the fourth and the fourth by the fifth. Judging from Rosenberg's studies, the processes of the second and third vertebræ frequently become united before being joined by those of the first sacral vertebra, but this is by no means constantly the case. I do not agree with Rosenberg that the first sacral vertebra must be called a lumbo-sacral vertebra until the ends of its cartilaginous costal transverse processes are intimately fused with those of the second sacral vertebra. In early embryonic development the surrounding blastema must be taken into account.

Coccygeal Vertebræ.—These first become distinct from the sacral vertebræ during the latter part of the sixth week, when the ends of the costal elements of the sacral vertebræ become united by blastemal tissue. It is, however, by no means always easy to distinguish the sacro-coccygeal boundary at this period because the transverso-costal elements of the first coccygeal vertebræ are relatively well developed and may become united by strands of connective tissue with those of the last sacral. The thirtieth vertebræ at this period should not, however, be counted as an integral part of the sacrum unless the costal elements really help to form the lateral sacral plate. When cartilage unites the ends of the costal elements of the sacral vertebræ into a cartilaginous lateral sacral plate it becomes easy to distinguish the sacral from the coccygeal vertebræ. If the costal elements of the thirtieth vertebra are united by cartilage to the twenty-ninth it becomes a sacral vertebra, but not otherwise. This condition is not infrequent in embryos, but it must be remembered that sacra with six vertebræ are frequently found in the adult. It is uncertain whether or not the costal element of the first coccygeal vertebra normally has a separate center of chondrification. It is fairly certain that no such centers are found in the other vertebræ.

During the period of ossification separate centers usually appear for the costal elements of each of the first three sacral vertebræ. It is said that these centers may appear merely in the first two vertebræ. They may appear in all five.

In conclusion, I may say, it seems to me, that the data at present available go to show that regional variation in the embryonic vertebral column corresponds approximately with that in the adult. A study of a large number of embryos correlated with a study of vertebral variation in the race from which the embryos came is necessary before accurate data on the subject can be obtained.

OBSERVATIONS ON THE SALIVARY GLANDS OF MAMMALS. By ROBERT R. BENSLEY. *From the Department of Anatomy, University of Chicago.*

Although much progress has been made in recent years in studying the changes that present themselves in the cells of the salivary glands in the different stages of their functional activity, no successful attempt has been made to subdivide the general classes of mucous and serous or albuminous glands into subordinate categories. It was pointed out that any such subdivision must be on physiological or biochemical grounds, because of the lack of fundamental differences in the structure of the protoplasm of glandular cells. Such differences as appear are rather concerned with the mode of aggregation, appearance, staining and microchemical reactions of the stored up secretion-antecedents and their various prophases. Accordingly, in studying glandular cells, it is of first importance to learn the characters presented by them in the living condition. For this purpose it was pointed out that the fluids usually employed as indifferent fluids are not truly indifferent, and that this need is best filled by the blood serum of the animal under investigation obtained by centrifugation of freshly defibrinated blood. In the study of fixed material it is of the first importance to secure a method of fixation which will retain in the cell the antecedents of the secretion, if possible in the form in which they are present in the living cell. The latter is not always possible, but even where the form of these antecedents is altered in the fixed material, if the substance is retained it may be available to discriminative staining reactions, or to microchemical reactions. The order of procedure, then, in an investigation of a salivary gland from this standpoint is: (1) The examination of the fresh material in blood serum, using teased preparations, or sections cut with a Valentine knife. For this purpose freezing methods must be avoided, as they produce profound changes in the form of the secretion antecedents. (2) Experimental fixation to obtain a method which preserves the secretion antecedents in the form which they have in the living cell. (3) The examination of the fixed material to establish definite and differential microchemical reactions or staining reactions for the secretion antecedents.

Proceeding in this way, the writer has been able to obtain certain results which seem to justify the subdivision of the serous class of cells into a number of subordinate groups. To one group belong the demilune cell of the submaxillary glands of the cat and dog. In the fresh condition, examined in blood serum, the secretion of these cells is seen to be in the form of granules, of small size, but of so low refractive power that only by the use of the best apochromatic lenses can they be seen. In this respect these granules are much less easily seen than the low refractive granules of the mucous cells. The secretion when fixed in aqueous sublimate or in Zenker's fluid does not stain by any method which has been applied, and sections from such material stained in toluidene blue show the mucous secretion metachromatically stained, but no metachromatism is visible in the demilune cells. Staining with muchæmatein and mucicarmine is positive for the mucin antecedents, but negative as regards the secretion of the demilune cells. On the contrary, when the tissue is fixed in Orth's formaline bichromate mixture or in Kopsch's mixture the secretion is retained in the demilune cells, although not in the granular form it presents in the living cells.

In these preparations the secretory content of the demilune cells stains metachromatically in toluidene blue or saffranin, thionin, etc. The metachromatism of the demilune secretion is often more intense than that of the mucous content. No other substances stain metachromatically in these preparations but the secretion of the demilune cells and mucous cells and the granules of mast cells. In these Orth and Kopsch fixations also the secretory content of the demilune cells of the cat stains with muchæmatein and mucicarmine, applied according to the directions of the writer in former papers on glands. This metachromatism produced by special fixation the writer proposes to call tropochromatism, and to designate cells which are capable of giving this reaction tropochrome cells. In addition to the demilune cells of the submaxillary gland of the cat and dog the so-called clear cells of the submaxillary gland of the rabbit, rat and gopher belong to this category of tropochrome cells. Other serous cells, as, for example, the demilunes of the horse's submaxillary, fail to give any metachromatic reaction, whatever the form of fixation. Examined fresh in serum, these cells exhibit the characteristic highly refractive granules of zymogenic cells. These granules are easily fixed by solutions containing formalin or mercuric chloride, and when fixed are readily stained by neutral gentian iron hæmatoxylin, etc., but show no metachromatism when fixed in Orth's or Kopsch's fluid and stained with toluidene blue, etc. Such cells the writer proposes to call homochrome. This being a negative character, it follows that the homochrome group of cells are likely to prove heterogeneous in character and to be subdivisible into other subordinate groups. This has been in part accomplished by the writer, and the results will be communicated in the complete paper to be published shortly.

THE TRUE RELATION OF THE OLFACTORY NERVES OF MAN, DOG AND CAT. By Effie A. Read. Presented by Simon H. Gage. *Cornell University.*

In all of the works on comparative and veterinary anatomy it is stated that the olfactory nerves have a plexiform arrangement. In no animal examined was this found to be the case. In the dog and cat, where the examination was most complete, the olfactory nerves form a fan-shaped expanse. On their way from the olfactory cells in the nasal mucosa to the olfactory bulb they converge, forming larger and larger bundles before they traverse the cribriform plate. The bundles may cross one another, but there is no plexus of nerves formed.

In man, from the time of Scarpa (1785) until the present (1907), all figures and descriptions of the olfactory nerves emphasize the plexiform arrangement. This appearance is most striking in the superior concha, as the nerves traverse canals in the bone instead of being spread out on the surface, as with the dog and cat. Differential staining showed, however, that there was no true nerve plexus. The abundant connective tissue ensheathing the nerve bundles and lining the bony canals and the blood vessels frequently form plexiform unions, but not the nerves. Each neuraxone in man, as in the lower animals, is then independent from the olfactory cell to the glomerulus of the olfactory bulb.

AN ANALYSIS OF THE OLFACTORY PATHS AND CENTERS IN FISHES. By RALPH EDWARD SHELDON. *From the Laboratory of Anatomy, University of Chicago.*

In the brain of the carp, Cyprinus carpio, the olfactory nerve passes from the mucosa to the olfactory bulb in two bundles, forming the olfactory fibers of the first order. From the bulb tracts of the second order run through a long crus to the olfactory lobe. From the lateral part of the bulb arise four tracts which end in the lateral olfactory nucleus of the same and opposite side. From the caudal portion of this nucleus, the nucleus tæniæ, runs the tractus olfacto-habenularis to the habenula ending in the opposite side. From the habenula run two tracts, Meynert's bundle to the corpus interpedunculare for motor correlation and also a tract to the region of the nucleus rotundus. From the middle of the bulb arise two tracts which end in the mesal olfactory nucleus of the same side. Thence a tract runs to the nucleus rotundus and the hypothalamus. On the mesal side of the bulb arise several tracts which join, going to the lateral olfactory nuclei of the opposite side, to the mesal olfactory nuclei of the same side, to the epistriatum and perhaps to the hypothalamus and nucleus rotundus. A portion of this bundle also forms the interbulbar commissure. There is also a commissure connecting the two lateral portions of the forebrain, lying in the caudal part of the precommissure. From a nucleus just caudad of the commissure, the nucleus preopticus, a tract runs ventro-caudad to the hypothalamus. The central part of the basal lobes forms the striatum from which a large tract, the tractus strio-thalamicus, runs to the hypothalamus and the nucleus rotundus region. From the hypothalamus is a large ascending tract, the tractus epistriaticus, ending in the epistriatum of the opposite side.

The following table should be substituted for the table, on page 109 of Vol. II, accompanying Miss Dunn's Abstract—A Study in the Gain in Weight for the Light and Heavy Individuals of a Single Group of Albino Rats.

	Grams at 14 days.	Grams at 23 days.	Per cent of gain.	Grams at 66 days.	Per cent of gain.
Rat 1 ♂	20.1	29.8	48	72.5	260
Rat 2 ♂	17.1	24.5	41	67.3	293
Rat 3 ♀	16.3	27.1	66	64.8	298
Rat 4 ♀	14.8	21.5	45	53.5	261
Rat 5 ♀	13.3	21.6	57	63.5	363
Rat 6 ♂	12.8	21.9	70	52.7	310
Rat 7 ♀	11.8	19.8	68	53.8	356

This is the correct form for the table printed on p. 109 of Vol. II of the Anatomical Record.

Considering that gustatory tracts enter the hypothalamus and that tracts leave it for motor centers, it is very probable that an important function of the hypothalamus is to act as a correlation center for taste and smell and to furnish connections for these with the motor centers. The region of the nucleus rotundus is evidently concerned to a great degree with the correlation of the olfactory sense with the motor centers. The forebrain is partly a secondary olfactory center and is probably also a correlation center for taste and smell through the ascending tract from the hypothalamus.

THE NERVOUS SYSTEM OF THE AMERICAN LEOPARD FROG, RANA PIPIENS, COMPARED WITH THE EUROPEAN FORMS, RANA ESCULENTA AND RANA TEMPORARIA. By Henry H. Donaldson, *The Wistar Institute, Philadelphia.*

From observations on these three species it appears that they are similar in general form and proportions, but that Rana pipiens has:

1. A heavier central nervous system, 11-12 per cent.

2. A heavier brain and spinal cord (the spinal cord in R. temporaria is nearly the same as that in R. pipiens).

3. A heavier brain in relation to the weight of the spinal cord.

4. A greater percentage of water in both the brain and spinal cord.

5. A larger number of medullated fibers in the spinal nerves.

6. A slightly greater proportion of sensory fibers. (5. and 6. When compared with R. esculenta.)

7. Shorter internodes, calling for a larger number of sheathing cells. (When compared with R. temporaria.)

These characters may all be counted to the credit of Rana pipiens, as indicating a slightly higher development of the nervous system.

The full statement of these results will appear shortly in the Journal of Comparative Neurology and Psychology.

A STUDY IN THE GAIN IN WEIGHT FOR THE LIGHT AND HEAVY INDIVIDUALS OF A SINGLE GROUP OF ALBINO RATS. By Elizabeth H. Dunn. *Department of Anatomy, University of Chicago.*

While weighing some fifty groups of albino rats at various ages from birth to fourteen days, it was noted that while the averages of various groups differed rather widely, the individuals of a single group did not depart far from the average for that group unless there existed a single very heavy or very light individual.

A group that showed rather wide variations within itself attracted attention at about the eighth day after birth, and since the members of the group seemed equally healthy, it was thought that this difference in weight was a prenatal and not a postnatal difference, and that a study of the increase of weight in such a group might be suggestive.

Weighings were instituted on the fourteenth day and continued every third or fourth day until laboratory conditions vitiated the findings.

The initial weights at fourteen days, the weights at twenty-three days, when the young became practically independent of the mother, and the weights at sixty-six days, about sexual maturity, were selected for tabulation. The percentages of gain at these dates on the basis of the initial weight at fourteen days were included.

	Grams at 14 days.	Grams at 23 days.	Per cent of gain.	Grams at 66 days.	Per cent of gain.
Rat 1 O.........	20.1	29.8	48	72.5	260
Rat 2 O.........	17.1	24.5	41	67.3	293
Rat 3 O.........	16.3	27.1	66	64.8	298
Rat 4 O.........	14.8	21.5	45	53.5	261
Rat 5 O.........	13.3	21.6	57	63.5	363
Rat 6 O.........	12.8	21.9	70	52.7	310
Rat 7 O.........	11.8	19.8	68	53.8	356

As previously ascertained, the average weight at fourteen days for both males and females is 15 + grams. The average for this group is 15 + grams, while the extremes are ten grams apart.

The average daily gain for the white rat is 1 + grams. The average gain for Rat 1 of this group was 1 + grams and for Rat 7.9 — grams, therefore the daily gain for the individuals of this group indicates their normal condition.

The percentage gain for the individual rats shows that the lighter rats, while putting on a less absolute weight, had at the end of sixty-six days gained a greater percentage of their original weight than had the heavier individuals.

The findings may be summarized as follows:

Rats in a litter tend to maintain their original order relations as to weight, extra heavy rats maintaining their ascendency.

Lighter rats in a litter while having a less average daily gain in weight have an actual greater daily gain when their initial weight is considered, that is, their percentage of gain is greater.

The actual differences in weight at successive periods tends to increase, as do the percentage relations.

These findings hold true for the litter as a whole and for each sex considered separately.

THE NUCLEI OF ORIGIN OF THE CRANIAL NERVES IN THE 10 MM. HUMAN EMBRYO. By G. L. Streeter. *University of Michigan.* With two Figures.

Through the kindness of Dr. Huber, the writer had the opportunity of making a study of the nervous system in an unusually good 10 mm. human embryo, for the use of which he takes pleasure in acknowledging his obligation. The embryo had been cut in a faultless series of 5 micra sections and the tissues were in an excellent state of preservation, making it especially well adapted to purposes of reconstruction. The brain and the cranial and cervical nerves were reconstructed in wax after the Born method, and the following paper refers to some of the findings:

This stage in the growth of the brain is particularly interesting in that it represents what might be called a primitive or primary brain. The primary neurones of the cranial and spinal nerves, including their peripheral extensions into the muscle masses and central extensions into the wall of the brain tube, are already well laid down, and, in fact, what we see in brains at this time is almost entirely this primary apparatus. The higher receptive and co-ordinating tracts are still in a rudimentary state. It is before the development of the olive, the pontine nuclei and the cerebellum; and the forebrain still consists of a thin-walled neural tube, showing but little sign of differentiation.

In contrast to the retarded state of growth of the higher centers, the spinal and the third to twelfth cranial nerves have advanced so far in their differentiation that their appearance closely resembles the features of the adult. Due to this precocious growth of the cranial nerve elements the rhombencephalon furnishes one-half of the bulk of the entire brain. Peripherally it is possible to trace out the complicated communications between the cranial nerves and the formation of the cervical and brachial plexuses. The characteristic communication, for instance, between the first cervical and hypoglossal nerves, with the consequent *descendens hypoglossi,* is already established, and it can be seen how the latter unites with the combined branch from the second and third cervical nerves forming a typical *ansa hypoglossi,* from which branches can be seen entering the muscle masses of the hyoid group. It is likewise possible in this embryo to trace the nerve roots centrally into the brain and outline the nuclei of origin of the motor roots and follow the extension of the sensory roots up and down in the wall of the neural tube.

In the reconstruction it is these structures that have been modelled out, and thus there is represented of the centripetal elements the dorsal funiculi of the spinal cord, and the spinal tract of the trigeminal nerve and the fasciculus solitarius of the seventh, ninth and tenth cranial nerves. Of the motor elements there is the nucleus of origin, which forms a continuous column of cells extending from the spinal cord into the brain. This column is longitudinally subdivided into a median and lateral column. The median column gives off rootlets ventrally, including the ventral spinal roots and hypoglossal nerve, and, placed at intervals more cephalad, the abducens, trochlear and oculomotor nerves. The lateral column gives off rootlets leaving the lateral part of the tube, including the motor elements of the spinal accessory, vagus, glossopharyngeal, facial and trigeminal nerves.

The so-called rhombic grooves, or transverse furrows, which are present at this time in the floor of the fourth ventricle, can be definitely made out in the model. That these grooves are a true feature of growth in the mammal and are not artifacts is an opinion that has been accepted with much conservatism; but, now that they have been reported in the pig, rabbit, dog, sheep, cat and rat, and recently by Mrs. Gage in the human embryo, there can no longer be any doubt as to their reality. The writer gave them an ultimate test in the pig by examining the fresh embryo while still warm in its own amniotic fluid, and under the binocular microscope it could be seen that the grooves had the same characteristics that are present in preserved specimens.

In the model there are six distinct rhombic grooves, which correspond closely with those seen in the living pig embryo by the writer and with the description published by Bradley (1905, Jour. Anat. and Physiol., Vol. XL) of the preserved pig embryo. These commence in the region of the pontine bend and extend caudad. Their shape, comparative size and arrangement is indicated in the accompanying Fig. 1.

Their relation to the cranial nerves is likewise indicated in the same figure. If the grooves are labelled *a, b, c, d, e* and *f,* then it can be seen that we have the following relations: the trigeminal nerve arises conjointly from *a* and *b*, the facial nerve runs transversely beneath the floor of groove *c,* which usually is the deepest and most sharply cut of all six grooves, the acoustic nerve has its attachment to the

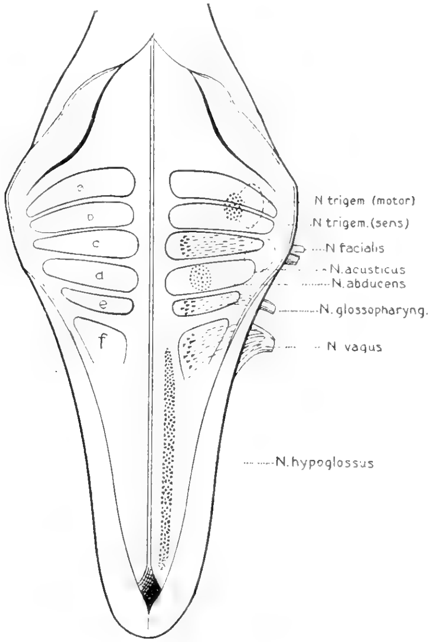


Fig. 1. Diagram of the floor of the fourth ventricle in the 10 mm. human embryo (Huber embryo No. III) illustrating the rhombic grooves and their relations to the cranial nerves. The point of attachment of the acoustic and the sensory root of the trigeminal nerve is shown by dotted circles; the motor nuclei are represented by heavy dots.

marginal plate adjoining grooves *c* and *d*, the abducens nerve arises from *d,* a shallow and somewhat quadrilateral groove, the glossopharyngeal nerve runs under the floor of the narrow groove *e*, and the vagus arises from *f,* which groove merges caudally into the general floor of the ventricle.

This nerve distribution is constant in the different mammals, and it is very likely that in this we have an explanation of the significance of these grooves. The predominant view regarding them heretofore has been that they are neuromeric and in a series with the spinal segments and the coarser transverse divisions of the mid- and forebrain. Instead of this, if emphasis is laid on the fact that they stand in constant relation to the lateral group of cranial nerves (fifth, seventh, ninth and tenth), then they may be fitted in with and form part of the branchiomeric system. This view has in its favor the fact that they are not only united by nervous trunks, but also numerically correspond to and are embryologically contemporary with the branchial and facial arches, in a manner shown in the following table:

Maxillary Process	Trigeminal N.	Groove *a*.
Mandibular Arch		Groove *b*.
Hyoid Arch	Facial N.	Groove *c*.
	Abducens N.	Groove *d*.
Third Branchial Arch	Glossophar. N.	Groove *e*.
Fourth Branchial Arch	Vagus N.	Groove *f*.

The one discordant feature is groove *d*, which has no corresponding branchial arch. It is possible that this should be considered, not as a true branchiomeric groove, but as simply the interval between grooves *c* and *e;* or, on the other hand, we may in this instance have to do with a displaced or lost arch, which is suggested by the aberrant course of the abducens nerve which arises from this groove.

Though the scope of the present communication is not intended to include a more detailed description of the cranial nerves and their nuclei, yet there is one feature regarding the facial nerve and its relation to the abducens nerve to which attention should be directed. It is the reversed relative position which these two structures occupy in embryos at this time as compared with the adult condition. Here the sixth nerve is more caudal than the seventh. As seen in Fig. 1, the nucleus of the facial nerve is situated near the median line under the third rhombic groove, groove *c*, from which nucleus the nerve fibres extend laterally, forming a slightly arched flattened bundle under the floor of this groove, and eventually emerge from the ventro-lateral border of the neural tube near the attachment of the acoustic nerve. The nucleus of the abducens nerve is situated beneath the fourth rhombic groove, groove *d,* and in some vertebrates is reported as invading the adjoining caudal groove, groove *e.* The nerve fibres of the abducens emerge directly ventral. The entire appearance and behavior of this nerve corresponds with the hypoglossal nerve, with which it is generally considered to stand in serial relation.

As development continues, the floor of the neural tube thickens and the different structures shift their relative position. During this process the abducens migrates cephalad, but, like the hypoglossus, it maintains its relation to the floor of the fourth ventricle. The facial nucleus, however, like the motor nuclei of the ninth and tenth nerves, with the development of the formatio reticularis, is crowded ventro-lateralward. The migration of the nuclei of the facial and abducens nerves and the

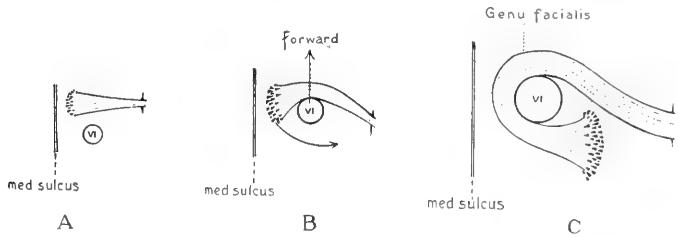


Fig. 2. Diagram illustrating the development of the genu of the facial nerve in the human embryo. The drawings show the right facial nerve and its nucleus of origin, in three stages: the youngest, A, being the 10 mm. embryo, and the oldest, C, the new-born child. The relative position of the nucleus of the Abducens nerve is represented in outline. Its nerve trunk could not be shown, as the structures are represented as seen from above.

shifting of their relative positions is represented in Fig. 2, in which A corresponds to the 10 mm. embryo and C shows the relation eventually assumed by these two structures in the adult. B represents the intermediate condition, with the directions in which the relative shifting occurs indicated by arrows. It is evident on comparison of the three stages that in case of the formation of the genu of the facial nerve we have to do with a mechanical procedure which is brought about by the forward migration of the abducens nucleus therewith pushing before it the main trunk of the facial nerve. At the same time the genu is extended caudally by a ventro-lateral migration of the facial nucleus.

Description of an Apparatus for Recording the Activity of Small Mammals.

BY

JAMES ROLLIN SLONAKER.
Stanford University, California.

With Eight Figures.

In studying the activity of animals, it is often quite essential that their performances should be readily recorded by a convenient apparatus. Such apparatus should not only be simple in construction and manipulation, but also as nearly as possible automatic. It should be so made that the amount of activity can be readily determined at any time and periods of rest and activity graphically recorded.

In my study on the normal activity of the white rat at different ages (Slonaker, '07) the apparatus used proved to be very convenient. It was quite similar to that used by Dr. C. C. Stewart in his experiments on the "Variations in Daily Activity of Different Animals" (Stewart, '98), but several modifications and improvements have been made. It is this apparatus which I now propose to describe.

The apparatus consists of three essential parts: (1) a revolving cage; (2) a nest box with water and feed boxes attached; (3) recording parts which register the number of revolutions and the periods of activity and rest during each twenty-four hours.

The cages are cylindrical in shape and are composed entirely of one-fifth inch mesh galvanized wire netting. The outside dimensions are 18 inches long by 18 inches in diameter. For animals smaller than the white rat, finer meshed netting and smaller revolving cages could be used. However, young rats of only 25 grams weight, turn cages of this size with ease. Brass bearings (Fig. 1, B) are soldered to the center of each end of the cage through which a quarter inch steel axle (A) extends. The axle is supported on two long wooden pieces (F), one by three inches, and twenty inches apart. Between these two supports the cages revolve (Fig. 2). A number of cages may thus be arranged in a series.

The author has had as many as eight operating at one time (Fig. 7). The axles are held stationary by two wire nails (Fig. 2, N) passing through each end into the wooden frame.

On one end of the cage a door is cut large enough to enable one to remove the nest box (Fig. 2, Nb) for cleaning. This box is attached firmly to the axle, so that when the cage revolves, it remains at rest. It is made of tin with removable bottom which provides for thorough cleaning and scalding. The bottom is securely held in place by two spring clips (Sp), one on either side.

On the end of the nest box nearest the door are placed a tin box for food and a copper box for water (Fig. 3, Fb and Wb). As will be explained, these can be reached by the animal only after it has left the nest box, descended to the revolving cage, and climbed over the outside of the nest box. At the other end of the box is the entrance to the nest (E).

This is an inclined tunnel covered over with tin, and having a floor of wire netting. The lower end of this entrance is at one side of the center of gravity. This arrangement compels the rat when leaving the nest to jump onto the cage before reaching its food. This starts the cage revolving at once.

A ladder (Ld) of wire netting hanging down from the opposite side enables the rat to get to the upper side of the nest box and so to his food. For the purpose of ventilation, holes (Fig. 3, O) are cut in the roof of the nest box, and a number of small holes are punched in the floor. Sawdust placed in the bottom of the nest makes it easy to clean.

In the cylindrical part of the cage a series of openings one-half inch wide by three inches long are made. These openings, which extend from one end of the cage to the other, prevent accumulation of excrement or particles of food. As the cage revolves, the debris drops through these openings at each turn.

Friction caused by the accumulation of debris is thus reduced to a minimum, as particles remain in the cage but a few revolutions.

A large pan (Figs. 1 and 2, P) 20 x 24 x 1 inch is placed under each cage to catch the particles which drop through. A layer of sawdust in each pan absorbs any moisture that is dropped and makes cleaning easy.

On the same end of the cylinder as the door, a brass rod, one-eighth of an inch in diameter and one and one-half inches long, is screwed into the brass bearing plate one inch from the axle and at right angles to the plate (Figs. 1 and 2, Ep). As the cage revolves in either direction this eccentric rod lifts the lever (Figs. 1 and 2, L), one end of which lies on the axle. The fulcrum of the lever is on the side of the same board which supports the axles of the cages.

The lever is triangular in shape and is thus able with each lift of the eccentric to exert a downward pull at its other end and a horizontal pull at its lower portion.

To each of these points of the lever small wires are attached. The one pulling downward (Fig. 1, C) is attached to the recording clock and the other (W) to the recording pen.

The recording clock consists of an ordinary alarm clock with second hand. The balance wheel is removed and a spring is attached to the escapement, so that with each lift of the lever the escapement is pulled down and one ratchet of the escapement wheel passes. The spring pulls the escapement up again, when the eccentric on the cage allows the lever to come to rest on the axle. The number of revolutions of the cage is thus recorded in seconds, minutes and hours by the clock. The number of revolutions which equal a minute can easily be determined by counting. The ordinary alarm clock will record about 180,000 revolutions with one winding.

The movement of the lever is also transmitted by means of a small iron wire (W) to the writing lever (Fig. 5, Wl).

It is very essential that the wire should be free from kinks and bends. It can be readily straightened by slightly stretching it. The wire is made taut by using a very light turnbuckle (Fig. 5, Tb). These wires run through continuous glass tubes (Fig. 2, G) which lead along the support to the recording kymograph. The use of glass tubing reduces the friction to a minimum, and keeps the wires of different cages separate.

The writing lever (Wl) consists of a thin piece of hard wood pivoted by means of a screw to a block of wood fiber. The block is adapted to slide and clamp on an iron standard. Since the lever and block occupy but a little space, there is room for all the pens to be supported on the same standard. This is shown in Fig. 6. A glass or hard rubber inkwell (Fig. 5, I) is fastened on the side of the lever. Leading from this inkwell is a capillary glass tube (Cp), which is attached to the lever by means of ceiling wax and thread.

The end of the capillary tube is fused to a small round point with a very small opening and is bent so as to meet the kymograph paper at right angles. The ink is thus carried by capillary attraction to the moving paper of a continuous roll kymograph.

With each revolution of the cage in either direction a pull is exerted on the wire W and a vertical line is made on the paper. When the tension on the wire is released, the spring (S) pulls the writing lever to its original position. Each vertical line, therefore, represents one revolution of the cage. If the kymograph paper moves fast enough, each revolution will be distinctly recorded; but as it moves only from two to four inches each hour, these vertical lines coalesce and form a solid band during periods of great activity.

The time is recorded by means of another capillary glass pen attached to an electro-magnet (Fig. 6). A clock in the circuit with the magnet makes electric contact once each hour, thus spacing the paper into periods of one hour each.

If it is desired to space paper into minutes, one needs only to have the second hand make contact once each revolution instead of the minute hand.

I have used three ways of keeping the kymograph in motion: (1) electric motor; (2) water motor; (3) an apparatus driven by a weight. The last has proved by far the most satisfactory. With an electric motor, one is at the mercy of the electrician, who often cuts off the current without notice. With the water motor, the pressure varies, giving varying rates of speed, and the sink is likely to become stopped, with disastrous results. The apparatus run by a weight is as nearly constant as it is possible to have it. The speed of the apparatus which I use is regulated by different sized fans. It is also modified by change of weights. The speed of the kymograph can also be varied by changing the belt onto other pulleys of the driving apparatus. The weight is supported by a one-eighth inch steel cable with a breaking strain of about 800 pounds.

The cable is wound up on a cylindrical drum, provided with a rachet and gear similar to that of an ordinary clock. One hundred feet of this cable will run the apparatus at the speed I use, thirty-six hours at one winding. Fig. 7 shows this apparatus and its connection with the kymograph.

The apparatus thus resolves itself into two essential parts. First, the revolving cage and its accessory parts for obtaining and transmitting a certain kind of action. Second, the recording apparatus, composed of the clock which accurately records the number of revolutions made, and the writing lever and kymograph, which graphically show the distribution of the activity during the day and night.

The entire apparatus is nearly automatic. It needs attention but once a day, which consists of winding up the weight, winding the electric clock, filling the inkwells, reading the recording clock and feeding the animals. The last requires the greatest amount of time.

An objection might be raised to this apparatus because it does not record all the activity of an animal. Observations of the white rat prove that most of its activity is manifested in running, practically all of which is recorded.

Since the animals are placed in separate cages of like weight and dimensions, and each cage has its own recording clock and writing lever, these records may be directly compared at any time.

BIBLIOGRAPHY.

Slonaker, J. R. The Normal Activity of the White Rat at Different Ages, Jour. of Comp. Neurol. and Psychol., Vol. XVII, No. 4, 1907.

Stewart, C. C. Variations in Daily Activity produced by Alcohol and by Changes in Barometric Pressure and Diet, with a Description of Recording Methods. Am. Jour. Physiol., Vol I, No 1, 1898.

EXPLANATION OF THE FIGURES.

Fig. 1. End view of revolving cage showing recording clock connected by wire, C, to lever, L, supporting frame, F, and catch pan, P.

Fig. 2. Side view of revolving cage showing openings, Oc, through which debris falls into catch pan, P; nest box, Nb; water and feed box, Wb; entrance, E; ladder, Ld, which goes up on opposite side of nest box; spring clip, Sp, which holds removable bottom; and eccentric pin, Ep, with lever, L, resting on it.

Fig. 3. Top view of nest box showing openings, O, for ventilation; entrance at E; location of ladder Ld; and water, Wb, and food, Fb, boxes.

Fig. 4. End view nest box showing position of entrance, E, ladder, Ld; method of supporting to axle and the spring clip, Sp, which holds the removable bottom. A small portion of the cage is also shown.

Fig. 5. Diagram of writing lever showing method of transmitting motion from revolving cage by means of wire, W. All the levers are supported on the same standard, each being connected by its own wire with the cage which it represents.

Fig. 6. Showing arrangement of pens, time marker below, electric clock, and one of the revolving cages with its recording clock and catch pan.

Fig. 7. Showing arrangement of eight revolving cages with their accessory parts. The motor apparatus and kymograph are seen in the center.

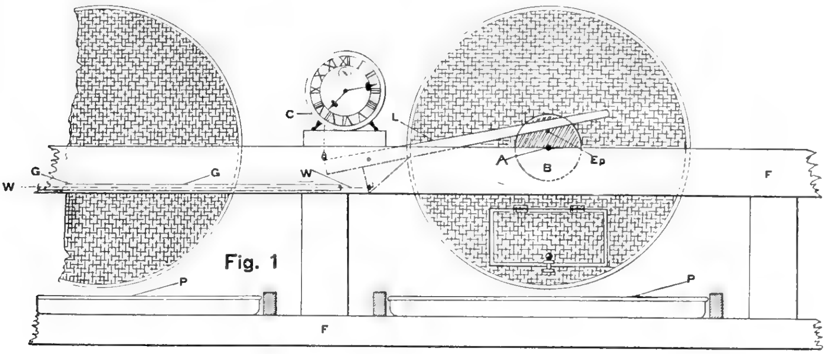


Fig. 1

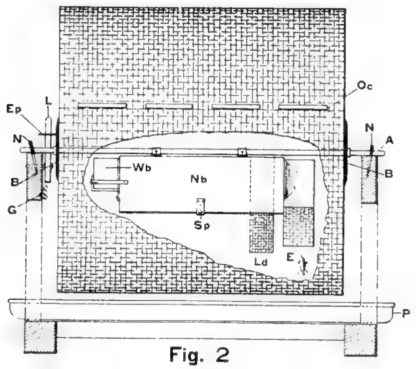


Fig. 2

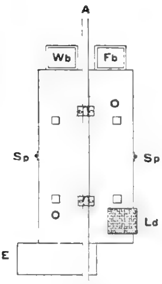


Fig. 3

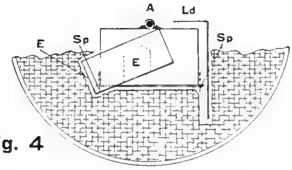


Fig. 4

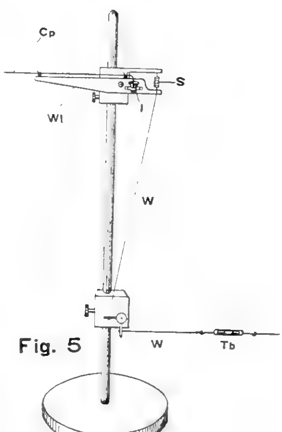


Fig. 5

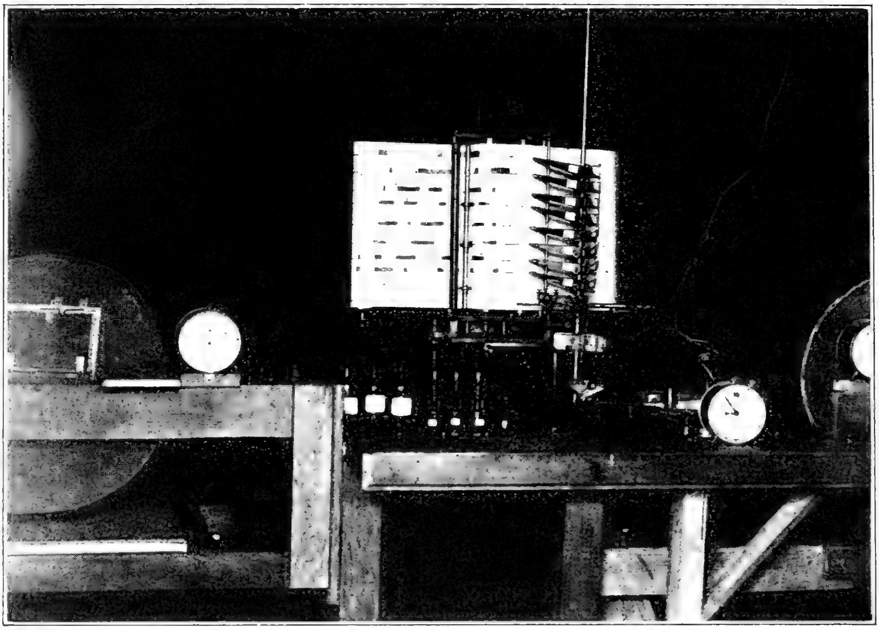


FIG. 6.

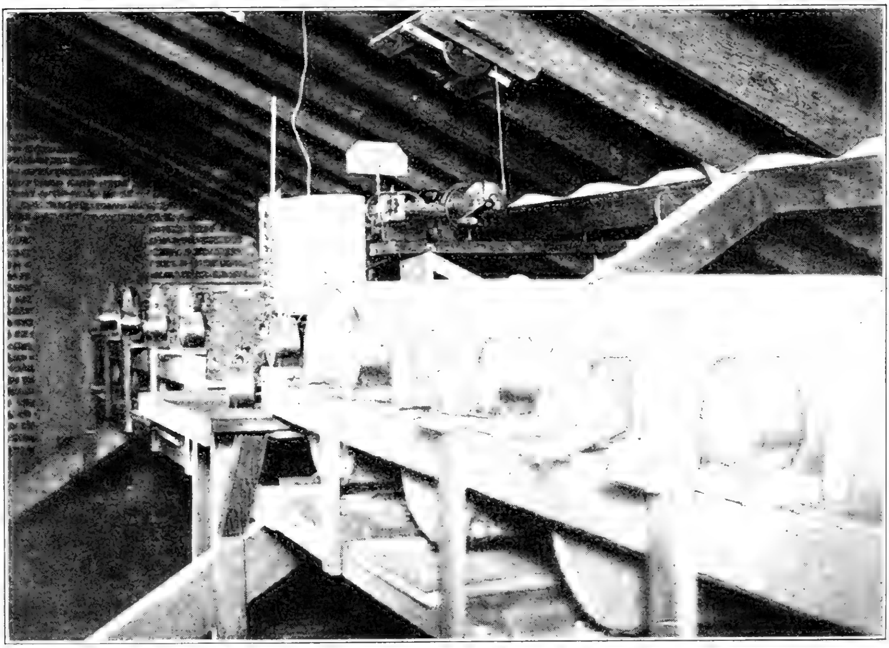


FIG. 7.

BOOK REVIEWS.

"The Liver in Antiquity and the Beginnings of Anatomy," by Prof. Morris Jastrow. *University of Pennsylvania Medical Bulletin,* Vol. XX, No. 11, January, 1908.

"An Omen School Text;" Old Testament and Semitic Studies in Memory of William Rainey Harper, Vol. II, Chicago, 1908.

Primitive man undoubtedly must have observed Nature about him more or less carefully and attempted to express those observations in various ways. Any careful observation of the form of animals and of animal structure in any respect constitutes in a sense anatomical study. It is only fair, then, to recognize that records left by Palæolithic man have been for some time known to science. In this wider sense, the crude drawings on the walls of the Aurignac cave, for instance, depicting as they did the Mammoth, the Irish Elk and other contemporaneous mammals, are examples of primitive anatomical observation no less than of earliest art.

If we reflect but a moment it is apparent also that one cause was operating to necessarily acquaint man, at least in some degree, with the internal structure of those mammals with which he lived, viz: his use of them for food. What acumen of observation came to be used when the victim of the chase lay at the hunter's feet or was prepared for the feast, is not even vaguely known to us. But it is reasonably certain that in a rough way all of the larger viscera were early known and in time named.

Another circumstance of the life of early man furnished cause for primitive anatomical study, viz: the sacrifice of animals in religious rites. Inasmuch as in the records of these rites we possess much evidence of purposeful anatomical study (surprisingly exact, be it remarked), we must admit that in his investigations in this field Professor Jastrow has demonstrated one of the places where we can see the beginnings of anatomy. He has laid all students of anatomy in its wider aspects under obligation to him by his interesting exposition of one of the first chapters in the history of anatomical science.

Though anatomical dissections were undoubtedly practiced some centuries before Christ,[1] it it surprising to know that anatomy, through a curious relation to these religious rites, must be said to go back at least

[1]Indeed, Democritus of Abdera is said to have dissected the human body as early as 460 B. C.

some three thousand years B. C., and this Professor Jastrow has apparently demonstrated.

This earliest anatomy, or anatomical study, was but a necessary incident to the performance of certain divination rites among the Babylonians and Assyrians. Divination, a seeking for signs to be interpreted in a definite way, was always in answer to some inquiry concerning the future. An animal was sacrificed and in it was read the mind of the god; and that the divine will should be reflected in an animal rather than elsewhere was merely a consequence of the belief that here especially the unseen Power had chosen to dwell: hence the reverence in which all life was held by the ancients. Now the liver was chosen for inspection as a natural consequence of that early, deep-grounded belief in the soul's residence in that organ. The "center of vitality"[2] was there; and there especially, then, one should look for the workings of the divine mind.

Thus the divining priest studied the lobes, the gall-bladder, the portal vein, the gates of the liver, the bile ducts, and other structures. Each was named and, moreover, the young aspirant for the priesthood had for his instruction in the temple school clay models of the sheep's liver, in which all of these structures were more or less accurately placed. It is most interesting to know that some of these models have escaped the ravages of time and been preserved. The figure shows such a model, belonging at one time in the school of the temple of Marduk in Babylon and dating from the period of Hammurabi, 2000 B. C.

By a comparison of the parts distinguished in such models and the omen texts (which have also been preserved) most of the structures recognized and the names given them have been learned. We copy Dr. Jastrow's figure of the sheep's liver, appending both the modern nomen-

[2]Professor Jastrow calls attention to the fact that we are accustomed to think that the heart was, among ancient nations, looked upon as the seat of the soul, "but while this is true for Greece, Rome and India, as well as for the Hebrews at a certain stage of culture, even in these civilizations there was an earlier period in which that distinction was accorded the liver." In the Greek, one mortally wounded is "struck in the liver," and Dr. Jastrow is disposed to interpret the punishment of Prometheus, whose liver is gnawed by a vulture, as also resting on this view. "In Hebrew poetry, likewise," he says, "the word for liver (kabed) is used synonymously with the word for soul (nefesh), and even as late as the days of Mohammed the story is told that on an occasion of great sorrow the prophet wept all night 'as though his liver would crack' where we would say 'as though his heart would break.' "

clature and the Assyrian synonym for each structure recognized so long ago.

How did the augur or priest read these structures in answer to the inquiry propounded? "In order to reach a decision as an answer to any given question, all the signs and phenomena noted on the liver were recorded, the meaning of each determined, whether it was favorable or unfavorable, and then, by a combination of the prognostications a conclusion was reached whether a proposed undertaking, a battle, a journey, a proposed appointment to an official post should be risked, or whether the outcome of a disease or an occurrence of some kind would be favorable or unfavorable. The general principle underlying the elaborate system of interpretation that was in the course of time developed,

FIG. 1.—Babylonian clay model of sheep's liver with a divination text of the period of Hammurabi (c. 2000 B. C.).

rested on a more or less logical association of ideas. If a certain sign on the right side was favorable, the same sign on the left side was usually unfavorable. Most of the interpretations bore on public events, but could be applied also to private affairs. Thus, if the gall-bladder was swollen on the right side, it pointed to an increase in the strength of the king's army, and was, therefore, interpreted as a favorable sign in general; while the swelling on the left side prognosticated the success of the enemy, and was, therefore, an unfavorable sign. If the gall-bladder lay tightly imbedded in the gall-bladder groove, it meant, if on the right side, that the king's army would be in the firm grasp of the enemy, and, therefore, to be regarded as an unfavorable symptom; if, however, the left side of the gall-bladder was tight, that the enemy would be kept as a prisoner, and, therefore, a favorable symptom for the

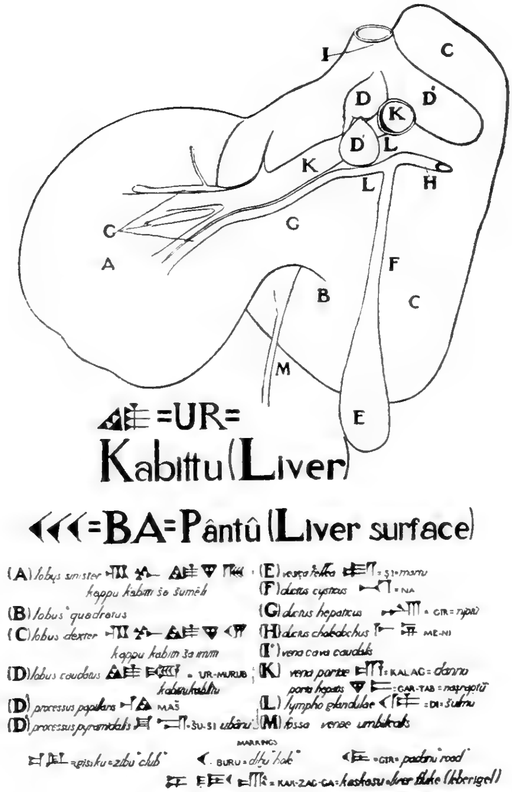


Fig. 2 (Jastrow's Fig. 3).—Lobus dexter—"right wing." Ductus hepaticus—"the outlet." Lobus sinister—"left wing." Vena portae—"the strong." Fossa vesicæ felleæ—"river of the edge of the liver." Porta hepatis—"crucible." Fossa venæ umbilicalis—"river of the liver." Lobus caudatus—"middle of the liver." Processus pyramidalis—"finger of the liver." Processus papillaris—"small." Vesica fellea—"the bitter."

king's army. If the biliary duct was long, it pointed to long life; if the hepatic duct was well enclosed in the gate of the liver, it meant success in battle; if, however, it lay above and beyond the hepatic duct, it indicated a position exposed to the attack of the enemy. If the finger-shaped appendix (processus pyramidalis) was broad, it was interpreted as joy; if it was small, while the other appendix (usually small) was large, it pointed to an inversion of the natural order. The son would be mightier than the father, the servant would prevail against his master, *i. e.,* in general that the 'small' would be great and the 'great' submit to the 'small.' Gallstones, designated as 'knots,' are also not infrequently mentioned in the divination texts, and in connection with other symptoms are either favorable or unfavorable."

Practically the same system of augury—of hepatoscopy—was practiced by Etruscans, Greeks and Romans, and it only fell into disrepute and finally disuse when the liver's importance as the central vital organ was called into question and usurped by the heart and, at length, in the time of Hippocrates, by the brain. For though at one time the heart was added to the liver in the inspection of the sacrificial animal, the rite no longer made the deep impression of its earlier days. With the liver no longer recognized as the seat of the soul, perpetuation of the rite was not only meaningless, but at length often a matter of deception. "It is hence not surprising to find such a strategy as is recorded in several classical writers of a ruler who, in order to encourage his soldiers to give battle, engaged a priest to write the words 'victory to the king' on the palm of his hand with the letters reversed, to put the smooth side of the liver of the sacrificial animal on his hand, make a pretense of examining it, and then to hold up the liver in the sight of the army with the miraculous inscription."

Be this as it may, however, the rite was unabused for many centuries in Assyria and Babylonia; and in its performance, it appears, some knowledge of the details of the outer structural features of the liver was gained, at a time which must be reckoned as in hoary antiquity, some three thousand years before the Christian era.

Herbert M. Evans.

"Surgical Applied Anatomy," by Sir Frederick Treves, Bart. Fifth Edition, revised by Arthur Keith, M.D., F.R.C.S. Illustrated with 107 figures, including 41 in color. Published by Lea Brothers & Company, Philadelphia, 1907.

The new edition of Treves' "Surgical Applied Anatomy" has added some sixty pages of text and a number of new illustrations. The little volume ably fulfils the object for which it was intended—primarily to recall the more important anatomical relations for the student in his preparation for final examination in surgery. It is, in fact, a ready reference for the student and physician based upon Treves' long experience as a surgeon and an anatomist. Effort was made to present the subject in such a manner that a first or second year student might appreciate the application of certain anatomical relations. We consider it the best book written in English to refer to a student in answer to his ever ready query, "What is the important thing to be remembered?"

The work in no way replaces any of the reference works on topographic anatomy such as Joessel-Waldeyer or Zuckerkandl, or are the illustrations as detailed as in von Bardeleben's Atlas or in Deaver's exhaustive Surgical Anatomy. The book assumes little more than a general knowledge of the human body and states the importance of the pathological conditions, which, by the way, are defined in a very concrete manner in an interesting way. The treatment of the subject leads us to believe it to be a compilation of Treves' lecture notes.

Embryology is introduced mainly to explain the congenital abnormalities; the nerve supply with reference to reflexes and referred pains; the vascularity in regard to the healing qualities of the region and the dangers from hemorrhage in surgical procedure; the muscular system in its effect on dislocations and fractures. The last named topic is in our opinion about the most effective, although it is naturally not as detailed as Stimson's excellent work.

The book is of convenient size, concise, sufficiently illustrated, well arranged and above all readable. We have recommended it to our students, especially in conjunction with the section on topography in Quain.

The fifth edition, revised by Keith, has not in our opinion materially bettered the work. While the addition of colored plates is to be commended, we regret that no color scheme was hit upon. Similarly the addition of color to figure 105 detracts distinctly from the picture, while a number of other illustrations might have been redrawn to advantage. The chapters on the extremities are possibly the best in the book, while the part on the chest might be rewritten to advantage and illustrated by the excellent figures in Merkel.

Apart from this very general criticism we regret the use of terms such as "tarsal cartilage" (p. 56), "supraumbilical" portion of the ear (p. 72), "cloacal urethra" (p. 459). Also the "explanational" anatomy as found on p. 45, accounting for the tortuous course of the large arteries to the brain," "with the object probably of diminishing the effects of the heart's systole," is not well taken, and the arguments in favor of supination being stronger than pronation (p. 285) are far from convincing.

A. G. Pohlman.

THE ANATOMICAL RECORD

Vol. II. JULY, 1908. No. 4

Variations in the Wall of the Large Intestine and in the Number and Staining Properties of the Goblet Cells.

BY

RICHARD W. HARVEY.

From the Anatomical Laboratory of the University of California.

With Eight Figures.

The purpose of this paper is to describe some variations observed in thickness of wall and in the depth and arrangement of the glands of Lieberkühn of the different regions of the large intestine in different states of distension, and also to note some variations in the number and staining properties of the goblet cells in the different regions. The regions or parts of the large intestine considered are the cæcum, ascending colon, transverse colon, descending colon, and rectum. Comparisons are made first, between different regions in the same degree of contraction, and second, the same regions are compared, the contracted with the distended condition. These comparisons comprise:

1. Variations in the thickness of the muscular tunic in the different regions.
2. Variations in the shape of the intestinal (Lieberkühn's) glands in the different regions.
3. Variations in the depth and cross section of the intestinal glands in the different regions.
4. Variations in the depth and cross section of the glands and in the thickness of the muscular tunic produced by distension.
5. Variations in the number and staining properties of the goblet cells in the different regions.

Material and *Methods:* Sections of human large intestine were used in making the comparisons involving the staining qualities and number of the goblet cells, and, in addition to the human, a dog's large intestine was used in all comparisons involving measurements.

The human material had been obtained in an unusually fresh condition from the body of an executed criminal, and proved to be exceptionally good for the purpose in hand. Even the superficial cells of the epithelium were remarkably intact and usually in no way disarranged. At the time of obtaining the material, short lengths of the intestine were distended with Zenker's fluid by means of a large syringe, each piece being ligated so as to retain the fluid forced into it, then severed from the rest of the intestine and immersed, distended as it was, in a copious amount of the same fluid. Attempts were made, but roughly, owing to the haste that was necessary, to use the same amount of pressure in distending the different pieces. Other pieces of this intestine, in each case immediately adjacent to those distended, were clipped off and, undistended, were dropped into the vessels containing the corresponding distended pieces. These pieces became fixed, of course, in a highly contracted condition. Unfortunately, both distended and contracted pieces from each of the regions here considered were not prepared at the time, and thus the necessary pieces for a complete comparison of the human material were not available for each region. The pieces of human intestine which could be used may be described as follows:

From the cæcum—two pieces, one contracted, and the other distended.

From the ascending colon—one piece, somewhat contracted.

From the transverse colon—two pieces, one contracted, and one much distended.

From the descending colon—two pieces, one contracted, and one distended.

From the rectum—two pieces, one contracted, and one partly distended.

Obviously supplemental material was necessary to fill in the gaps in the evidence obtained from the human material. The dog's large intestine was chosen for this purpose because of its slight resemblance to the human large intestine, and also to determine the variations in the dog itself. The supplemental material, in addition, made it possible to compare variations of the dog's intestine with the human intestine.

The large intestine was removed from a freshly killed dog, and the rectum tied off at its junction with the descending colon. A large rubber-bulb syringe containing normal salt solution was inserted at the anus, and pressure applied to the bulb. When the intestine had reached a presumably normal degree of distension the anal end was tied. The distended rectum was then severed and placed in Zenker's fluid. Pieces of the descending colon, transverse colon, ascending colon and cæcum were distended and fixed in the same way, the degree of pressure exerted in each case being, as nearly as could be determined, the same as in the rectum. The cæcum was distended entire. When sufficiently hardened, the different pieces were slit open and the salt solution (now, by osmosis, dilute Zenker's fluid) emptied out, and the fixing fluid replaced with fresh.

In choosing the bits for study, small squares of the human intestine were cut from midway between the tæniæ coli in each case. Two similar areas of the dog's intestine were cut out, one from the distended part and one from the contracted end of each piece, near the ligature. No tæniæ are definitely differentiated in the dog's large intestine. In all cases, these bits taken were placed in separate vials, appropriately labeled, and thus carried through the procedures necessary. The tissues intended for measurements were embedded in celloidin and cut, and the sections stained in hæmotoxylin and congo red. Measurements were taken with an eye-piece micrometer whose spaces had been standardized in microns.

Normal Variations of Different Regions of the Large Intestine.

The intestinal wall was found to be normally thinnest in the cæcum and gradually thickens as the anus is approached. In contraction the mucosa forms folds to accommodate itself to the contracted muscular wall, and the glands, therefore, are compressed within the crevices between folds, and thus are frequently bent at a sharp angle with the plane of the surface. In distension the folds are straightened out, except in the rectum, the crevices disappear, and the glands stand uniformly perpendicular to the surface.

The glands are closely packed together, here and there a lymph nodule pressing them apart. They are straight tubular in shape. Those of the cæcum are short and thick, somewhat club-shaped, with a constriction at the neck, and less thickly distributed than those further on in the colon. In the ascending colon the glands are more closely packed together than elsewhere, are much more long and slender than in the cæcum, are compressed against the muscularis mucosæ at the fundus, and are slightly constricted at the neck. In the transverse colon the

Region.		Depth of Gland.		Cross Section of Gland.		Interglandular Space.		Thickness Mus. Mucosæ.		Thickness Tunica Mus.		Thickness Intestinal Wall.		No. Goblet Cells.	Stain.
		Con.	Dist.	Con.	Dist.	Con.	Dist.	Con.	Dist.	Con.	Dist.	Con.	Dist.		
Cæcum.	Human.	373	324	106	108	10	27	13	11	544	302	1540	1339	34	Faint.
	Dog.		474		58		24		43		317		1247		
Asc. Colon.	Human.	331		98		17		24		377		1093		30	Medium to Faint.
	Dog.	599	583	68	62	5	15	44	35	916	507	2109	1478		
Transv. Colon.	Human.	431	285	90	50	12	49	40	15	785	123	1416	646	28	* Very Dark.
	Dog.	596	329	70	57	8	62	40	18	888	229	2140	893		
Desc. Colon.	Human.	460	389	95	90	20	55	41	33	662	186	1278	685	36	Dark.
	Dog.	581	385	70	67	6	30	52	27	926	317	2140	1047		
Rectum.	Human.		492		100		21		54		287		893	45	Medium.
	Dog.	436	383	85	77	13	43	72	33	748	236	1724	1170		

* Separately stained preparation.

TABLE 1. Recording average measurements showing in microns the variations in thickness of the wall of the large intestine in the different regions, both human and dog, contracted and distended, and giving the number and relative depth of staining of the goblet cells.

glands are likewise long and slender, though they are shorter than those of the ascending colon, are less thickly distributed, and are more bulging at the fundus. The glands of the descending colon, though longer than those of the cæcum, are shorter than those of the transverse colon, are about equal to the latter in cross section, and are constricted at the neck. They are closely packed together, and in places are much compressed against the muscularis mucosæ. The rectal glands are short and stout, nearly uniformly tubular, and more sparsely distributed than in the cæcum.

In no region of the large intestine was there seen evidence of branching as has been observed in the duodenum and jejunum. Between the folds of the mucosa of the rectum two or three glands sometimes open

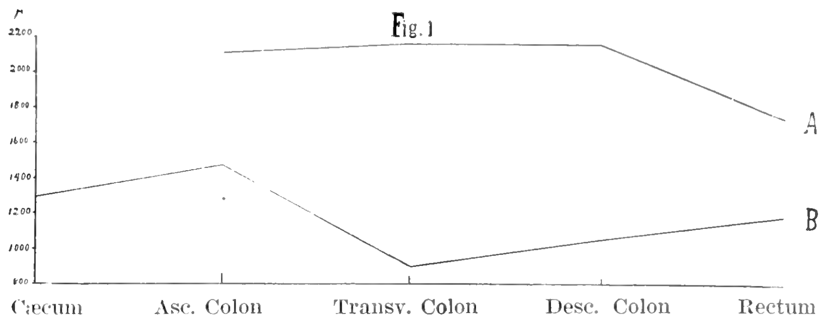


FIG. 1. Curves plotted from measurements recorded in Table 1, expressing the variations in thickness of the intestinal wall in the different regions of the dog's large intestine, A when contracted, B when distended.

into a kind of vestibule; but this condition is probably due to compression rather than being a persistent structure or a suggestion of branching.

The accompanying table records measurements in microns averaged from measurements of a number of different glands in each region of the human and dog large intestine, affording data for the comparison of variations in depth and cross section of glands, in the interglandular space, and in the thickness of the entire intestinal wall and of the muscular tunic and the muscularis mucosæ. Measurements were taken from the cuticular border of the surface epithelium, or that directly bounding the lumen of the intestine, to the outer margin of the tunica adventitia, except in the section of transverse colon of the dog, the surface epithelium of which was destroyed. Fig. 1 is plotted from the tabulated measurements of the dog's intestinal wall contracted (A) and distended (B). The ordinates are graduated in microns and the abscissæ are equal spaces, representing the five different regions.

Under like conditions of contraction and distension the thicknesses vary as follows: In contraction the greatest thickness is in the transverse and descending colons, the least in the rectum; in distension, the greatest thickness is in the ascending colon, the least in the transverse colon. The greatest diminution in thickness with distension occurs in the transverse colon, the least in the rectum.

Variations in Depth of the Glands of the Different Regions in the Contracted and Distended Conditions.

The depth of glands was measured from the basement membrane of the surface epithelium to the basement membrane of the fundus; and, in all cases, glands cut longitudinally throughout their length were

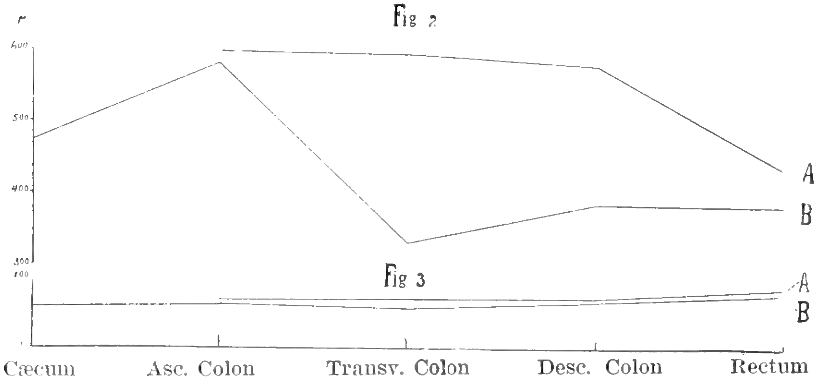


Fig. 2. Curves plotted from measurements recorded in Table 1, expressing variations in the depth of glands in the different regions of the dog's large intestine, A when contracted, B when distended.

Fig. 3. Curves plotted from measurements in Table 1, expressing variations in cross section of glands in the different regions of the dog's large intestine, A when contracted, B when distended.

selected, that the measurements might coincide with the lengths of their axes.

The contraction being approximately the same for each region, the depths of the glands are found to vary as follows: Greatest in the ascending colon, gradually diminishing to the least depth in the rectum. Fig. 2, A is plotted for the contracted dog's intestine from the measurements tabulated in the table above. The distension being approximately the same for each region, the depth in the distended pieces appears to be greatest in the ascending colon, but least in the transverse colon instead of in the rectum, and between these two extremes in the remaining regions. Fig. 2, B is plotted from the tabulated measurements of the dog's intestine distended. The greatest diminution in depth with distension is seen to be in the transverse colon, the least in the ascending colon. Mathematically expressed, the depth of the glands of Lieberkühn of the large intestine varies inversely as the distension. A comparison made with the human cæcum, but not taken into account in plotting the curves of variation shows variations which correspond with those of the dog's intestine.

Variations in Cross Sections of the Glands in Different Regions in the Contracted and Distended Conditions.

The cross section of the glands was determined by measuring the distance between the basement membranes of the sides of each gland in longitudinal section. It does not take into account the constrictions and bulges, but is, as far as possible, the average diameter of a gland. Under like conditions of contraction and distension the cross sections or diameters of the glands are found to vary as follows: In contraction, the greatest diameter is in the rectum, the least in the ascending colon, between which is a gradual diminution, as shown in the table and by Fig. 3, A. In distension, the greatest cross section is in the rectum, as in contraction, while the least is in the transverse colon instead of in the ascending colon (Fig. 3, B).

Comparing the contracted intestine with the distended, it appears that distension produces a diminution in the diameter of the glands. The greatest diminution in the diameter of the glands occurs in the transverse colon, the least in the ascending colon. Mathematically expressed, the diameters of the glands vary inversely as the distension, just as do the depths of the glands. The human cæcum contracted and distended shows corresponding variations. This similarity in the variation in depth and diameter indicates that distension, instead of compressing the glands against the muscular tunic and making them thicker, as well as shorter, must result in stress upon the glandular epithelium which produces a slight general decrease in the thickness of their epithelium and in the diameter of their ducts, and which stress, instead of compression, must, to some extent, lend to the decrease in their depths. Measurements show this to be true, and it may be seen in the outline drawings in Fig. 4. This figure shows that the fundi of the glands only are occasionally affected by compression against the greatly thinned submucosa and muscular tunic.

Fig.4

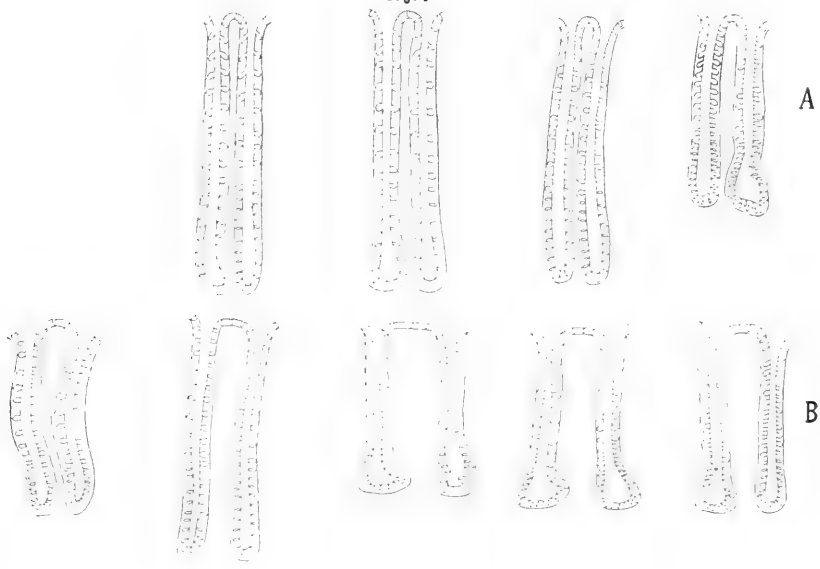


FIG. 4. Outline drawings, made with camera lucida, all under the same magnification, and corrected by micrometer measurements, showing the variations in the depth and diameter of the glands and in the interglandular spaces of the different regions of the indicated dog's large intestine, A in the contracted, and B in the distended condition.

Variations of Interglandular Space in Different Regions in the Two Conditions.

The interglandular space was measured from the basement membrane of one gland to that of an adjacent gland, both glands being longitudinally sectioned through their axes. The degree of contraction and distension being the same for all regions, the measurements, recorded in the table, show that the spaces vary as follows: In contraction, the greatest breadth of space is between the glands of the rectum, next the transverse colon, then the descending colon, and the least breadth in the ascending colon. That is, in a given contracted condition the glands of the ascending colon appear to be most thickly distributed. Fig. 5 A expresses these relations in the form of a curve.

In distension, the greatest space is in the transverse colon, diminishing in the rectum, descending colon, and cæcum in the order given, to the least space which is found in the ascending colon (Fig. 5, B). That is, in a given distended condition, as well as in the contracted,

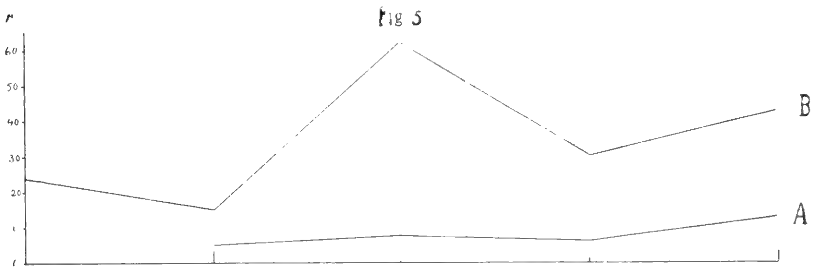


Fig. 5. Curves, constructed from the measurements recorded in Table 1, expressing the variations in the breadth of the interglandular spaces of the glands of the different regions of the dog's large intestine, A, when contracted, and B, when distended.

the glands of the ascending colon are most thickly distributed. Mathematically expressed, the interglandular space varies directly as the distension.

These observations indicate obviously that in all conditions the mucosa of the ascending colon is more thickly studded with glands than any other region of the large intestine. Further, the observation made above, that distension decreases the depth of the glands, coupled with the observation that it results in an increase in the breadth of the interglandular spaces, indicates that distension must increase the absolute area of the superficial epithelium or of that glandular surface directly exposed to the intestinal contents.

Variations in Thickness of Muscularis Mucosae.

The thickness of the muscularis mucosæ was measured from the inner margin of the inner, circular layer, to the outer margin of the outer, longitudinal layer. Contracted, the muscularis mucosæ is thickest in the rectum, diminishes in the descending colon and ascending colon, in the order named, and is thinnest in the transverse colon (Fig. 6, A). Distended, it is thickest in the cæcum, diminishes in the ascending colon, rectum, and descending colon, in the order named, and is thinnest in the transverse colon (Fig. 6, B).

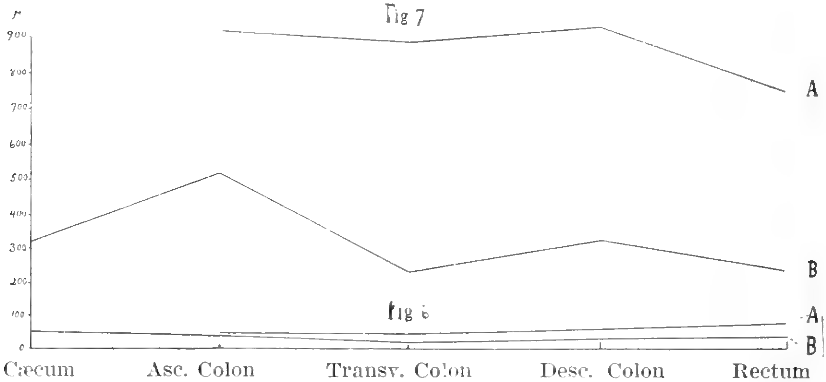


FIG. 6. Curves, constructed from the measurements recorded in Table 1, expressing the variations in thickness of the muscularis mucosæ of the different regions of the dog's large intestine, A when contracted, and B when distended.

FIG. 7. Curves, constructed from the measurements recorded in Table 1, expressing the variations in thickness of the tunica muscularis of the different regions of the dog's large intestine, A when contracted, and B when distended.

The greatest diminution in thickness of the muscularis mucosæ, due to distension, occurs in the rectum, and the least in the ascending colon. Mathematically expressed, the thickness of the muscularis mucosæ varies inversely as the distension.

VARIATIONS IN THICKNESS OF TUNICA MUSCULARIS.

The thickness of the tunica muscularis was measured from the inner margin of the inner circular layer to the outer margin of the outer longitudinal layer, which latter in the dog forms a continuous sheath instead of being partially assembled to form tæniæ coli as in the human. In contraction, the thickness of the muscular tunic of the dog is greatest in the descending colon, diminishes in the ascending and transverse colons, in the order named, and is least in the rectum (Fig. 7, A).

Distended, the greatest thickness is in the ascending colon. It diminishes in the descending colon, cæcum, and rectum, in the order named, and it is least in the transverse colon (Fig. 7, B). The greatest diminution in thickness, due to distension, is in the transverse colon, and the least in the ascending colon. Mathematically expressed, the thickness of the tunica muscularis varies inversely as the distension.

Variations in Goblet Cells.

Method of staining: Mayer's Muchæmatein,[1] so effectively used by Bensley,[2] though not absolute in its mucin reactions, yet furnishes evidence as to the comparative staining properties of the goblet cells in the different regions when the conditions of staining are exactly alike. Bensley found that, by modifying Mayer's solutions, positive results could be obtained. In fact, it is largely a matter of experiment what strength of solution should be used and the time it should be applied. The best results were obtained with a stock solution over a year old, each 100 c.c. of which was diluted with 100 c.c 70 per cent alcohol. This solution was applied for five minutes. To insure uniformity in application to the sections from different regions of the intestine, all the slides bearing the thin paraffine sections from the different regions were clamped together in a Miller's multiplex slide-holder,[3] and immersed together in a jar of the stain. A freshly prepared solution required a much longer time to give results which were not nearly so good. The sections, still held in the slide-holder, were washed simultaneously in distilled water, dehydrated by passing through the alcohols, cleared in xylol, from which they were taken separately to be mounted in balsam. Several sets of sections were stained until co-ordinate results were assured.

Counting the goblet cells is likewise largely a matter of practice and the elimination of the personal equation. The glands selected for counting were those cut longitudinally along their axes; and the goblet cells counted were those lying in the nearest focal plane. To determine the latter it was only necessary, while counting, to slightly turn the fine adjustment and exclude all cells of a lower focal plane. It was

[1] P. Mayer, Mitth. a. d. Zool. Station zu Neapel, XII, pp. 303-30, Leipz., 1897.

[2] R. R. Bensley. The Cardiac Glands of Mammals. Am. Journ. Anat., Vol. II, No. 1, 1902, pp. 118-119.

[3] E. F. Miller. A Multiplex Slide-Holding Device. The Johns Hopkins Hospital Bulletin, Vol. XVI, No. 169, April, 1905.

found impracticable to count by a plan of cell-measurement, assuming that the longest cells would be those lying in the same focal plane, because the cells of the neck were found to be considerably larger than those of the fundus.

Variations in Number of Goblet Cells in Different Regions in the Distended Condition of the Human Large Intestine.

The tabulated results of the counts, given with the measurements in Table 1, are for the human intestine only. They are averages of the number counted in the nearest focal plane of the longitudinal sections of several glands of each region. The regions examined were approximately equally distended, excepting the much distended transverse colon and the somewhat contracted ascending colon. The results are plotted in Fig. 8, the ordinates being the number of cells, and the abscissæ the five regions of the intestine.

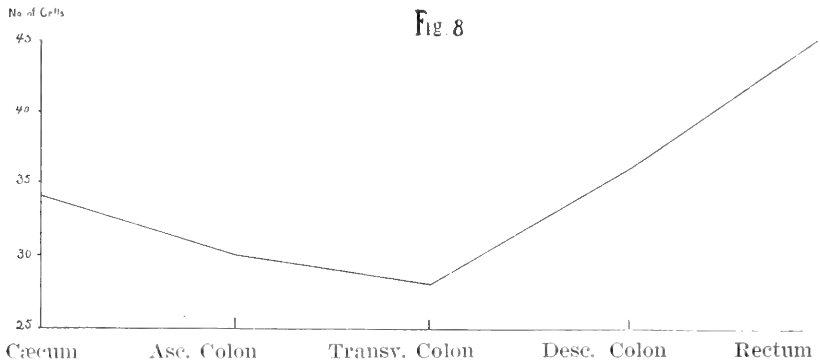


Fig. 8. Curve constructed from the results tabulated in Table 1 of the average number of goblet cells in the nearest focal plane of longitudinal sections of glands in the different regions.

Beginning with the cæcum, the number of goblet cells per gland decreases in the ascending colon; and they are fewest in the transverse colon. In the descending colon they increase in number, and are most abundant in the rectum.

Variations in Mucous Reactions of the Goblet Cells in the Different Regions.

Since the sections of different regions were stained simultaneously any variations in the depth of stain are indicative of differences in mucous reactions, and not over- or under-staining; the time discrepancy is completely eliminated by the use of the slide-holding device. In the section of transverse colon, stained with the others, the stain showed a coagulum in the goblet cells, and the tissue itself took the stain. A block from another piece of transverse colon was taken and prepared in the same way, but stained separately, though under the same conditions of time and solution. The sections of this block likewise stained much more deeply than any of the others. The fact that this color reaction was observed with a separately stained preparation is taken into account. Whether the deeper staining property of this region was due to any extent to some abnormality of the region at the time the tissue was obtained, or whether it was induced by some irregularity in the technique previous to the staining, is not so absolutely certain. The technique is supposed to have been the same throughout for this region as for the other regions. Including this preparation, it may be said concerning the variations in staining that the goblet cells stain faintest in the cæcum, medium to faint in the ascending colon, heaviest of all in the preparation of the transverse colon separately stained, dark in the descending colon, and medium in the rectum. It is realized that variations in the mucous reaction may be explained as due to chemical differences of the stages in the cycle of mucous production in which the cells are caught at the time of fixation.

Summary.

Comparative measurements of the contracted and distended large intestine of the dog show that variations occur in the intestinal wall and glands of the different regions, and that variations in those of the same region are produced by distension. These variations, observed in the dog, are found to be true in the human intestine in the cases in which contracted and distended sections of the same region of the same intestine were available for this study.

1. The entire intestinal wall varies in thickness inversely with distension, most in the transverse colon and least in the rectum. It is obvious that, in the normal condition, the wall of the different regions varies in thickness.

2. The depth and cross section of the glands in the different regions vary inversely as the distension. The interglandular space varies directly as the distension. These variations are least in the ascending colon and greatest in the transverse colon. While they occur under the

conditions of both contraction and distension, they also occur normally in the different regions, the longest, narrowest and most thickly distributed glands being in the ascending colon, and the shortest, thickest and most thinly distributed in the rectum, the contracted cæcum not having been available for use in the comparison.

3. The resultant of the forces acting on the gland in distension is in the direction of the lumen of the viscus, tending to pull the gland out, and thus to decrease its depth and increase the actual area of glandular surface exposed in the lumen of the intestine.

4. The greater epithelial surface thus exposed in distension is applied directly to the intestinal contents, and therefore the area directly utilized for absorption and directly stimulated to secretion is increased in the distended condition.

5. The number of goblet cells per gland varies in the different regions, being greatest in the rectum and least in the transverse colon.

6. The chemical properties or stages in mucous production of the glands vary in the different regions, indicated by the variations in staining qualities under similar conditions.

In conclusion, I wish to express my acknowledgment to Professor Hardesty, at whose suggestion and with whose guidance and advice this investigation was undertaken.

ABSTRACTS.*

FUSION OF THE SEMILUNAR AND CUNEIFORM BONES (OS LUNATUM AND OS TRIQUETRUM) IN BOTH WRISTS OF AN ADULT MALE NEGRO—SHOWN BY THE X-RAY. By EUGENE R. CORSON. *Savannah, Ga.*

While examining by X-ray a negro's wrist for a Colles' fracture, the semilunar and cuneiform bones were seen to be fused. An examination of the uninjured hand showed a similar condition. There was no external evidence of the fusion and the normal movements of the wrist were in no way impaired.

Although I have taken many X-rays of the wrist among both white and colored, I have never before found an anomaly of any kind in the carpus. While anomalies of the wrist are rare, this fusion of the semilunar and cuneiform bones has been occasionally observed. In an analysis of the twenty-six cases already reported, Thomas Dwight shows in his "Atlas of the variations of the bones of the hands and feet" that at least twelve of the twenty-six were in blacks. See also his discussion in Piersol's Human Anatomy.

A careful study of many skiagraphs of the wrist has shown me a remarkable uniformity in the position of the carpal bones, and especially of those of the first row, in their relations with the radius and ulna. The semilunar bridges the radio-ulnar articulation. This was first brought out by a study of Colles' fracture, where a weakening or rupture of the internal lateral ligament allows the hand to drop to the radial side. In this movement to the radial side the articulation between the semilunar and cuneiform is brought nearly in line with the radio-ulnar joint. In the accompanying cut (Fig. 2) of the uninjured wrist it is seen that the semilunar portion of the fused bones is in the usual position.

In my paper (An X-ray study of the normal movements of the carpal bones and wrist) I pointed out the almost ball and socket arrangement of the first and second row—of the head of the os magnum in the socket made by the semilunar and scaphoid, one of the most inter-

*Abstracts of some of the papers read at the twenty-third session of the Association of American Anatomists, Chicago, January 1, 2 and 3, 1908.

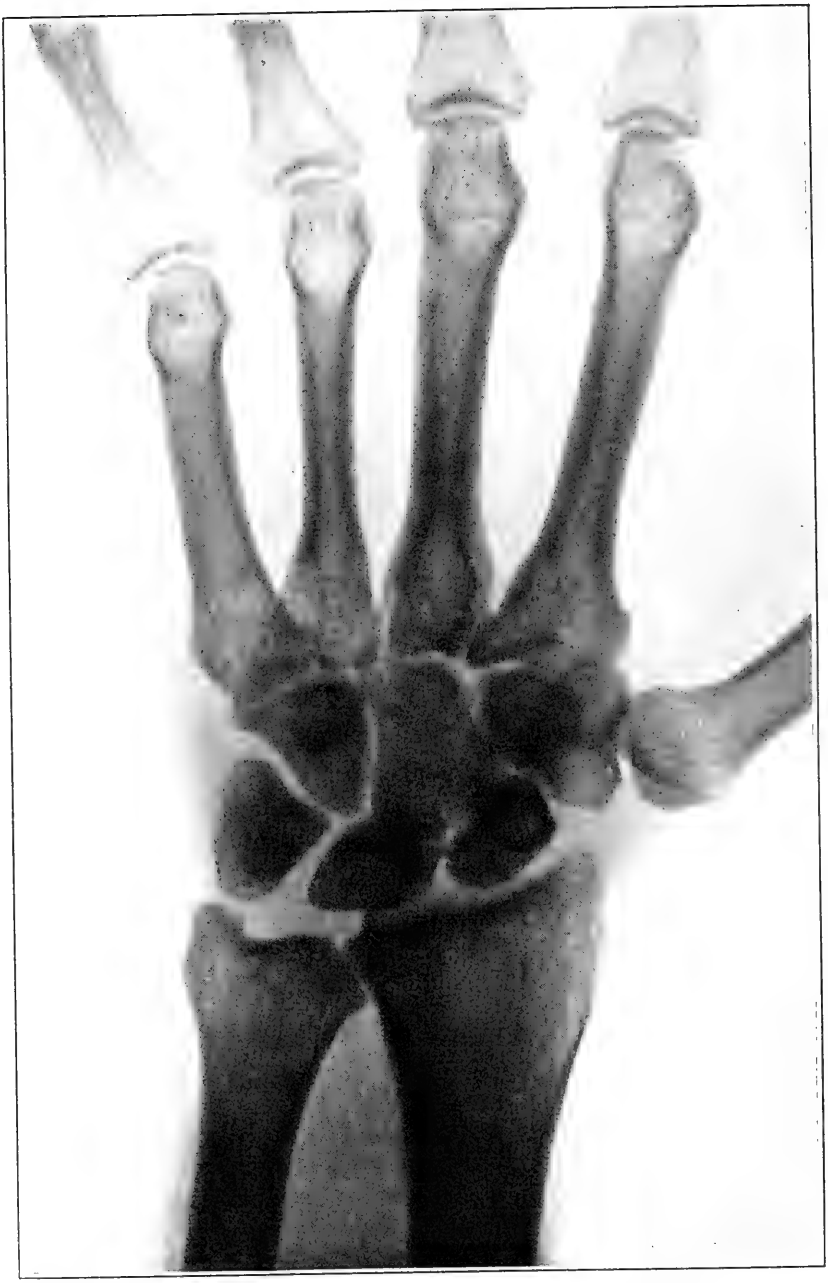


FIG. 1. X-ray picture of a normal wrist of a male negro.

esting features in the anatomy of the wrist. It was also brought out that the carpal bones move as two rows and not as a cluster. The most important movement, of course, is at the radio-carpal joint; next in importance is the movement between the first and second rows, while

FIG. 2. X-ray picture of the wrist of a male negro showing fusion of the semi-lunar and cuneiform bones (Os. lunatum and O. triquetrum). Compare with the normal wrist in Fig. 1.

the movement between the second row and the metacarpals is practically nil.

To apply this knowledge of the normal movements of the bones of the hand to the fusions which occur, independent of disease, it will be seen, as one might expect, that those bones between which much motion exists rarely if ever fuse, while with those between which there is little or no motion fusion occasionally occurs. That is, there is fusion between bones in the same row, as in the present case with the semilunar and cuneiform bones, or between the second row and the metacarpals, as pointed out by Professor Dwight in the case of the fusion of the second metacarpal with the trapezoid, or the congenital fusion of the proximal parts of the fourth and fifth metacarpals, or in the tarsus, of the external cuneiform and the third metatarsal.

THE FIBROGLIA FIBRILS OF NECTURUS. By CAROLINE McGILL. *From the Department of Anatomy, University of Missouri.*

In the intestine of Necturus, forming a basement membrane for the lining epithelium and scattered throughout the subepithelial connective tissue, are fibrils which closely resemble the fibroglia fibrils described by Mallory. These fibrils always, at some point in their course, are in connection with the granular protoplasm of the cells from which they arise. In some places, throughout their entire length, they are surrounded by granular protoplasm.

With all stains used the fibrils stain just as do myofibrils. Throughout, the similarity to myofibrils, not only in staining, but also in size and general arrangement, is so close that it seems unnecessary to consider them other than a type of myofibril. Some evidence that they are contractile lends further support to this view.

HISTOGENESIS OF GASTRIC GLANDS. By EDWIN G. KIRK. *From the Laboratory of Anatomy, University of Chicago.*

The development of the cardiac, fundic and pyloric glands of the pig was traced from the stage of the 2 cm. embryo to the time of birth. At about 3 cm. short intra-epithelial ridges appear in the stomach. These intersect in all directions, thus enclosing depressions which are the primary gland tubules. The basement membrane is yet a level plane, the ridges thus simply representing the line of cells which have increased more rapidly in height than those of the intervening areas or depressions. Very soon, however (4 cm.), the ridges are reinforced by the upgrowth from below of mesoblastic ridges. (This essentially confirms Salvioli's work on rabbit.) The simple tubules deepen rapidly through continued upgrowth of the lamina propria. Growth occurs more rapidly at the nodal points of the ridges, so that a villoid appearance results. This observation seems to explain the two apparently antagonistic views as to the nature of the first irregularities; namely, that they are ridges, or, on the other hand, papillæ, whose bases later fuse. In the later stages, by a lagging of growth at the nodal points, the definitive condition is reached. In the later stages mesoblastic processes push up into the bottom of the simple tubules. At first these grow clear to the surface, thus increasing the number of tubules. The later ones grow up only part way, thus giving rise to compound tubules; this compounding occurs in the pylorus of about 17 cm., fundus 20 cm., and cardia 22 cm.

All developmental processes—both form development and cyto differentiation—are most precocious along the greater curve and in the pylorus and adjacent fundus.

The parietal type is the first to differentiate. These cells appear in the fundus tubules of 4 cm. From the first, they are in line with the general epithelium, rather than appearing between the bases of the epithelial cells, as sometimes described. As the tubules deepen, new parietals appear, always at the bottom; later they differentiate in the middle third of the tubule (future cervix). After 7-9 cm., they increase both by differentiation of new ones and by karyokinesis of the old.

Mucous cells, both chief and goblet, appear first along the lesser curve, at 6 cm. After 9 cm. the pyloric cyto differentiation is practically complete. In the fundus, the mucous cells of foveola and cervix differentiate at 12-16 cm. Up to 19 cm. the cells lining the deeper part of the fundic tubules—aside from the scattered parietals—are yet of the embryonic type. At 19 cm. zymogen granules appear in their distal ends. Thus it is seen that the serous chief cells pass through no mucous stage.

After 20 cm. the main increase in length of the tubules is in the deeper part or fundic segment.

The form development of the cardiac tubules is essentially identical with that of the fundic up to the 14 cm. stage, after which the growth of the cardiac tubules is retarded. At 17 cm. all the cardiac cells are differentiated, three types being present—goblet, mucous chief and parietal. The parietals are the first to appear, just as in the fundus. A few zymogenic cells appear in the depths of the cardiac tubules at about the 21 cm. stage. Later these disappear, probably being converted into mucous chief cells. As in the adult pig, there is in all stages of development a broad zone between fundus and cardia, transitional as to form and size of tubules and as to cytologic characters. At birth the parietals are very abundant in the cardiac tubules. As the adult tubules have practically none, the cells must either degenerate or transform into mucous chief cells—probably the latter. Their exact fate is now being investigated. The cardiac glands are not primitive, but rather retrogressive. They represent fundic glands undergoing a process of involution. It is of interest that the first cell type to differentiate from the primitive embryonic cells—namely, the parietals—are younger phylogenetically than the mucous or the zymogenic cells. The early appearance of the ductules suggests a functional explanation of this apparent anomaly.

Development in the cæcal pouch is so erratic and complicated that reference must be made to the full paper, to be published later.

THE DEVELOPMENT OF THE SWIMMING MOVEMENT IN AMPHIBIAN EMBRYOS. By G. E. Coghill, *Denison University.*

The first reaction of embryos of Triton torosus to a touch on the side of the head or on the tail bud is a flexure of the head. As the embryo advances in age the flexure progresses caudad till the whole trunk is involved. After the stage of complete trunk flexure is reached the head may be reversed before the initial flexure is completed in the caudal region. This produces an "S reaction." Any particular flexure develops, also, by cephalo-caudal progression. This mode of movement in a series of "S reactions" produces normal, upright, direct swimming. It appears, then, that the earliest centralization of the nervous system, ontogenetically, is in the region of the funicular nuclei, which region functions as a tactile locomotor center, in correlation with the cephalo-caudal progression of movements in locomotion. This law in the development of movement is correlated with the order of development of the nervous system cephalo-caudad, and it may have been an important phylogenetic factor in establishing this mode of development of the nervous system of vertebrates. It is in harmony, also, with the theory of migration caudad of the afferent roots of the cranial nerves, since such a shift would bring these roots into a most direct course to the primitive locomotor center.

THE COURSE OF THE BLOOD THROUGH THE FETAL MAMMALIAN HEART. By A. G. Pohlman. *From the Department of Anatomy, Indiana University.*

A series of experiments were carried out on the living fetal pig to determine the course of the blood through the heart with a view of determining whether mixed blood passed through the foramen ovale

(Harvey, 1628); whether most of the blood entering the heart through the inferior cava passed through the foramen (Sabatier, 1791); or whether Wolff's conception (1778) that the vena cava opened on the foramen in such a manner that the blood was split into halves, one passing into the left and one into the right auricle.

Corn starch suspended in normal salt solution was injected into the selected vein (cava superior or umbilical vein) and recovered simultaneously and under identical conditions from the beating ventricles. The result shows that granules injected into the umbilical vein are recovered in equal amount from either ventricle (disproving Sabatier's theory), and granules injected into the superior cava are also recovered in equal amounts from both ventricles (disproving Wolff's theory). Double injection of superior and inferior cavæ showed a mixing of blood in the right auricle and proving the Harvey theory.

Investigations on the turtle seem to show that the blood of the two auricles does not remain distinct in the common ventricle, and that the present scheme of the course of the blood through the turtle heart, like that through the mammalian heart, is incorrect.

SOME RESULTS OF RECENT INVESTIGATIONS ON THE MAMMALIAN HEART. By ROBERT RETZER. *From the Anatomical Laboratory, Johns Hopkins University.*

In my paper before this society last year, attention was called to the fact that the Purkinje fibres are the final branches of the atrio-ventricular bundle, as had been dscribed by Tawara. I have since continued the investigations on the structure and development of the Purkinje fibres, and results which are not alone interesting in themselves, but which open a field of research on the histological structure of the heart, were obtained.

Owing to the abundance of accessible material, the study was confined to pig's heart. Comparisons were also made with hearts of human embryos in Professor Keibel's and Dr. Mall's collections, and these confirmed the results obtained by the more minute study of the embryo pig's heart. The hearts were fixed in one of the usual fixing fluids, imbedded in paraffin and cut from front to back. For convenience, the heart is considered with the base upwards and the septum in a sagittal plane. Reconstructions were made of the hearts of 34, 23 and 14.5 mm. embryos.

Before describing the development of the Purkinje fibres, a few words must be said about the development of the heart, because that portion which interests us mostly, the sinus and the formation of the atrial septum, is incorrectly described by His and Born. As the latter's description has been accepted by most embryologists, a short resumé of the points at issue will not be out of place. In the rabbit embryo, Born finds that the first or posterior septum of the atria is perforated before it reaches the septum intermedium and a second one arises from the anterior and upper wall, which becomes the ultimate septum. The venous valves, which arise as invaginations of the sinus walls, grow as thin lamellæ towards the lumen of the right atrium. The left partly atrophies and partly fuses with the septum I, the right forms the valvula venæ cavæ (Eustachii) and the valvula sinus coronarii (Thebesii).

In the pig the septum secundum, in Born's sense, does not exist. Search for it was made in vain in the embryonic hearts of man, monkey and rabbit. This supposed septum which His correctly described as a "muskulöse Leiste" is nothing but a fold in the atrial wall at that place. The conus arteriosus is the physically fixed point and the growing atria in their efforts to expand and form auricles grow around the fixed point and cause a bulging inwards of its wall. It is therefore a "passive" formation and never attains such a size that one is justified in calling it a septum. The septum I of Born remains the ultimate septum. I am at present not able to say whether the perforation that one sees is due to a rupture of the thin lamella, which at first consists of but two rows of cells, or is actually an opening formed during the growth of the heart. The valvula venosa sinistra remains throughout life as a portion of the atrial septum. It fuses with the septum and assists in the closing of the foramen ovale.

It was stated above that the valvulæ venosæ dextra and sinistra are formed by invaginations of the sinus. The questions naturally arise, What becomes of the sinus in the adult mammalian heart? Are the Eustachian and the Thebesian valves and a portion of the atrial septum the only vestiges of the sinus? Even reconstructions of successive stages would not help us if we were to consider only the morphological changes that take place, but as soon as we direct our attention to the histological structure of the musculature in various parts of the embryonic heart, we are confronted with a fact that gives us the key to the answer. As soon as the heart becomes differentiated into sinus, atria, ventricles and conus the musculature of each of these divisions has a distinctly differentiated structure, which becomes more marked as the heart grows older and which persists in the adult. The reason why this has been overlooked so far is probably due to the fact that this differentiation undergoes marked changes that go hand in hand with the physiological changes. While the heart is a simple tube, the various portions perform the same function—the heart contracts similarly to the intestine with a peristaltic movement. The musculature is then not differentiated, but consists of a mesenchymal syncytium. As soon as the tube becomes bent into an S shape and constrictions arise in the region of the canalis auricularis and later between the ventricles and the conus arteriosus and between the sinus and the atria, the muscu-

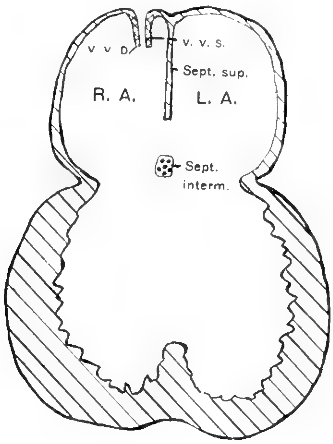


Fig. 1.

Fig. 1. The folding in of the sinus, forming the right and left venous valves.

lature becomes differentiated in order to adapt itself to the change in function. The conus is the most highly differentiated; then, in order, come the ventricles, the auricles and the sinus. It lies without the scope of this paper to give in detail the minute description of the cystogenesis of the various musculatures. It was, however, the cognizance of these variations in structure that made it possible to trace the origin of the Purkinje fibres to the sinus.

As long as the heart has not been definitely divided into four chambers there is a continuity of the musculature of the atria and ventricles in the sulcus coronarius and ostia venosa. This is the same condition that we find in the fishes and amphibia. As soon as the septa have formed, this musculature is replaced by connective tissue, the ostia venosa, then being called annuli fibrosi. At the same time, however, that the musculature of the sulcus coronarius is being replaced by connective tissue, the septum intermedium, which was originally composed of connective tissue, becomes invaded by musculature from the sinus, and through it the muscular continuity between the atria and ventricles, which would otherwise be destroyed, remains established. In hearts of pig embryos of 15 mm. we begin to see the sinus musculature breaking

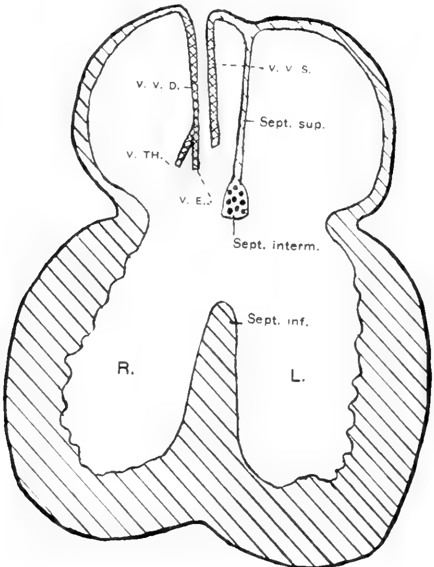


Fig. 2.

FIG. 2. The division of the right venous valve into the Eustachian and Thebesian valves. The septum superius has reached the septum intermedium.

through the septum intermedium. In a 20 mm. pig this musculature has formed a small strand which passes forward just above the ventricular septum, and in a little later stage we see the bifurcation of the strand, one branch passing beneath the endocardium to the right side of the ventricular septum and the other to the left. In the ventricular portion we recognize the forerunners of the ultimate Purkinje fibres, but not so in the atrial portion. This difference remains throughout life (Tawara).

The differences in structure of the musculature of various parts of the fœtal heart have also made it possible to trace the fate of the conus musculature. In a fœtus of 160 mm. the musculature of the conus is different from that of any other part of the heart, and therefore it is safe to say that it persists in the adult, and is not replaced by the ventricular musculature.

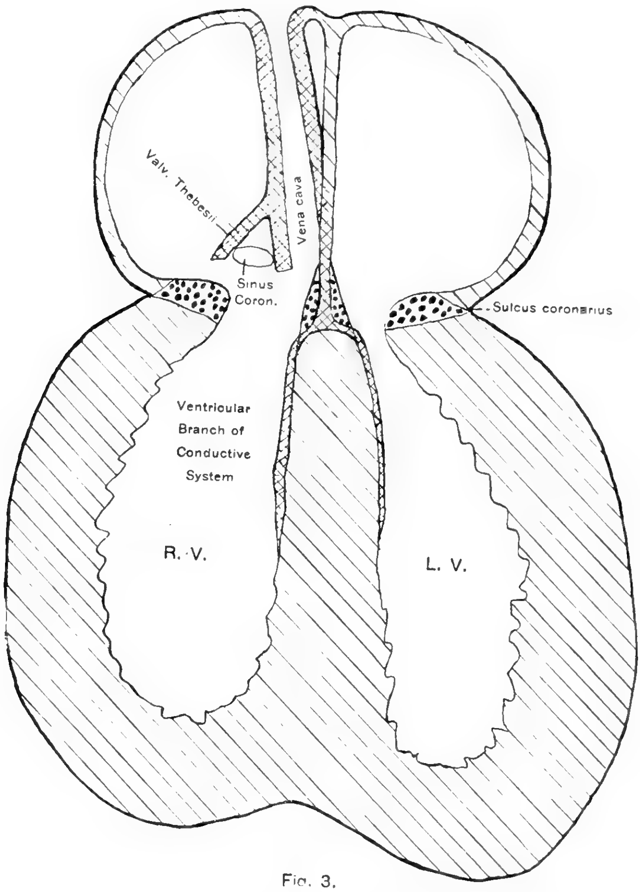


Fig. 3. The invasion of the septum intermedium by the sinus musculature and the division of it into the right and left branch of the conductive system. Fibres from the right venous valve join those of the left posteriorly to the plane of the diagram.

Both in the embryonic and the adult heart has it been impossible to verify Tawara's "Knoten." Professor Aschoff, under whose direction Tawara's work was done, kindly looked through my series with great care and agreed with me that "Knoten," as he had seen it in the sheep, cat, rabbit, calf, etc., is not present. He tells me that the condition in the pig is most like that in the human heart. The "Knoten" is not confined to the atrial portion, but spreads out to both ventricular branches. It must be considered as nothing but a condition due to a difference in the age of the fibres. The atrial part of the Knoten is the result of rapid direct division of the nuclei and the ventricular portion the result of the division of the fibrillæ. The nuclear division is, however, not confined to the atrial portion of the "conductive system."

A description of this system must necessarily be too long to fall within the limits of this paper, and will be deferred to a later communication containing a more complete analysis of the structures of the heart. The conclusion derived from the study of the development and cystological structure of the conductive system is that it is a neuromuscular apparatus akin to the neuro-muscular spindle of voluntary muscle. Whether it is sensory in its function is a problem for the physiologists to decide. It is interesting to note at this place that the first sympathetic ganglion cells that appear in the embryonic heart lie in the atrial septum immediately above the beginning of the "conductive system." Thus far the connection between these ganglion cells and the system has not been established, but researches on this subject are under way. The Purkinje fibres are surrounded by a plexus of nonmedullated nerves. The similarity between these and elastic fibres is presumably the foundation for the statement that the endocardium contains a large number of elastic fibres arranged similarly to the tunica elastica interna (Henle) of the arteries.

The following is a very satisfactory method for demonstrating the Purkinje fibres: With a scalpel make incisions into the myocardium of the ventricle of the sheep's or pig's heart, so as to outline a centimeter square. The endocardium consists of two layers. With fine forceps, strip off the first layer, consisting of the endothelial cells and white fibrous tissue. Then tear off the second layer, which consists mostly of fibrous tissue to which the myocardium and the Purkinje fibers adhere. This preparation is then placed, myocardium uppermost, on a slide and scraped with a scalpel until thin. The advantage of tearing off the first coat is that it enables you to get a clearer picture of the Purkinje fibres and their transitions to cardiac muscle, and also of the nerve fibres when stained with methylene blue.

It will be interesting to pathologists to know that rhabdomyoma of the heart is a pathological condition, probably hypertrophy, of the Purkinje fibres and not of the cardiac muscle. A specimen that was shown me last year showed without doubt the similarity between the new growth and a mass of Purkinje fibres.

THE TOPOGRAPHY OF SPINAL NERVE ROOTS. By WESLEY M. BALDWIN. *Cornell University Medical School, Ithaca, New York.*

This investigation consists of an examination of thirty adult human cadavers to determine the relation of the tips of the spinous processes of the vertebræ to the superficial origin of the spinal nerves from the spinal cord and to their distribution in the skin of the back. During this investigation the subjects were placed face down on the dissecting table with the head so flexed that the nose and forehead were both in contact with the table. All measurements were made with a steel tape, following the curvature of the body.

It was learned (1) that in general the spinous processes are exceedingly variable in position, and hence should only be used to give relations merely approximating exactness; (2) there was not observable the astonishing prevalence of anomalous conditions of thoracic nerve root origin mentioned by Adamkiewicz in 1882; (3) corresponding anterior and posterior roots differ but slightly in the level at which they leave the cord; (4) in the cervical, lumbar and sacral regions corresponding roots of the two sides emerge at practically the same level, but in the thoracic region there was a distinct tendency for the nerves of one side to arise from a uniformly higher level than corresponding nerves of the opposite side; in some cases the right roots were higher, in others the left were higher; (5) lastly, in many cases, the thoracic nerves did not pursue a perfectly straight course from their origin to the intervertebral foramen, but, running to a level lower than their foramen, they turned abruptly and ran upwards for several millimeters before emerging from the spinal canal; (6) in the cervical region it was usual for adjacent dorsal root fascicles to fuse before reaching the cord.

The average length of the spinal columns, measured from the foramen magnum to the tip of the coccyx, was 73.6 cm.; the longest, 78.8 cm.; the shortest, 67.4 cm. The average length of the spinal cords, measured from the foramen magnum, was, in female subjects, 41.5 cm.; in male, 45.9; the longest, 52.8 cm. (male); the shortest, 40.7 cm. (female).

The cords terminated on an average at the level of the lower border of the body of the first lumbar vertebra.

The distance along the surface of the skin of the back of the neck from the spinous process of the axis to that of the seventh cervical vertebra was found to be on an average 6.5 cm., with limits of 6.0 cm. and 7.1 cm. Since the spine of the axis can be palpated as the first median bony prominence caudal to the external occipital prominence, this would seem to suggest a ready and accurate method for the enumeration of the spinous processes of the other vertebræ.

An Accessory Device for Aid in Cutting Serial Paraffin Sections.

BY

EDWARD F. MILLER.

Anatomical Laboratory of the University of California.

All who have had to make serial paraffin sections for purposes of reconstruction will realize the advantages of a device by which all the sections of a given piece of tissue may be cut of equal thickness throughout the entire block.

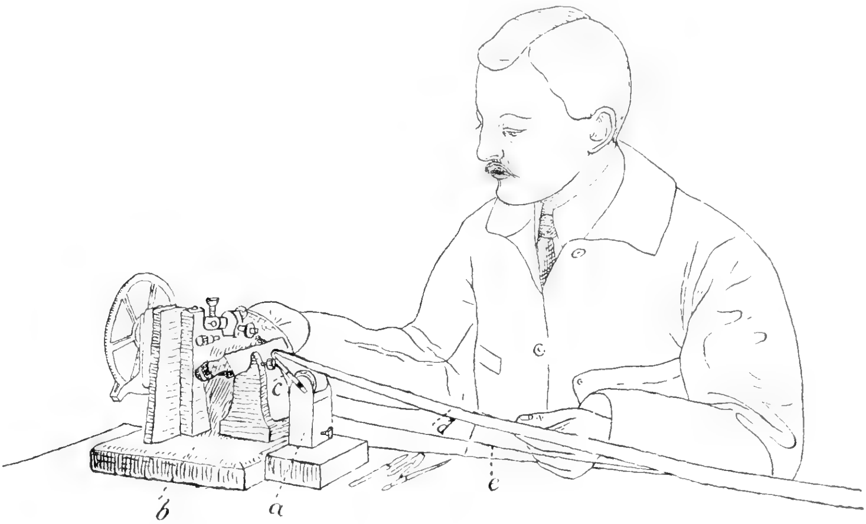
The device described below is the result of an attempt to obviate two of the difficulties usually met in preparing serial sections:

(1) The necessity of having to stop the microtome at intervals of ribbons of short length, in order to remove these ribbons from the knife and place them aside, most always results in having to start the ribbon again and consequently, quite often, the loss of several sections. Also, very often during the pause, either because of imperfections in the construction of the microtome or because of peculiarities in the paraffin block, the first one or two succeeding sections are either thicker or thinner than the thickness desired and intended for the series. The first section is usually too thick and this is no doubt largely due to a slight swelling of the paraffin block during the period of cessation of friction and pressure against the knife, and the second section is usually too thin, due probably to the fact that the knife has bitten more deeply in cutting the preceding section.

(2) It also frequently happens when serial sections are made and removed in short ribbons in the usual way that confusion results in keeping them in their natural order. The short ribbons may be disturbed from the order in which they are placed, may be turned over and may be accidentally placed with their ends reversed. Further, since in

the beginning of a new ribbon one often is unable to have it start perfectly and consequently must deal with short pieces and often has to save even single sections, much difficulty is experienced in keeping these short pieces in place and the single sections in their correct orientation. It too frequently happens that in mounting these short pieces and single sections they will be misplaced or mounted upside down. This results in considerably altering the value of the series because of the difficulty in determining the proper sequence of the sections involved.

As is well known, these difficulties very seldom occur if the microtome may be kept in motion after the ribbon is once started until the end of the block, that is, if one is able to cut his piece of tissue into one continuous ribbon.



Showing the accessory device in its relation to the microtome and the position of the operator. *a*, the clockwork enclosed in case; *b*, the microtome; *c*, the tape guide; *d*, the tape, and *e*, the string tape-tensor.

After considerable experiment in this laboratory, a device was finally hit upon by which these difficulties were in large part overcome. Because such are probably met with by all who have to prepare sections in series and especially for reconstructions, it is thought that a description of the device may be of interest.

The device is wholly accessory to the microtome and was constructed from parts obtained from an ordinary spring clock. The main spring and three of the larger wheels are so arranged as to draw out a piece of tape $1\frac{1}{2}$ inches broad, wound on a journal, as fast as is necessitated by the speed at which the ribbon of sections is made. The speed is regulated by the left hand, while the right hand is occupied in turning the microtome. The device is intended to work with the Minot rotary microtome, but may be adjusted to any microtome of this variety. It is so arranged with reference to the knife that the ribbon, as it is formed, comes to lie immediately upon the upper surface of the tape. This relation is shown in Fig. 1.

The tape, *d*, in this figure is about five yards long, wound on the journal, and held close to the knife by the guide, *c* (*h* in Fig. 2). The end of the tape is attached to a string which runs on a small, grooved wheel made fast at the other end of a long work-table and this string, *e*, runs back to the machine and is wound on a spool which is part of one of the cog-wheels, designated by *e* in Fig. 2. Thus the tape is always kept straight and taut by the clockwork in the device, which winds the string as fast as the tape is drawn out by the hand. The tension is so adjusted that the clockwork will not draw out the tape unassisted. The string, or tape tensor, always runs under the tape, and so cannot interfere with the paraffin ribbon upon its upper surface.

The base (*a*) upon which the clockwork is held is made of solid metal, so that its weight may tend to hold the device as firmly as possible in place. In this case the base was cast in lead, both for weight and because of the ease with which holes might be drilled into it for mounting the clockwork.

The Minot rotary microtome will allow the continuous cutting of a block of tissue of only about 16 mm. long, because the feed of this instrument is limited to about 17 mm. This feed exhausted, the machine has to be stopped, the feed pushed back to its starting point, the object carrier loosened by its clamp, and the block drawn out to the knife again. Only by this limitation of the microtome is the length of the ribbon possible to be obtained from blocks of more than 16 mm. determined. With the aid of the device small embryo pigs, for example, may be cut serially into a continuous ribbon. Of course the width of the cutting surface of the block has to do materially with the length of the resulting ribbon, but a tape five yards long is sufficient for carrying ribbons of length ordinarily required. It has been found that an embryo pig 20 mm. long, if cut sagitally in serial sections of 10 microns, will make a ribbon of about five yards in length. If cut transversely, however, the ribbon would be longer, and the microtome does not allow the cutting of 20 mm. continuously. Therefore, five yards of tape is sufficient to accommodate lengths of ribbon possible to be cut without cessation with the Minot rotary microtome. With microtomes allowing the continuous sectioning of longer blocks, a longer tape would be advisable.

The wheels of the device are supported in a frame, *b*, Fig. 2, on the top of which the journal, with the coiled tape *f*, is fastened, and the tape guide *h*, is adjusted by means of the tape guide clamp, *i*. The adjustment of the tape guide allows it to be brought as near as desired to the edge of the microtome knife at whatever angle it may be placed.

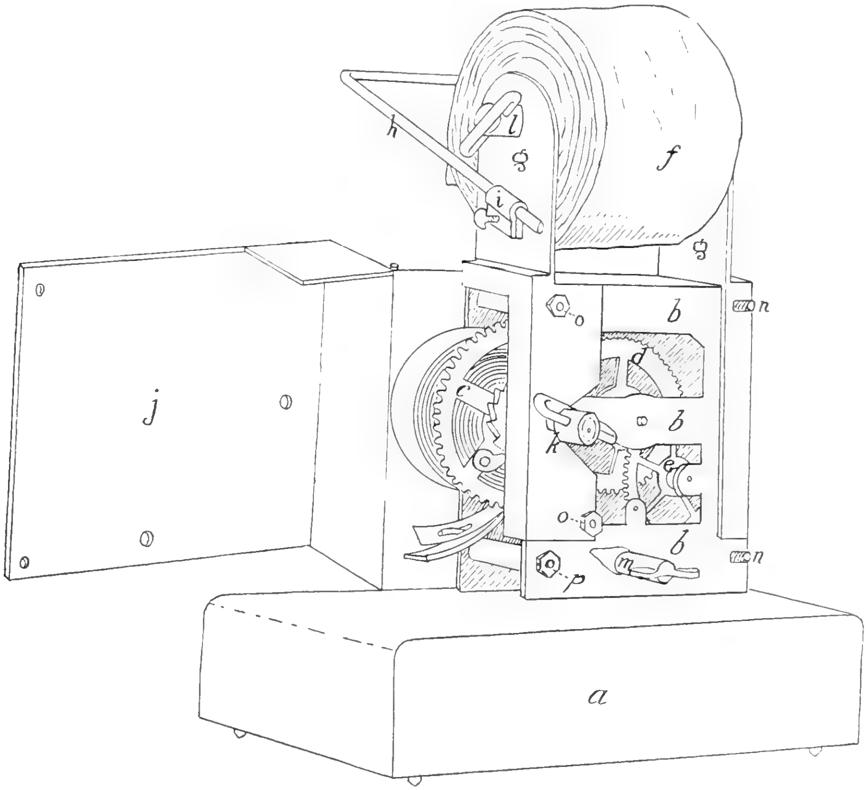


FIG. 2.—Showing the construction of the device. *a*, heavy metal base; *b*, frame; *c*, spring cogwheel; *d*, intermediate cogwheel; *e*, spool-cogwheel on which tape-tensor is wound; *f*, tape; *g*, tape standard; *h*, tape guide; *i*, tape guide clamp; *j*, movable part of case swinging open; *k*, spring key; *l*, tape key; *n*, fastening screws for movable part of case (*j*) and for frame (*b*) as well as for tape standard (*g*); *o*, fastening screws for frame (*b*) and tape standard (*g*); *p*, fastening screws for frame (*b*).

The tape is rewound after use by means of the tape key designated by *l* in Fig. 2. The clockwork is wound by the key, *k*, and the tension of the spring is retained by the ordinary clockwork clutch on the cog-wheel, *c*. The clockwork is prevented from running and its speed may be regulated as desired by the brake key, *m*. The whole clockwork is enclosed and protected by a hinged case, *j*, which is held together by the fastening screws designated by *n*, in the corner of the frame. The frame is held together in the ordinary way by the bolts, whose taps are designated by *o* and *p*, as well as by the fastening screws already mentioned for holding the case in place.

When the ribbon of five yards or less is obtained, the tape is allowed to become slack enough for the entire length of tape involved by the ribbon to lie flat upon the table. Then, depending upon the number of sections desired in one line upon the slide, the ribbon upon the tape is cut into segments of the required length. With the brush these segments are then transferred to the slide in their natural order, in the usual way, the number of slides resulting depending upon the length of the ribbon, and the method of fixing the sections to the slide depending upon the purpose for which the sections are to be used. For ordinary stains the so-called "albumen-water method" is employed, but with certain special stains, like Mallory's method for white fibrous tissue or digestion on the slide, the albumen must be omitted, and the water method alone be employed, with specially cleaned slides. In all cases the sections are preferably mounted on water on the slide, so that, upon warming, all folds and irregularities may be straightened out. The first ribbon thus mounted, if the size of the block makes another ribbon necessary, the parts of the machine may be readjusted, sectioning resumed until completed. Thus the device obviates all stops in the sectioning except those made necessary by the limitations of the microtome.

It is well known that it is often difficult to start a block of paraffin into perfect ribbons, but that when the ribbon is once started it will continue as such until the next stop of the microtome; and thus one always desires to keep the machine going as long as possible. The device here described is under the complete control of the operator at all times. The clockwork and the tape playing out is just in front of the microtome and convenient to the hand. The usual precautions, of course, have to be taken against air currents in the room disturbing the ribbon. Such, however, are not liable to be so disastrous with this device as when the ribbons are removed in shorter segments and placed upon sheets of paper to rest until the operator is ready to mount them, for, the tape being of cloth, the ribbon does not blow from it so readily as from paper, and if disturbed, the ribbon, being in one continuous piece, may be recovered far more easily and the disturbance will be found far less disastrous. The tape used here is made from thick, closely woven, black muslin. Black is chosen because of the greater ease with which the ribbon may be observed upon it. Coarse, black silk ribbon, something of the variety used in hatbands, is suggested as probably more efficient than muslin.

The best results have been obtained, as will be in any procedure for making paraffin sections, either with blocks of freshly embedded tissue or re-embedded blocks, for it often seems that embedded blocks which have been stored for any length of time do not section so well serially as they seem to if they are re-imbedded, cooled quickly and kept at an even temperature while sectioning. It has been found here, and no doubt is the experience of others, that when dealing with paraffin of high melting point in a cool room, it is necessary to work with a spirit lamp or incandescent bulb near the microtome and a thermometer close to the block in order to obtain and regulate the temperature that is found most propitious. In most cases a temperature close to and not exceeding 30° C. has been found best.

BOOK REVIEWS.

"A Very Young Ovum in Situ," by Prof. G. Leopold. Translated by W. H. Vogt, M.D. C. V. Mosby Company, St. Louis, 1907. Sixty-nine pages with sixteen lithographic plates. Price, $3.50.

The few embryologists who are familiar with Professor Leopold's scientific work may welcome the translation of this monograph, but it appears to the reviewer that the work of the translator and the expense of the publisher are for naught.

The monograph of Peters, which describes the youngest human ovum, is very recent and is in every respect far superior to Leopold's. Leopold does not contradict, nor add to any of the statements made by Peters. For this reason it would have been better to translate Peters' monograph, but even that is unnecessary, since within a very short time after its publication the youngest human ovum (Peters') found its way into literature, including that of America.

However, Leopold's monograph is of value as a careful description of a pathological ovum. If the reviewer is not mistaken, some of his other young ova, which are widely copied (see Williams' Obstetrics, 1903, Figs. 107, 108 and 109), are also pathological and by no means as young as Leopold would have us believe they are. (See His. Archiv für Anatomie, 1897.)

Only a superficial comparison of Leopold's last monograph with that of Peters' shows at once that there are marked differences between the two very small ova described by these authors. In Peters' ovum we have a beautiful and vigorous specimen, with a most active syncytium carefully adjusted to the mucous membrane of the uterus. Its implantation seems to have been perfect, corresponding with that seen in other mammals, and it contains an embryo which fits with the series described by other authors. Leopold insinuates that the ova described by Graf Spee, Heukælom, Mertens and others "can hardly be pronounced normal specimens free from objections." In reality, the criticism applies to his own specimen, for it is encapsulated in an atrophic decidua, is covered with long slender villi tipped with a scanty syncytium and the cœlom is collapsed and filled with mother's blood. No anlage of an embryo was found, but intermingled with the blood in the cœlom there is an extensive hyaline magma (Plate X) which alone indicates that the ovum is pathological.

In the preface (p. 7) Leopold shifts the responsibility for this elaborate publication upon Graf Spee, "who did not question in the least the good histological preservation of this specimen." It is interesting to note that Graf Spee, in reviewing this work (Schwalbe's Jahresbericht für Anatomie, 1906), states that the ovum must have been torn, for it is filled with mother's blood, and probably for this reason the embryo was not found. He further states that nothing new is given in Leopold's monograph, all of which may be found in Peters'; in fact, he says, for new interpretations, the specimen is not of sufficiently good quality.

It is found that the pathological ova from early tubal pregnancies, as well as those from uterine pregnancies, often appear like that described by Leopold. The implantation is imperfect, the syncytium scanty, the villi atrophic or hypertrophic and well imbedded in a great mass of mother's blood. The wall of the chorion collapses, becomes filled with blood and the anlage of the embryo is often missing. Leopold's monograph describes such an ovum at a very early stage, which may be compared with Peters', undoubtedly a normal one, of the same size.

That Leopold's specimen came from a woman who committed suicide is no proof that it is normal, when we consider that 7 per cent of all pregnancies end in pathological ova. It may be in one of the 7 per cent. Furthermore, over one-third of the abortions of the second month and over three-fourths of those of the first month are pathological specimens, and it is probable that if we obtained all of the specimens of the first two weeks the per cent would be still larger. The probability of pathological to normal in very young specimens found in the uterus is undoubtedly as high as one in five.

The reviewer is of the opinion that Leopold's specimen will not trouble the literature on normal human embryology, but may for a time find its way into text-books on obstetrics. It is, however, of great value in the study of pathological embryology, but this is not increased by its translation.

The drawings are fairly good, the lithography is excellent, but the typography and paper are of inferior quality. The plates were made in Germany and the text was printed in America.

Franklin P. Mall.

"Clinical Atlas. Variations of the Bones of the Hand and Foot," by Thomas Dwight, text 35 pages. Thirty-six full-page plates, accompanied by legends. J. B. Lippincott & Co., 1907.

Professor Dwight states in the preface to this Atlas that it is intended primarily for medical practitioners, especially for those who make use of X-ray apparatus in diagnosing fractures of the extremities. As such it should prove of great value, since its beautiful photographic illustrations serve to make easily intelligible important variations in skeletal structure which might confuse a radiographer unacquainted with them. The literature on skeletal variations of the hand and foot, while extensive, is complex and confusing. Professor Dwight's book will, therefore, prove of interest and value to scientific anatomists as well as to medical practitioners.

The variations with which the Atlas chiefly deals are those of supernumerary bones of the carpus and tarsus. In the introduction special reference is made to the extensive studies of Pfitzner on the variations of the bones of the extremities in man and to the work of Thilenius on the embryological development of the carpus. The theories of Pfitzner concerning the primary elements of the carpus and tarsus are adopted in the main by Dwight. The nomenclature used by Pfitzner is also closely followed, although instead of the terms of the BNA the older English terms are used to designate the usual bones of the carpus and tarsus.

While Dwight recognizes the speculative character of the theories advanced by Pfitzner, his text might lead one to think that the embryonic, much more nearly than the adult, carpus and tarsus resemble the hypothetical carpus and tarsus with many elements formulated by Pfitzner. As a matter of fact, the ontogeny of the carpus and the tarsus in man is fairly direct. There is evidence that an os centrale is a nearly constant though transitory element in the carpus of the human embryo,[1] and that the os naviculare and os hamatum each arise from two fairly distinct centers, but most of the primary elements postulated by Pfitzner to account for supernumerary bones in the human carpus are visible only as uncommon variations in the human embryo. Extensive statistical studies of embryonic conditions are necessary before we can know

[1]According to Rosenberg (1876) and to Graefenberg (1906) the embryonic os centrale normally disappears. According to Graefenberg it does not constitute one of the two parts of the navicular. Dwight accepts the contrary view.

whether these variations are more common in the embryo than in the adult.

Although certain elements which become mere parts of the tarsal bones have been described as normally independent in the tarsus of the human embryo, studies of the development of the tarsus have failed to reveal these elements as regularly present. The tarsus, therefore, appears to develop in an even more direct way than the carpus.

We therefore think that Dwight has taken a wise course in the descriptive part of his text in discarding speculative hypotheses and describing the supernumerary bones in connection with those normal constituents of the tarsus and carpus with which they are most closely associated. He is here on solid ground, where he can readily be followed.

We trust that this valuable Atlas of Dwight will have a wide circulation and that it will help the medical profession and teachers of anatomy in this country to appreciate the value of giving more attention to the variability of human structure. The present cut-and-dried anatomy of most of our text-books must some day give way to a human anatomy based on statistical studies showing the type of structure most frequently found and the common and uncommon variations from this type as well as the factors associated with these variations. Our students have been led to memorize too many details of structure, often inaccurately described, and have not been enough encouraged to master the broader and more essential aspects of the subject. On the other hand, as books of reference, the anatomies most commonly in use are far too lacking in details, especially just such details as are revealed in this Atlas.

C. R. Bardeen.

Studien und Forschungen zur Menschen- und Völkerkunde, unter wissenschaftlicher Leitung von Georg Buschan. II.

Die Morphologische Abstammung des Menschen. Kritische Studie über die neueren Hypothesen; von Dr. J. H. F. Kohlbrugge. Stuttgart, 1908. Verlag von Strecker & Schröder.

Dr. Kohlbrugge, apart from his merits as a student of anthropology and comparative anatomy, is a strong writer and an independent thinker. He published in 1897 a small pamphlet, "Der Atavismus," discussing the subject both in relation to the theory of descent and to human morphology. It was a very severe criticism of the theories and speculations of men who stood high in science.

He has now brought out in the same vein this larger work of some 100 pages, in which the descent of man is considered (with one exception, which we shall note later) strictly from a morphological standpoint. He points out how evolutionary thought has drifted considerably from that of Darwinian times, and gives a series of sketches and criticisms of the work of the most prominent students and teachers of the day. As to Darwin, he says plainly that his "influence has been much overestimated; he discovered neither evolution nor descent; we are indebted to him only for an effort to explain the latter in a materialistic way," and goes on to declare that anthropologists of to-day are almost all Lamarkians and hardly any of them Darwinians. This statement we are inclined to believe correct, but it is a curious commentary on popular ideas; for the half-educated never believed more strongly than to-day that Darwin made a great and lasting discovery, almost as well established as that of gravitation.

Great have been the changes since the first appearance of Haeckel's scheme, beginning with the lemurs and running through platyrrhenes, catarrhines and anthropoids up to man; and here Kohlbrugge makes a remark which we believe to be a very true one and which is really the crucial point of this discussion, namely, that when we see resemblances between anthropoids and man we are not justified in saying that they have a common ancestry, but simply that they are alike; or, to express his idea otherwise, resemblance is not necessarily to be accounted for by descent. There is nothing new in this; but it is remarkable how long it has taken the scientific world to grasp this elementary truth.

He gives us an interesting sketch of Schwalbe's new line of human descent, which rejects both Old World and New World monkeys (two of Haeckel's steps) and brings man and the anthropoids from a common stock. The divergence occurred long ago; for all existing anthropoids have developed in a one-sided fashion adapted to tree life. Pithecanthropus, who plays an important rôle in Schwalbe's theory, is an intermediate form, though not necessarily in the line of descent. His femur, essentially human, became modified before his essentially ape-like head. The erect attitude came first and brain growth afterwards. Above pithecanthropus is the Neanderthal race to be known as homo primogenius, the skull presenting features never found in that of homo sapiens. We have not space to follow Kohlbrugge in his attacks on

Schwalbe's theory based on measurements of skulls. He says that the skull of pithecanthropus in some respects resembles the chimpanzee and in other hylobates, and that man resembles each of the three in some points more closely than he does the others. He does Schwalbe the justice to say that he himself admits (rather a damning admission) that the discovery of a new primate might upset the whole plan. He compares the whole work to a pyramid balanced on its apex. After all, before accepting conclusions concerning the growth of skull and leg based on a single specimen of each, one cannot but wish that they had been found less than fifteen meters apart. We must agree that pithecanthropus has rather lost caste, especially since it is not so sure that he may not belong to the diluvian period. Kohlbrugge admits that the importance of the skull is not to be denied, as it shows that a race has existed nearer to man than to the anthropoids.

Our author next turns to Kollmann, who starts from the fact that the head of a young ape is very much more like that of a child than the head of an old ape resembles that of a man. Kohlbrugge shows how Aeby had years before practically stated the theory: "Not the greater, but the smaller differentiation from the primitive stage (anlage) characterizes the higher degrees in the general line." Ranke also had written: "The relations of the two parts of the skull" (cranium and face) "correspond in a great degree to those of the young adult European at about the middle of embryonic life. This is the form of skull from which further development proceeds; we must, therefore, according to the laws of modern embryology, consider it the original and stem-form of the human race." Kohlbrugge's commentary is that according to this the first men did not come from adult but from embryonic anthropoids whose more favorable form of skull they managed to preserve in further growth. Kollmann accounts for the evident resemblances in the morphology of man and apes by the principle of "convergence," in accordance with which we find similar structures in animals of widely different descent. Kohlbrugge describes quite amusingly how Kollmann, wanting to find some form between man and his primitive form (somewhat resembling the chimpanzee), turned to the dwarfs of the primæval African forests, and then, in his desire to find similar races in other parts of the globe, called many races pygmies which, according to Kohlbrugge, did not deserve it. Starting with the idea that our proximal ancestors (Urmenschen) were not more than one meter high, he derives from the pygmies, white, black and yellow, the progenitors of the present races, alleging that smaller forms precede the larger. To this others have retorted that there is no evidence of ancient pygmies, and that those of to-day stand in the same relation to man that little dogs do to large ones. There is much in the discussion that is very interesting bearing on the question of Mendelism in races and on directed breeding of animals. Gustav Wolff is quoted as holding that all arguments from the artificial breeding of animals are against rather than in support of the theory of descent, as they show how forms always return when the progeny runs wild. Kohlbrugge has observed that new races do not arise from the crossing of old ones. The crossing of Europeans and Javanese shows (except in one place) that the former are the dominants and the latter the recessives. Between Javanese and Chinese the latter prove dominant. On the whole, we agree with Kohlbrugge that till fossil pygmies be discovered this part of Kollmann's theory counts for little. He gives more serious study to the embryological aspect.

Kohlbrugge calls attention to Aeby's forgotten book on the skull of man and apes, and examines the indices based on the proportion of the height to the breadth, that of the face to the cranium, that of the plane of the foramen magnum and others. His measurements show that the form nearest to man among apes is the gibbon, and that on the whole the South American monkey crysothrix is nearer still. Abey is quoted to the effect that any system of descent is inadequate which does not recognize that the type of man is not in any one organ, but in all the physical and psychological features, and then declares that while we are far from having this universal knowledge, we have learned enough about the different parts of the body, from brain and skull and liver, the biceps brevis (of the leg), the folds of the skin of the hand, to find it impossible to sketch any plan of descent. "It seems almost as if every part had its own line of descent different from that of the others."

The sidelights which we get from the study of monkeys and lemurs are more perplexing than illuminating. The South American monkeys are in some respects more primitive than the catarrhines, while in other respects, as Kohlbrugge shows, they are more like men. This seems to apply particularly to some fossil forms. Van den Broek would fill the gap with ateles; but Kohlbrugge insists, rightly enough, that this is a platyrrhine and has no relationship with catarrhines and anthropoids. On the other hand, he argues that it is as justifiable to bring man down from ateles as from an anthropoid, or indeed to consider both as instances of convergence with man and to declare that his hypothetical ancestor was related to neither group. He then brings Haacke into the discussion, who denies any relationship of man and apes, declaring the latter to be instances of one-sided development. The following statement of Haacke's will appear to many rather more than radical: "Whoever speaks of an intermediate form between man and ape, or man and anthropoid, only proves that he does not know the laws of development which govern the race history of mammals."

Hubrecht is next brought forward, who delivers another blow at the old-fashioned line of descent by objecting to the lemurs, chiefly on account of the placenta, which is of a much more primitive kind than that of man, suggesting that of the ungulates. Now tarsius has a good placenta, like that of man, apes, bats, rodents and insectivora; but he has been reckoned a lemur. Hubrecht would make him one of the ancient race of the insectivora, probably the most primitive group of mammals, and would bring man from this source, putting the anthropoids and even pithecanthropus out of the line. We have heard so much about the changes which have occurred in man as he gradually assumed the upright position that it is startling to be told that his ancestors never were fourfooted like the horse or the elephant, and that "the idea of a painful uplifting of the forward extremity by which the hand has been gradually acquired (erworben) is physiologically nonsense and philogenetically false." Hubrecht considers the half-erect position an extremely old one, leading readily to the upright one, and points to the birds and dinosaurs in confirmation.

We regret that we have not space for the very interesting discussions on the affinities of certain remarkable forms whose position in zoölogy is not yet definitely settled. Tarsius, among lemurs (if indeed it be a lemur), and ateles, among South American monkeys, are curious as presenting signs of convergence with the anthropoids.

Our author gives much space to the interesting speculation of Klaatsch, who in some respects follows the same line as Hubrecht. In general his views are that as far back as palæzoic times a race of land vertebrates had already complete primate-like characteristics in their extremities, with hands and feet composed of five rays, of which the first was opposable. Those forms that swim and fly shot off from this main group, which retained the climbing mode of life and rose higher in the scale only through its brain. From this point of view one can hardly expect any resemblances to beasts in fossil human remains. The pithecanthropus is no ancestor, but a near relation to hylobates. Klaatsch believes that more such anthropoids have existed and that pithecanthropus stood very near to the common root. The prehensile foot is retained by the marsupials and lemurs as well as by the primates, and from it the human foot has been evolved. Kohlbrugge remarks that this theory reminds one of Karl Snell, who, as far back as 1863, declared that man came from no known form, because all were too specialized to be his ancestor, but directly from the primitive form of vertebrates, of which all other forms are side offshoots.

Klaatsch apparently considers the Neanderthal race in the line of descent, but he rejects the so-called atavisms based on resemblances to apes and to recent mammals. He believes in tertiary man and in the early separation of higher and lower races. He institutes interesting comparisons of the adult human conditions and those of very young apes, saying that youthful conditions of the chimpanzee and gorilla reappear in a large scale in pithecanthropus. He calls the ancestors of the anthropoids more human in many respects than their representatives of to-day, and remarks that the "less an ape has changed from the original form, just so much the more human it appears. Thus in some respects the American forms are above those of Europe." Kohlbrugge's paraphrase is that man comes from an original form much more like himself than any existing apes.

Just as Hubrecht despises the conventional evolutionary idea of the origin of the hand, so Klaatsch dismisses with contempt the old theory that the foot became what it is through efforts to rise on the hind legs.

The discussion of what constitutes higher and lower races naturally brings in many very suggestive side issues. Kohlbrugge remarks, "It is a fact not to be denied, to which LeDouble called attention, that in every race there is a socially higher and anatomically finer type on the one side and a socially lower anatomically coarser type on the other." He then points out how these conditions are artificially increased; how in the cities, among learned men, the body is "degraded" to being merely the bearer of the brain, while in peoples in a state of nature the only functions of the brain are to fill the stomach and protect the body from external dangers. What is to be expected of the latter but that they should become like apes? Just as we have heard of parallel development of apes with man, so here we have parallel development of man with apes; but in the opposite direction.

Kohlbrugge insists that the Mongols have a greater cranial capacity than the Europeans. So do the natives of Terra del Fuego, so probably, he says, do the Esquimaux and certainly the Canary Islanders. If we appeal to the proportion of cranium to face we again come to grief. It is a very important fact that we find all kinds of skull in every people. This applies not only to the traveled Europeans, but to Australians and Papuans. The brain gives Caucasians no comfort. Our author maintains that its size is quite independent of intellectual development. It seems to him hopeless to seek in it a criterion for the classification of races as higher and lower. He found, to his surprise, that the frontal lobes of Australian brains are richer in fissures than those of any other race. He exults over our discomfiture and bids us found our claim to superiority on other features such as our degenerate toes and bad teeth. Klaatsch compares the bones of the anatomically highly placed Tasmanian with those of the lowly placed Australian; and decides that they can have come together only far back in an ancestral condition. Then (continues Kohlbrugge) one must either assume that this ancestral form was a very pithecoid one from which the Tasmanian freed himself by a development parallel to that of the European, which was the former view, or the Tasmanian continues nearest to the original human-like form, while the Australian has wandered from it, developing ape-like features. This latter, says our author, would be the new explanation, the logical carrying out of Klaatsch's principles. "In the same sense in which Klaatsch wrote 'The more primitive an ape has remained, just so much more human-like is he,' so one should read here, 'The more primitive a Tasmanian has kept himself the more European he is.' I believe the latter is as defensible as the former,—at the same time the Tasmanian, in the absence of the boomerang, seems intellectually lower than the Australian."

After remarking that the Caribs of Surinam consider themselves the highest beings upon earth, Kohlbrugge asks if all our knowledge for thousands of years has not yet freed us from the absurd superstition that one race is higher than another. We shall not follow our author into the slight digression into psychology which he has allowed himself. though we quite agree with him that it discloses a very one-sided view of the question to treat it only morphologically, especially as it is in view of his psychological properties that we place man so high. He comments justly enough on the despotism which claimed to know the way of evolution and demanded that its claims be acknowledged, the originators thinking to scamper in seven-leagued boots over ground which will require hundreds of years of the most earnest investigation.

He hopes that "the above representation will certainly convince anyone who harbors such ideas that we really know nothing about the great problem of evolution, that we have not even seen its face."

One puts down the book with a feeling of bewilderment; and is this all that is left of "the descent of man"? It would seem so. Indeed, we men of the craft knew it before. We knew that there is no single theory that can claim to be substantiated and that a host of them are mutually contradictory. Under these circumstances a critic like our author has as good a time as a bull in a china shop. In some instances one may question whether he does not go too far and again whether his style does not tend, perhaps of set purpose, to make things as confusing as possible; but on the whole science owes him a debt for pointing out the looseness of much that is given for demonstration and argument.

Thomas Dwight.

Anatomy of the Brain and Spinal Cord, with Special Reference to Mechanism and Function. By Harris E. Santee, M.D., Ph.D. Fourth edition, revised and enlarged. Philadelphia: P. Blakiston's Son & Co., 1907.

This, the fourth edition of Santee's book, is a considerable improvement upon preceding issues. The mode of treatment is perhaps not the best, as the description proceeds from the complicated brain structures to end with the spinal cord, interpolating embryologic and histologic considerations in each successive region. The origin, course, termination and function of conduction paths are admirably summed up in a final chapter.

The author avows a consistent use of BNA terms, but the book abounds with names that are not to be found in either the Latin or the English versions of the Bâsle nomenclature. Even were the author to unqualifiedly adopt the BNA, we would not hasten to commend him for it. The reviewer's opinions on this subject have been expressed in a review of Barker's "Anatomical Terminology" (Johns Hopkins Bulletin, June-July, 1907), and we venture to quote the following passage from the preface to Piersol's recently published Textbook of Anatomy: "Consistent use of the Bâsle nomenclature seems less in accord with the conceded directness of English scientific literature than the enthusiastic advocates of such adoption have demonstrated."

Another debatable topic is suggested by the classification of the subdivisions of the brain as it is presented in Santee's book as well as others. The designation of three subdivisions (forebrain, midbrain and hindbrain) has been found acceptable from every comparative standpoint in brain morphology, but attempts have been made to establish a further segmentation into definite anatomic divisions regarding which opinions and usages differ widely and have proven to be a hindrance rather than an aid to the homologization of brain structures in the vertebrate series. The difficulties in formulating a satisfactory schema of the segmental divisions of the brain will be overcome, perhaps, only by distinguishing the neuromeres or neural segments conforming to the general segmental plan of the vertebrate body. Thus far only the earliest embryonic stages and the disposition of certain of the cranial nerves afford a clue to the definitive segmentation of the brain. The whole matter is yet so obscure that confusion would be avoided by restricting description to the three primary divisions and their derivatives without insisting upon the recognition of further definitive segments proposed by various authors in consequence of preconceived ideas obtained from the complicated adult structure of the brain. Most extant accounts of the anatomy of the brain over-emphasize the distinction of brain parts from each other. The continuity of the parts can only be interrupted arbitrarily, and such procedure leads to a too narrow conception of brain structures single and apart rather than serial and connected. Neuro-anatomists are therefore likely to welcome a change from the traditional treatment such as was recently suggested by J. B. Johnston.

The presswork of Santee's book is excellent, but most of the original drawings are poorly executed and crudely labeled. A diagrammatic representation of the ventricles of the brain is particularly atrocious; an outline drawing of the Retzius' photogravure of the cast would have been better. The author, by the way, enumerates six ventricles (including pseudocele and central canal of the cord) and even refers to a "ventricle of the corpus callosum," which we find is in reality the callosal fissure.

The list of errata inserted after printing is quite inadequate; typographic errors (in a fourth edition) are unwarrantably frequent and personal names are too often misspelt; *e. g.*, von Monokow, Helwig, Bevin Lewis, Follopii. On page 184 we see "line of baillarger," while on page 84 the adjective in "sella Turcica" is dignified with the capital letter denied to Baillarger, and also to Deiters on page 371. The adjective derived from pons should be "pontile," not "pontal." In a footnote on page 59 the author says: "The name of this sulcus is written 'occipito-parietal' rather than 'parieto-occipital;' this is a simpler word to pronounce, as it avoids having 'oocc' in the middle of it." Yet, on page 81, he suggests "temporo-occipital" and frequently uses this compound. Occipital fissure would answer for "occipito-parietal f.," and the "temporo-occipital f." is equivalent to the shorter subtemporal f. employed by several American writers. The fasciculus thalamo-mammillaris (Vicq d'Azyri) and the tegmental part of the fasciculus pedunculo-mammillaris are incorrectly described on page 85; less incorrect is the description given on page 110. We are disinclined to accept Dr. Santee's demarcation of the occipital lobe in the basal view in Fig. 26. Little or none of this lobe encroaches upon the tentorial surface of the cerebrum. A most unfortunate heading on page 98 reads: "Interior Surface of the Forebrain." Nothing is said regarding the weight of the brain and its parts except with reference to the cerebellum, and the metric system is not used. There is no mention of the capsule extrema (or paraclaustral lamina).

The description of the conduction paths constitutes the most valuable part of the book. In other respects the work possesses no great advantages over the better modern textbooks and the classic works of Edinger and Barker.

E. A. Spitzka.

STERZI, DOTT. GUISEPPE: Il sistema nervoso centrale dei vertebrati. Ricerche anatomiche ed embriologiche. Vol. I. Ciclostomi. A. Draghi, Padova, 1907. Pp. 731. 194 figures in text.

The last two decades have seen a remarkable renaissance of scientific activity in Italy. This has been very noticeable in the increased production of work in biology and anatomy. While Italian workers have covered a wide range of subjects, their work has been on the whole of a high order, marked by breadth of view and thoroughness of treatment, largely due to a wide and sympathetic study of the literature. One of the prominent names in this new Italian literature is that of Sterzi. Having published numerous papers since 1899 dealing with the membranes and blood supply of the central nervous system in various classes of vertebrates, this author now publishes the first volume of what promises to be the most extensive work in any language dealing with the central nervous system of vertebrates. In his general preface the author disclaims the intention of writing a complete treatise, but says that he will give attention to the more obscure points. The first volume deals with cyclostomes and is a book of seven hundred and thirty-one pages. The subjects treated are the morphology and morphogenesis of the spinal canal and cranial cavity, of the central nervous system, its membranes, blood-vessels, the cerebrospinal fluid and the nerve sheaths. The Petromyzontes are treated first and at greater length, the Myxinoidei receiving a little over two hundred pages. The matter is very well arranged, the treatment includes full discussion of the literature and the illustrations are simple and clear. The text is supplemented by full literature lists and an index.

The sections of the book which will probably prove of greatest interest for neurologists are those on the development of the brain. In the telencephalon the author makes the following valuable contributions. The representative of the velum transversum is described as a transverse infolding of the membraneous roof continuous with lateral grooves separating telencephalon and diencephalon. The telencephalon consists (as described by the reviewer) of median and lateral portions, the so-called hemispheres being lateral evaginations near the front end of the brain tube. The recessus neuroporicus is not traced continuously to the adult condition, owing to lack of material, and the olfactory portion of the anterior commissure is placed above and behind the recessus neuroporicus, in which the author is at variance with his predecessors.

On the whole the book is a worthy addition to the work which has already come from Sterzi and his countrymen, and should find a place in every anatomical library. The succeeding volumes of the series will be awaited with interest.

J. B. Johnston.

NOTES AND APPOINTMENTS.

Dr. Robert Retzer, M.D. University of Leipzig, has been appointed Associate in Anatomy at the Johns Hopkins University.

Dr. Henry McE. Knower, A.B. and Ph.D. of Johns Hopkins University, has been appointed Associate in Anatomy in that institution.

Dr. Eliot R. Clark, A.B. Yale University and M.D. of the Johns Hopkins University, has been appoitned Instructor in Anatomy in the Johns Hopkins University.

Dr. Ross G. Harrison, Bronson Professor of Comparative Anatomy in Yale University, has gone to Bonn, Germany, to continue his work on living nerve fibres during the summer.

At its recent commencement, the University of Michigan conferred the degree of Doctor of Sciences on Professor Franklin P. Mall. Professor Mall received an M.D. from the same university in 1883, and A.M. (Hon.) in 1900. In 1904 he was honored with the degree of LL.D. by the University of Wisconsin.

The Second International Federative Congress of Anatomy will be held at Brussels in 1910. The exact date has not been definitely decided, but it will probably be in August.

The First Congress was held in 1905. The societies which took part and their delegates to the permanent Central Committee were the following: The Anatomical Society of Great Britain and Ireland, Professor Symington; Association des Anatomistes, Professor Nicolas; Association of American Anatomists, Professor Minot; Die Anatomische Gesellschaft, Professor Waldeyer; Unione zoologica italiana, Professor Romiti.

The Congress meets every five years. Its officers are the Presidents, Vice-Presidents and Secretaries of the Constituent Societies, and the Chairman of the Committee on Organization.

THE ANATOMICAL RECORD

Vol. II. AUGUST, 1908. No. 5

A Peculiar Case of Cryptorchism, and its Bearing Upon the Problem of the Function of the Interstitial Cells of the Testis.

BY

R. H. WHITEHEAD.

From the Anatomical Laboratory of the University of Virginia.

In a series of communications Ancel and Bouin[1] have brought forward the hypothesis that the interstitial cells of the testis establish and maintain the male secondary sex characters, including the phenomena of sexual passion, through the medium of a hypothetical internal secretion; and the writer[2] in a recent article has suggested that certain granules which he found present in the interstitial cells of various mammalian testes may be the physical basis of an internal secretion.

Through the courtesy of Dr. H. E. Jordan, Adjunct Professor of Anatomy in this University, I have had the opportunity to study some material which seems to present a striking confirmation of a portion, at least, of Ancel and Bouin's views, and also to increase the probability that the granules mentioned above constitute an internal secretion which brings about the phenomena of "heat" in the male horse.

Ancel and Bouin's conclusion as to the relation between the interstitial cells and the sexual passion were based, in large measure, upon a study of cryptorchid horses.[3] It is an old observation of veterinarians that such horses, although infertile, are as much actuated by the sexual passion as normal stallions; that the presence of even one undescended testis is associated with these phenomena, which promptly disappear

[1]Ancel et Bouin. "Recherches sur le Rôle de la Glande Interstitielle du Testicule," Compt. Rend. de l'Academie des Sc., T. 137, No. 26, 1903; T. 138, Nos. 2, 3, 4, 1904.

[2]R. H. Whitehead. "Studies of the Interstitial Cells of Leydig," No. 3, Histology; Anatomical Record (No. 8) of Amer. Jour. Anat., Vol. VII, No. 4, 1908.

[3]Ancel et Bouin. Jour. de Physiol. et de Path., T. 6, Nos. 6, 7, 1904.

when the testis is removed. On histological examination of the testes of such horses, Ancel and Bouin noted that the seminiferous tubules were atrophied and lined by Sertoli cells and early stages of sex cells, while the interstitial cells exhibited a marked hypertrophy. This hypertrophy they regard as strong evidence that the interstitial cells were actively engaged in producing an internal secretion.

The material, the results of the study of which I am about to present, consists of the *third* abdominal testis of a horse; the testes of a stallion, one of which had descended while the other had remained in the abdomen; and the scrotal testis of a young mule. It was collected by Dr. Jordan for the purpose of a study of the seminal epithelium, but because of its bearing upon the interstitial cells he has kindly permitted me to use it.

For purposes of comparison it will be convenient to describe briefly first the structure of the normal scrotal testis of the stallion. It consists of masses of seminiferous tubules lined by typical Sertoli cells and sex cells representing all the various stages of spermatogenesis. The tubules are separated from one another by a scanty amount of connective tissue, in which lie more or less isolated collections of interstitial cells. These have the typical structure described in my paper referred to above, the granules being evident even after fixation in Zenker's fluid. The horse's testis, however, is the only one in which I have been able to detect the granules after fixation in this fluid, experiments with the testes of the cat, dog, and pig being always negative in this respect. In addition to the typical interstitial cells, there are also a very few which contain large masses of lipochrome, a variety which will be referred to more particularly later on in this paper.

The third abdominal testis, which I shall describe next, was removed in April, 1908, by Dr. John Spencer, Veterinarian at the Virginia Agricultural Experiment Station, from a horse six years of age, from which two testes, one scrotal and the other incompletely descended, had previously been removed. We are fortunate in having a history of this animal, given in a letter from Dr. Spencer to Dr. Jordan. On May 16, 1906, the horse in question was brought by Mr. Charles T. Graham to Dr. D. E. Newland, of Crochett, Va., for castration. The horse was four years old that spring. Two testicles were removed, one of normal size and position on the left side. The remainder I quote from Dr. Newland's letter: "After exploring the inguinal canal on the other side with my hand, I found the other testicle hanging in the inner or abdominal ring. After a few unsuccessful attempts I was able to grasp the testicle with my fingers, and bring it down to where I cut it off with the emasculator. As the cord was very short, and I lacked experience, I did not get all of the epididymis. This testicle was rather small even for a cryptorchid. . . . Mr. Graham told me afterwards that the horse would neigh after mares and act like a stallion about as much as he ever did before being castrated, but he thought that probably this was due to habit, as the horse was four years of age and had served several mares." The following is from Dr. Spencer's letter to Dr. Jordan: "The occasion for further operating upon this horse was that he simply became unmanageable, as all ridgelings are. He was brought to me on March 27, 1907, with all typical characteristics of a ridgeling. . . . I first explored the left side, finding a well developed spermatic cord occupying the inguinal canal. I then explored the right side and found a less developed, however, perfect cord, to which was attached a portion of gland. Thinking that this might account for the trouble, although out of proportion, I removed it. The wounds healed without pus. In ten days the horse returned to his former vigorous behavior towards other animals. We could not then persuade the owner to have the canals again explored, but the horse has since become unmanageable, and returned here April 6, 1908, when I removed the testicle I sent you. The case again progressed without complication, and the horse has since settled down as an ordinary gelding. . . . The third testicle occupied a position in the abdominal cavity immediately inside and slightly posterior to the internal opening, and was about as well developed as the average abdominal testicle."

The testis, which measures 4 cm. x 7 cm., was cut into several strips left attached at the mediastinum, and preserved in 10 per cent formalin solution. It was invested by a thick capsule containing greatly convoluted blood-vessels, and the cut surfaces showed a large amount of connective tissue; and a well developed epididymis was present. In sections it is seen that the seminiferous tubules are aggregated into more or less circular areas by septa of rather dense connective tissue, the individual tubules in these areas being separated from one another by masses of interstitial cells. The tubules are lined by cells with long cytoplasmic processes, apparently all of one type, which are regarded by Dr. Jordan as degenerate Sertoli cells. The interstitial cells, on the other hand, are much increased both as to number and to size in a given area. Appropriate staining with neutral gentian or iron-hæmatoxylin reveals granules in greater abundance than I have ever observed, except, possibly, in the testis of a cryptorchid pig. Cells containing large masses of lipochrome are, apparently, entirely absent.

The clear history in this horse of marked sexual activity whilst the third abdominal testis was retained, and the histological condition of the organ—the tubules containing only degenerate Sertoli cells contrasted with hypertrophy of the interstitial cells—are valuable evidence in support of the view that the manifestations of sexual instinct in the male mammal are due to the interstitial cells. Furthermore, the structure of these latter cells with their large content of granules would seem to warrant the hypothesis that the cells accomplish this function by means of an internal secretion.

These conclusions receive support from a study of the other testes mentioned, for which we are indebted to Dr. W. G. Chrisman, of Charlottesville, Va. The first is an undescended testis of a stallion two years old removed at the same time with a normal scrotal testis. Here the seminal epithelium is such as is found in the early stages of development, consisting of young Sertoli cells and early forms of spermatocyte growth. No mitoses were seen, though the cells appeared perfectly normal. The interstitial cells are scanty in number. Only a few typical ones containing granules can be detected, but most of them are packed with globules of a pigment which, when unstained, has a greenish yellow color. It stains dark blue with iron-hæmatoxylin, and is distinctly colored, with Sudan III even in sections which have been imbedded in paraffin or celloidin; it undoubtedly belongs to that obscure group of substances known as lipochromes. The size and arrangement of the pigment within the cells is quite similar to those of the fat globules seen in the interstitial cells of various mammals. In the case of cells where the process is well advanced, the nucleus is pushed out on to the periphery, is small and pyknotic. It would seem to be a fair interpretation of the appearances noted in this testis to say that, owing to the presence of a normal scrotal testis, the interstitial cells of the abdominal testis were not called upon to perform their function, and had undergone, in large part, a form of pigmentary degeneration. It also seems fair to assume that had the scrotal testis alone been removed, the interstitial cells of the abdominal testis could have regained their normal structure and function.

Finally, I have to note the appearances in the mule's testis. Here Dr. Jordan finds that "the seminiferous tubules are lined with Sertoli cells, spermatogonia and a few primary spermatocytes in early stages. The nucleus of the latter appears to be in the spireme phase of the contraction stage and in process of regressive change. Mitoses are exceedingly rare, and those present are seen among the basal cells. Nothing corresponding to a secondary spermatocyte or a spermatid can be found, nor are spermatozoa anywhere present either in the seminiferous tubules or the epididymis. The absence of spermatozoa explains why mules are infertile *inter se;* as also the fact that no issue results from a cross between a female horse and a male mule (the cross between a female mule and a stallion is known to have resulted in offspring)."

The interstitial cells are fairly abundant, and consist both of normal cells with granules and of lipochrome cells like those noted in the undescended testis of the stallion. Thus the scrotal testis of the mule falls into much the same category as the abdominal testes of certain cryptorchids of pure species. In both cases there is a failure to form spermatozoa, and the animals are infertile; but in both active interstitial cells are present, and the animals exhibit the sexual passion.

If we assume that the latter phenomenon is a result of an internal secretion, the study of the third abdominal testis of the horse indicates that only the interstitial cells could elaborate this secretion; for the only other cells present which might do so (the Sertoli cells) were degenerate, while the interstitial cells were hypertrophied, and gave evidence of marked secretory activity.

Physical Anthropology and its Aims.[1]

BY

ALEŠ HRDLIČKA.

Smithsonian Institution, United States National Museum, Washington.

I.

An understanding of whatsoever exists, formulated and preserved in memory or writing, is knowledge; and systematic search for knowledge, on the basis of the highest standards of learning, is science. This in its application being of the utmost utility, constitutes the most important function of mankind. A branch of science is a portion of systematic research that extends to closely related phenomena and has become the special function of a definite class of qualified observers.

One of these branches is Anthropology, described by its principal promoter, Broca, as "the natural history of the genus *homo*," or, more in detail, as "that science which has for its object the study of mankind as a whole, in its parts, and in its relation with the rest of nature."[2] In the light of to-day, Anthropology may be defined more strictly as that portion of systematic research which deals with the differences in structure, in function, and in all other manifestations of mankind, according to time, variety, place, and condition. It is the science of structural, functional, and cultural differences in mankind in its epochs and its groups. That part of science which occupies itself with the body and its functions, studying their differences, causes, modes of development, and tendencies, from man's beginning, and among his present multiple groups—the research, in brief, into man's organic and functional variations—is Physical Anthropology.

The comparative element is the fundamental characteristic of anthropology and that which distinguishes it from allied branches of research. It shows clearly the position of physical anthropology in relation to

[1]The annual address of the President of the Anthropological Society of Washington, given February 11, 1908, under the auspices of the Washington Academy of Sciences.

[2]Article "Anthropologie" in the Diction. encyclop. d. sc's. méd., Vol. V, p. 276, Paris, 1866; also in Broca's Memoires d'anthropologie, Paris, 1871, Vol. I, p. 1. References to numerous definitions in R. Martin, System d. (physischen) Anthropologie, etc., Korr.-Bl. d. Deutsch. Anthrop. Ges., 1907, Nr. 9/12. See also L. Manouvrier, Rev. de l'École d'Anthrop., 1904, pp. 397-410, and F. Boas, "Anthropology," 8vo, pp. 1-28, The Columbia University Press, N. Y., 1908.

general human anatomy and physiology, and towards general biology. The objects of general human anatomy and physiology are the completion of knowledge regarding structure and its inseparable functions in the average man of the present day; while the chief aims of general biology are to trace the structural and functional relations of the different species of living beings to one another, and search for the causes and processes of organic variation and evolution. Physical anthropology is a continuation, an extension, of all these to the epochal, racial, other natural, social, and even pathological groupings of mankind, and reaches with its investigations beyond man only so far as is necessary for understanding the phenomena which it encounters. If it had not its present designation it could well be called "advanced human anatomy and biology."

Physical anthropology is still a young branch of science, though its roots lie far back in the development of human reflection. It is interesting to know that one of its main incentives was the discovery of America, with its new race of people. This was followed by discoveries of other lands and peoples in the Pacific and by slowly increasing knowledge of organized beings in general, including the anthropoid apes. All this aroused new thoughts in scientific men and doubts as to the correctness of the old theories of creation; and the fermentation in minds, though greatly impeded by the power of dogma, progressed until it finally began to pierce the heavy cloud and manifest itself in publications. Peyrere's "Preadamites" appeared in 1655, and, notwithstanding prohibitions and the small real worth of the book, was received with eagerness and read very extensively. In 1699 was published Tyson's "Comparative Anatomy of Man and Monkey." And in 1735 we see the actual foundation stone of modern anthropology laid by Linnæus. It was in Linnæus' *Systema Naturæ* that man for the first time was placed in instead of outside the line of living beings in general, and that his close organic relations with the rest of the primates was authoritatively expressed. Then came Buffon, with whom the new branch of the natural science of man takes a more definite form, and thence the progress towards Anthropology, as differentiated to-day, is continuous. The men who contributed towards its development are too numerous to mention; they include all the prominent naturalists and anatomists of the latter half of the eighteenth and the first half of the nineteenth century, such as Camper, Lamarck, Blumenbach, Soemmering, Lacépéde, Cuvier, Retzius, the brothers Geoffroy, Morton, Lawrence, Edwards, Serres, Pritchard, and many others.[3] Even the teachings of Gall, however erroneous in application, have assisted its growth, for they stimulated research regarding the variations of the head, skull and brain, and were the main incentive to Morton's remarkable work, "Crania Americana." And the discussions of the mono- and polygenists, particularly those of the nineteenth century, were of great importance. The first effort at some organization of forces in the new line was made as early as 1800, when a small body of scientific men formed themselves, in Paris, into a Society of Students of Man (Société des observateurs de l'homme). It was in this little circle that the term Anthropology (used previously as a title for some works on man of philosophical and in a few instances of simple anatomical nature) was employed in something like its present significance. This attempt at organization was, however, premature and had to be given up two years later (1803), after but little had been accomplished. In 1832, the Paris Museum of National History, under the influence of Professor William Edwards, transformed its chair of Anatomy into that of Natural History of Man, and to this Serres, in 1839, added Anthropology; but the time was still not ripe for the subject to assume much importance. From 1839 to 1848, Paris had a Society of Ethnology, which included the physical branch, again with but little result. It was not until the commencement of the second half of the nineteenth century, with the advent of Paul Broca and his collaborators, and the foundation of the Paris "Société d'Anthropologie" (1859), that the actual birth of the new branch of science has definitely taken place. This is less than fifty years ago; and how difficult the beginnings were even then will be appreciated from the following recently published[4] details: When permission to establish the society was sought, the Minister of Public Instruction, notwithstanding the rank and fame of the men who, with Broca, applied for the sanction, refused to have anything to do with the matter. He sent the petition to the Prefect of Police, but the

[3]For details concerning the history of anthropology see T. Benlyshe, Mem. Anthrop. Soc., London, Vol. I, 1863-4, pp. 335-458; P. Topinard's Elements d'Anthropologie générale, Paris, 1885, pp. 1-148; L. Niederle, Athenæum, Prague, 1889 (repr. pp. 1-19); F. Boas, Science, October 21, 1904, pp. 513-524; references to more or less direct contributions to the subject in R. Martin, o. c., and the "Recent Progress in Anthropology," Am. Anthrop., Vol. VIII. No. 3, 1906, pp. 441-556.

[4]L'Ecole d'Anthropologie de Paris, 1876-1906, 8vo, Paris (F. Alcan), 1907.

Prefect was equally unwilling and returned the document as he received it to the Ministry. It was not until after the influential intervention of Ambroise Tardieu, that one of the chiefs of the Police Department was persuaded that the scientific gentlemen were not quite as dangerous to the welfare of the Empire or society as was suspected, and not finding, besides, any law that forbade the gathering of less than twenty persons, he informed the eighteen future anthropologists that their meetings would be tolerated. But Broca was made responsible for anything that might be said at the meetings against the government or religion, and every meeting was to be attended by a plain-dressed officer.

From the establishment of the Société d'Anthropologie the progress of the new branch of research was more rapid. Before long similar societies were organized in England, Germany and other countries; the publication of anthropological journals was commenced; an efficient system of anthropometry, with the required instruments, was devised—principally by Broca, and detailed instructions in the system were published by the same author; collections and important lines of research were begun in different parts of Europe and also in the United States; and in 1876 was founded the Paris School of Anthropology, for academic instruction and training in the new branch of science. Finally, in 1885, appeared Paul Topinard's great text-book on Anthropology, the "Elements d'anthropologie generale," which to this day is an indispensable volume in our laboratories. A large step has also been made during this time in the differentiation of anthropology as a whole into its main subdivisions, namely, physical anthropology, ethnology, and archeology.

But this period of the first twenty-five years of anthropology as a separate branch of learning, period of the greatest activity, the detailed and still unwritten history of which is of absorbing interest, was not one of uninterrupted progress. There was encountered, above all, a crisis which affected especially physical anthropology, and from the effects of which the latter is now only beginning to recover. This crisis was the result of what may be called a schism in anthropometry, begun in 1874 by Ihering and completed by the German anthropologists at Frankfurt in 1882. This is not a suitable place for a discussion of the causes or details of the case; suffice it to say that at the present time a commission, composed of the foremost physical anthropologists of Europe—French, German and from other countries—is endeavoring, and with much success, to select the best from the existing methods in anthropometry and bring about a much needed uniformity.[5] A complete agreement on this subject will be of the greatest importance and mark an epoch in our branch of learning.

This chapter, necessarily superficial, will be appropriately concluded with a few words concerning the actual status of physical anthropology. The subject, like the whole history of this science, calls for a thorough presentation, but such is out of the question in an address of this nature.

Physical anthropology counts distinguished followers wherever science progresses; it has already an extensive bibliography of its own; it maintains a number of well equipped laboratories, where students are trained; it possesses a large series of important collections of material for investigation; it contributes the bulk of original matter to well established anthropological journals of high standing, such as the Bulletins et Mémoires de la Société d'Anthropologie de Paris, the Archiv für Anthropologie, the Zeitschrift für Morphologie und Anthropologie, the Biometrica, Man, etc., while numerous other results of investigation are being disseminated through periodicals devoted to anatomy, general biology, and to other subdivisions of anthropology; finally, it is a subject or a part of instruction in the Ecole d'Anthropologie, in the Anthropological Institute of the Zurich University, in several large museums, and in one or more of the principal universities in almost all civilized countries.[6] It is still struggling with numerous difficulties which retard it, but it has before it a wide and useful future.

II.

The questions are often asked by those whose preoccupation has not permitted closer following of this branch of research, what has physical anthropology accomplished? and what are its aims for the future? Both of these are weighty questions and deserve to be answered.

[5]For what has been accomplished see F. v. Luschan, Die Konferenz von Monaco, Korr.-Bl. d. d. Ges. f. Anthrop., etc., Juli, 1906, pp. 53 *et seq.*, in Arch. f. Anthrop., 1906, H. 1-2, and "Entente internationale pour l'unification des mesures craniométriques et céphalométriques," L'Anthropologie, 1906, pp. 559-572.

[6]For information regarding instruction in anthropology see J. Ranke, in Lexis, 1896, p. 117; W. Waldeyer, Korr.-Bl. d. d. Ges. f. Anthrop., etc., 1896, p. 70; G. G. MacCurdy, Science, December 22, 1899, and February 7, 1902; Recent Progress in Anthropology (a review of the activities of American institutions and individuals from 1902 to 1906), Amer. Anthropol., Vol. VIII, No. 3, 1906; V. Zaboroswki, Bull. and Mém. de la Soc. d'Anthropol. de Paris, 1902, and l'Anthropologie, 1904, pp. 13, 252 and 483.

The amount of work actually done must be considered together with the obstacles that stood, and to a large extent still stand, in the way of fruitful investigation. The most influential of these obstacles was and still is the imperfect state of anatomical knowledge, which is the starting point of physical anthropology. It is obvious that structural comparison, extending to various groups of humanity, can properly be carried on only on the basis of a thorough knowledge of structure in some one type of man, preferably the white race. Had anatomy been able to furnish such a foundation to physical anthropology, the progress of the latter would have been immeasurably easier and more rapid. As it was, the new branch began to differentiate itself while general human anatomy was yet very imperfect, and in consequence it was confronted with the tedious task of establishing or improving the bases for its future comparisons. Thus a large portion of the work of anthropologists was hitherto and still is purely anatomical. It is safe to say that fifty years ago, when the Paris Society of Anthropology was founded, there was not yet one single point in any part of the human organism that was well known and understood. Even at this day, with all the excellent work accomplished, there is not yet a single bone in the body, and perhaps no other organ, the knowledge of which and its total range of variation is perfect, and that in the white race alone, which has been most studied. The splendid anatomical text-books of the day give little more than generalities. The specialized literature is greatly richer, but when it comes to details there are innumerable lacunæ. Yet details are the essentials of all research, and they are indispensable in anthropological comparisons. It would almost seem from this that the birth of physical anthropology had been premature; but if one stops to consider the deep interest its problems have for humanity, it is seen that its early rise, even on the but partly prepared soil, was natural.

The second great obstacle to the progress of physical anthropology have been, and in a diminishing extent continue to be, the defects in collections of needed material. The third was the dearth of properly trained men, and in the fourth place should be named the difficulties, based on various prejudices or incomprehension, attending the collection of accurate anthropological data in many parts of the uncivilized and even the civilized world. Still further impediments, attending this more than other branches of natural science, were those accompanying the elaboration of the necessarily extensive series of data and especially their publication.

With regard to material, what collections of value for physical anthropology were there half a century ago? Fair beginnings have been made since that time in a number of European cities, and one particularly interesting one on this continent—that of Morton in Philadelphia; but all this was limited to crania and was useful to awaken suggestions rather than lead to definite conclusions. It required years of assiduous collection and excavation before actual scientific work of any extent could anywhere be attempted. Such collection has been going on to this day, and there are now several great besides many minor gatherings of identified material, including those in the National and other American Museums. Yet even now we are far from the ideal in this direction, or from collections which would include at least the bones of the whole skeleton, and the brain, and enable us to determine the complete range of variation in these parts of special importance in at least the most significant groups of humanity. What is required in this line will be clearer when it is appreciated that, to determine the total range of variation in a single long bone, such as the humerus, in any group to be studied, there are needed the remains of hundreds of individuals of one sex from that group. As it is, even the greatest collections fall still far short of the requirements, and the investigations carried on them can be seldom perfect or final.

The dearth of properly trained men has been and is at the present time a great hindrance in physical anthropology. The cause of this is simple enough. The branch demands extensive preparation and arduous work, for which it offers at best only moderate pecuniary reward. It has not yet reached the stage of its ultimate public utility and in consequence receives much less public recognition than the so-called applied sciences. Under these circumstances the recruiting of regular workers of the right class is precarious, a new physical anthropologist is almost an accident, and the supply of students is very short of what is needed.

The difficulties of gathering the requisite material, and even the crude data alone, have been infinite and are still very great; in fact, they are sometimes quite insurmountable. Religious beliefs and superstition, but also love, cover the dead body everywhere with a sacredness or awe which no man is willingly permitted to disturb. It is not appreciated that the secured remains are guarded in the laboratory with the utmost care and for the most worthy ends, including the benefit of the living. The mind of the friends is only apprehensive of mutilation and sacrilege, or simply fears the disturbance. These conditions extend with small exceptions to the civilized and savage alike, and to collect, in their presence, large supplies of material indispensable to physical anthropology is often very arduous and unsatisfactory. The impediment that this constitutes to the advance of the science is beyond computation. And the difficulties extend even to the data on the living. The stumbling blocks due to ignorance and superstition are particularly numerous in the way of measuring and are, curiously, met with even among the otherwise most enlightened. Compare with this the facilities of the zoologist or botanist!

Notwithstanding these and other obstacles, among others those placed in its way by the ill fitted or fool investigator, physical anthropology has already accomplished considerable useful work. It established a system of precise measuring of man and his remains, and furnished the needed instruments; it has directly advanced general anatomy, particularly that of the skeletal system and brain of man and other primates, and contributed to zoology, general biology, and to other natural sciences; it established the physical knowledge of the races and many of their subdivisions, and aided through its activities in the advance of its sister branches, ethnology and archeology; it gave a far-reaching impetus to search for the remains of early man, and determined the physical characteristics of the finds made; it actuated and to a large extent carried out the study of man's development from his inception onward; it brought about physical investigation and through this a vast improvement in our knowledge of the criminal and other defective classes; it led directly to the practical systems of identification of criminals; it took part in and promoted the studies in human heredity, variation, degeneration, and hybridity; it added to knowledge of the functions and pathology of the human body and especially the brain; it furthered vital statistics; and it has already begun to assist other branches in pointing out, on the basis of gained knowledge, ways towards the safeguarding and improving of the human race. This outline is necessarily defective, yet even it will show, I believe, that physical anthropology, notwithstanding the many and great obstacles in its road, has justified its separate existence and the decrees by which the French Government pronounced it, in 1864 and again in 1889, as a science of public utility.

III.

The object of the final chapter of this address is to outline in a brief way, and yet not too generally, the future field and aims, in a word, the future program—as apparent to the speaker—of physical anthropology. Could such a program be perfected it would itself mean an important step forward.[7]

The future activities of physical anthropology must extend to its own body and means, as well as to further research work proper; the more extensive and efficient the former the more important and prompt will be the scientific results.

The main needs—which logically become the aims—of the anthropologists themselves include more regular and extended recruiting of their ranks; a closer general unity and co-operation; definite unification and perfection of anthropometry in its whole range; systematization of the methods of treating and recording of data; the supply of modern text-books, and advance towards strictly specialized periodicals; the compilation of complete bibliography relating to this branch of research, and its continuation; the generalization of information concerning collections of material; and the augmentation and improvement of collections.

Recruiting with the right kind of men is very urgent. It conditions further development of academic instruction and laboratory training; it makes very desirable an extension of lectures on physical anthropology to medical colleges; but, above all, it necessitates financial resources from which scholarships could be offered to men to be trained in the laboratory and in field, and an improvement in the prospects of their employment with fair compensation after their preparative studies and training have been completed. The time required for the proper training of the physical anthropologist, coupled with that needed for the acquisition of indispensable experience, extends over several years of post-graduate activity, and as the men who are best prepared for such training and most likely to be recruited from are those who have completed a medical course, these years of specialized training and work mean a real pecuniary loss, which ought to be at least partly indemnified. Until provision is made in this point it cannot be expected that the requisite numbers of students will be attracted and specialize in physical anthropology. And this applies particularly to this country, where the prospects of the graduate in medicine—as well as in other sciences—are

[7]See in this connection and for further references to literature on this subject R. Martin's before cited paper on the "System of Physical Anthropology and Anthropological Bibliography."

brighter than in many parts of the Old World. The most suitable means of compensation during the preparatory years would be scholarships, continued with the right kind of men until they found position. The opportunities of employment of well trained anthropologists are not so few as one might be led to believe; the principal problem in this direction is more to augment the compensation so it corresponds better to the needed preparation and with the prospects of a man as well trained, had he followed another vocation, such as that of the physician.

Closer unity and co-operation among physical anthropologists of the different countries, the utility of which needs not be be dwelt upon, must always be one of our cherished aims, and the same is true of the unification and perfection of anthropometrical processes and standards, as well as the methods of dealing with the anthropometric data and their recording. Concerning the latter, the establishment of definite rules is still distant, the whole subject being in the process of evolution. One of the main questions, accentuated since the establishment of the journal Biometrica, relates to the employment and utility of higher mathematics in the analysis and presentation of the data. A simple exposition of facts, approachable to every educated person, carries with it so great an advantage to every branch of investigation and to the public as well, that the matter of extensive use of algebraic formulæ in publication cannot be passed over lightly. It would be folly to oppose the legitimate use of higher mathematics, which in special cases excel all other methods, and may, in fact, be the only means by which to arrive at a solution of a given problem; but when it comes to the presentation of the results arrived at, it cannot be denied that the high-mathematical method, while finding special favor with some, abstracts the subject matter from critical perusal by a large percentage of scientific men, not to speak of others. The whole matter demands very careful attention.

A supply of modern text-books is a pressing need. It was twenty years ago that Topinard's great handbook appeared, and nothing has been produced since that would bring it up to date and replace it. Yet a considerable advance has been made in every direction, and the need of a thorough up-to-date presentation of the accumulated facts and changes is acute. There is hope that the unification and precision of anthropometric methods, inaugurated at the Congress of Monaco, will stimulate efforts in this direction.

An advance towards strictly specialized periodical, to be devoted exclusively to physical anthropology, is merely an aim at a further step in differentiation, such as is manifested in all other branches of research after they have reached a certain stage of development. It depends upon the strengthening of the ranks of the physical anthropologists.

The importance of complete and continued bibliographical record is evident enough to every student and author, and is an aim calling for the earliest possible realization. Beginnings in this line have already been made, particularly with current literature, and more is promised, but the movement calls for definite organization and extension to the older publications.

Improvement in and generalization of information concerning collections in physical anthropology are highly desirable. Such information, furnished through periodically supplemented registers of material by and to all institutions, would greatly promote collaboration as well as the extent of research. An additional procedure of much consequence would be the deposit of smaller collections in larger centers in each country, where they could be better cared for and be more available.

Finally, a matter of vital concern to physical anthropology is the augmentation and improvement of its collections. It is necessary that these be supplemented in a systematic manner in all particulars. There are needed much additional osseous material, including all parts of the skeleton, for racial and other group studies; ample developmental series, on which could be determined racial and other peculiarities in all stages of growth; the largest possible acquisitions of skeletal remains from all the periods of peoples known the longest to history, such as the Egyptians, the Semites, the Chinese, for the ascertainment of physical variations in different localities in known time; large collections of brains, preserved by uniform methods, for the study of gross, minute, and chemical differences in that organ in definite groups of humannity; and substantial series of at least the skeletal parts and brains of the anthropoid and other apes, for purposes of comparison. The existing material, as well as that to be added, should be held in the best possible condition regarding identification, cleaning, repairs and preservation. All these are necessities, on the fulfilment of which further advance in physical anthropology depends directly. Other objects of desire, at least in our great museums, are series of specimens fit for exhibition, for the illustration to the public of at least the generally most interesting human variations, and large gatherings of good photographs, as well as accurate casts.

The above by no means exhausts what may be termed the internal wants and therefore aims of physical anthropology. There still remain the very important objects, of the virile development and advance of teaching; the foundation of separate central institutes of physical anthropology, like the Ecole d'Anthropologie; the forming of a special, international association; the conservation of original, detailed data, etc. But these are largely matters of development of the branch, dependent on progress realized in the points before specified, and their discussion can be postponed.

This leads us to the scientific aims proper of physical anthropology, and these are innumerable. They extend from questions of pure science and natural philosophy to those of high practical utility, and from those of local interests to those of all humanity. I shall pass briefly over those of a more general nature and conclude with those that are more specially American.

The most urgent and important scientific object before physical anthropology is the gradual completion, in collaboration with the anatomists, the physiologists, and even the chemist, of the study of the normal white men living under average conditions, and of the complete range of his variations—these facts to form a solid and sufficient basis for all comparisons. This goal is still very distant, notwithstanding the mass of work already accomplished. It is necessary to renew and extend the investigations on every feature, every organ, every function of the medium white man, until these are known in every detail. The facility and value of all comparative work will increase in direct proportion to the degree of consummation of efforts in this direction. The choice of the white man for the standard is merely a matter of convenience; the yellow-brown or black man would do equally as well, if not better, were he available.

The second task of physical anthropology is to perfect, or aid in perfecting, the detailed knowledge of the structure, function, and chemical composition—with their variations—in the primates. This field of investigation may be regarded as the vestibule to the space occupied by man's natural history and is indispensable to the understanding of man's past and continued evolution, collectively and in every particular. The fossil forms of the primates must naturally be comprised with the living.

The third great duty of our science is the determination of development and the variations in man's structure and also, as far as possible, in other organic qualities—particularly those of chemical nature—in relation to time. This comprises a delicate and thorough study of every specimen of man of geological, and of ample series of those of historical, antiquity. The research as to the bones of the geologically early man has been painstaking, but the specimens themselves are still very limited in number and imperfect; while the study of man's variations within the time of which there is closer and finally historical knowledge, is still in its infancy. The investigations here mentioned relate principally to the important phase of man's evolution as a man.

The fourth leading object of physical anthropology is the study of the human races and their subdivisions. This subject has attracted attention since the earliest time, and contributions to the theme are numerous as well as important; yet the road to go is still much longer than that already traveled. The very term "race" awaits as yet a final definition that would be universally adopted. There are still immense territories in Asia, Africa, Oceanica and America, of the populations of which our knowledge is very rudimentary, or wholly deficient; and the subdivisions of the white race still offer a vast field for further investigation. The appreciation of what remains to be done on the races and tribes of man impresses one forcibly that we are still only in the beginning of this study and barely emerging from empiricism. The future work in this special field must be more extensive, systematized and critical.

Directly connected with racial studies, but of more serious concern to many nations, are investigations into the effects, physical and potential, of racial mixtures on the progeny. Mixture of races is a matter which can be brought largely under control through law and through general enlightenment. In view of this, a precise knowledge on the subject is a necessity, and to furnish it must be one of the main aims of anthropology.

Next in sequence, but not in importance, are the studies concerning the numerous environmental groups of humanity—of groups developed and continuing under extremes of elevation, climate, and nourishment; or under the greatest specialization in clothing, food, occupation, or habits that are liable to permanently affect the body or its functions. All such conditions are followed by functional and structural accommodations of the system, and it is to be determined how they eventually affect the progeny. Learning the exact facts in these lines is beset with great difficulties, but the results are bound to be of much practical besides scientific utility.

A still further extension of the studies takes up the pathological groups of mankind, including the alcoholics, epileptics, insane, idiots, perverts, and other defectives or degenerates, and also criminals. This part of anthropological research is already well advanced and has, with the help of medical men, accomplished much of immediate benefit to society. But the aims of scientific work in this direction, a complete knowledge of these classes, are yet far from having been attained. Their realization depends to a very large extent upon the perfect understanding of the normal contingent of the human family.

Somewhat separate from all the preceding is the study in human ontogeny, in the development of the individual from birth onward, in all divisions of mankind and under all specific conditions. The contributions to knowledge in this line have already been substantial, though very nearly restricted to the whites. One of the most interesting parts of this study will be that of man's decline in the different races and under various definite conditions.

Finally, the ultimate aim of physical anthropology is that it may, on the basis of accumulated knowledge, and together with other branches of research, show the tendencies of the future evolution of man and lay down indications for its possible regulation or improvement.

A few words in conclusion regarding the duties of physical anthropology in this country and in America in general. American students ought to contribute, as much as it may lie in their power, to knowledge concerning the white race at large and of other peoples outside of this continent with its dependencies. They have already contributed in no small way to the study of child growth and should not stop in this direction; they should also pay close attention to and co-operate in all investigations concerning special, environmental, and pathological groups of humanity. But there are several problems which will be to them of especial importance and demand the bulk of their labor. These are the appearance of man in America; the composition and detailed characteristics, with their complete range of variation, and the affinities, of the indigenous race, including the Eskimo; the crystallization of the new contingent of the white race in America, particularly in the United States; the development of the negro element, particularly in this country; and the effects of the mixture of the white with the negro and the Indian. And alongside these range themselves parallel problems affecting the insular possessions of the United States. All these are scientifically as well as practically serious questions, and the research into them deserves to be generally promoted. There is no other branch of natural science which can occupy itself with them and define them; they are the rôle of physical anthropology in this country and demand its development.

ABSTRACTS.*

FURTHER COMMUNICATION ON THE VENOUS SYSTEM OF MARSUPIALS —By H. von Schulte. *From the Anatomical Laboratory of Columbia University.*

In addition to the deep venous return from the tail and posterior limbs afforded by the caudal and iliac veins and the postcava, there are in the Marsupials a series of superficial venous channels, which, while subject to considerable variation in detail, in their main outlines are sufficiently defined and constant to have some morphological significance.

An attempt is here made to present a note upon their arrangement in a few specimens in the collection of the Department of Anatomy, Columbia University, though it must be premised that, from the paucity of the material and its state of preservation, the account can have no pretense to completeness.

In an adult male, Macropus giganteus (Fig. 1), two large subcutaneous veins are situated upon the sides of the tail; cephalad they are directly continuous with the sciatic tributary of the internal iliac.

On approaching the pelvis, ventro-mesial branches of large size are given off, which, passing dorsad of the pelvic arch to the side of the cloaca, inosculate with the obturator, close to the thyroid foramen, and with the internal pudic veins, thus establishing deep anastomosis with the parietal branches of the internal iliac. Still farther laterad an anastomosis with the deep veins of the thigh is formed by a branch, which, having received a tributary from the postaxial border of the thigh, passes between the gracilis and adductor magnus to empty into the large vein, which returns the blood from the adductor group and opens into the proximal segment of the femoral. In this adductor vein, which considerably exceeds it in size, the obturator appears to terminate after passing through the thyroid foramen. Thus in these forms the obturator vein appears as a short trunk formed by the union of anastomotic branches from the adductor vein and the ventro-lateral branch of the lateral caudal. Its position at the border zone of the internal iliac and external iliac territories is also indicated by the

*Abstracts of some of the papers read at the twenty-third session of the Association of American Anatomists, Chicago, January 1, 2 and 3, 1908.

frequency with which, in the Macropodidæ, it opens into the external iliac, near, but perfectly discrete from, the internal iliac.

While the ventro-mesial branch of the lateral caudal is mainly anastomotic, yet it does receive several cloacal veins as tributaries. In addition a large vessel made up of radicles from the side of the penis and cloaca descends to join it, passing over the pubic ramus.

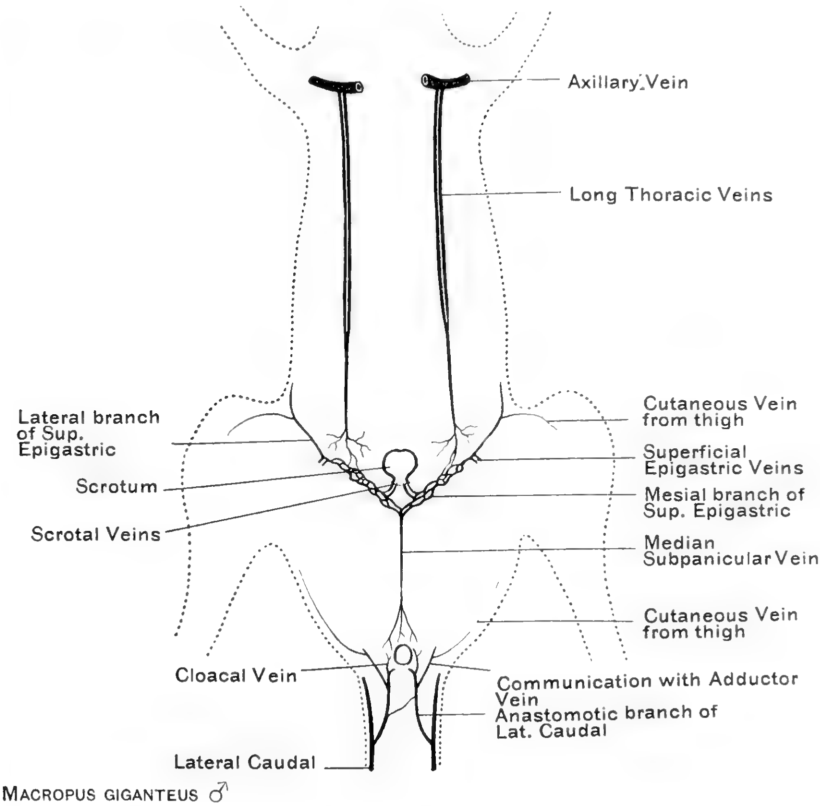


FIG. 1

This vessel is of some importance, as it appears to be the line along which a prepubic venous arch is formed in Onychogale and Bettongia.

In the median line of the abdomen a vessel, subpanicular in situation, is formed of radicles from the penis and front of the cloaca. This vessel bifurcates caudad of the scrotum, to become continuous with a series of large plexiform veins which accompany the processus vaginalis, and, receiving tributaries from the scrotum, constitute the mesial branch of the superficial epigastric vein. A lateral branch returns the blood from the superficial structures of the groin and receives a large tributary from the thigh. The two branches unite to form the paired venæ comites of the superficial epigastric artery and open into the femoral at the fold of the groin.

In the immediate vicinity of the union of the two tributaries of the epigastric, a number of superficial veins unite to form a large longitudinal vessel which runs cephalad to join the axillary vein. Some of these radicals appear to inosculate with the plexiform mesial tributary of the epigastric. This longitudinal vein is subpanicular, receives a number of tributaries from the integuments and is equipped with numerous valves, not more than a centimeter apart, which are competent to resist a downward injection, even when attempted directly into the veins. Cephalad the vein passes dorsad of the pectorals, from which it receives tributaries. Close to its termination in the axillary it is connected in a plexiform manner with the superficial vessels of the arm and shoulder. Thus these superficial veins of this Macropus fall into three areas, the continuity of the longitudinal channels being interrupted at the cloaca and at the groin.

A continuous superficial channel from the subcutaneous caudal to the axillary vein is present in a female Onychogale (Fig. 2).

The lateral caudal veins pass forward along the sides of the cloaca, where they divide into deep and superficial branches. The deep branches establish anastomoses with the obturator and internal pudic veins; the superficial are continued forward, receiving cloacal tributaries, to the ventral surface of the symphysis, where they unite to form a median vessel of large size.

This median subpanicular vessel continues cephalad to the caudal extremity of the pouch, when it bifurcates; the two resulting veins pass on the dorso-mesial aspect of the mammary glands and further cephalad become continuous with the long thoracic veins, which under cover of the pectorals, as in Macropus, empty into the axillary veins.

The median subpanicular vein resulting from the union of the subcutaneous caudals communicates with the mesial branch of the epigastric on each side by a single large vessel, of which that of the right side arises farther cephalad.

Thus the interval at the side of the cloaca in Macropus is bridged over in Onychogale, and a connection is established between the median subpanicular vein and the long thoracic. The lateral branch of the epigastric receives tributaries from the thigh and is continued along the side of the abdomen cephalad almost to the level of the lower ribs, but is not continuous with the long thoracic.

In a young male Bettongia (Fig. 3) it was possible to ascertain only that a medial subpanicular vessel was present between the cloaca and scrotum, at which point it bifurcated to join the superficial epigastrics.

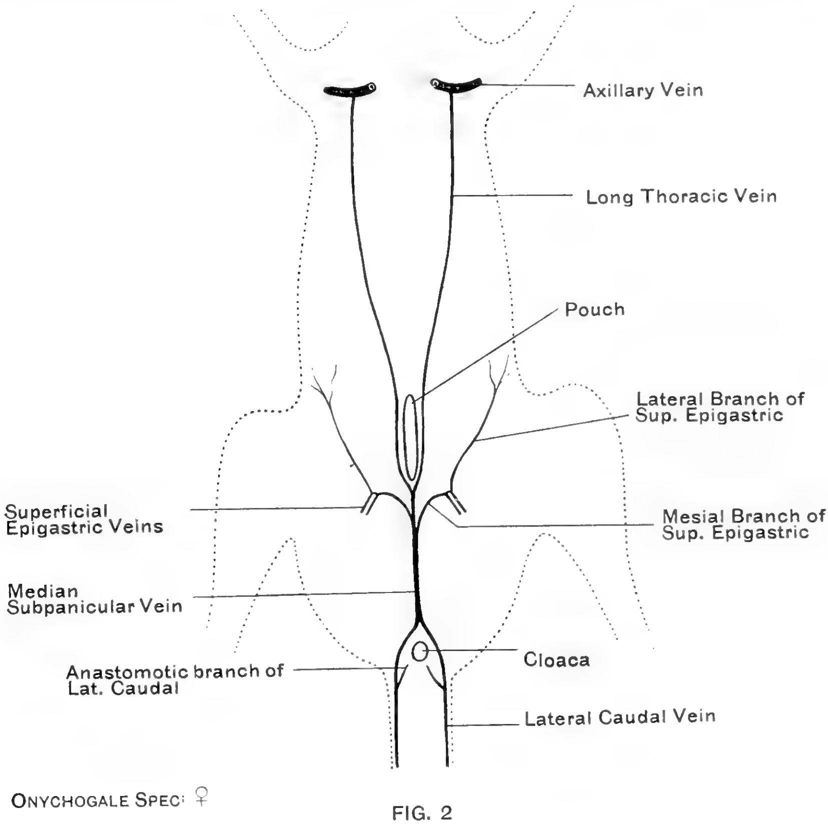
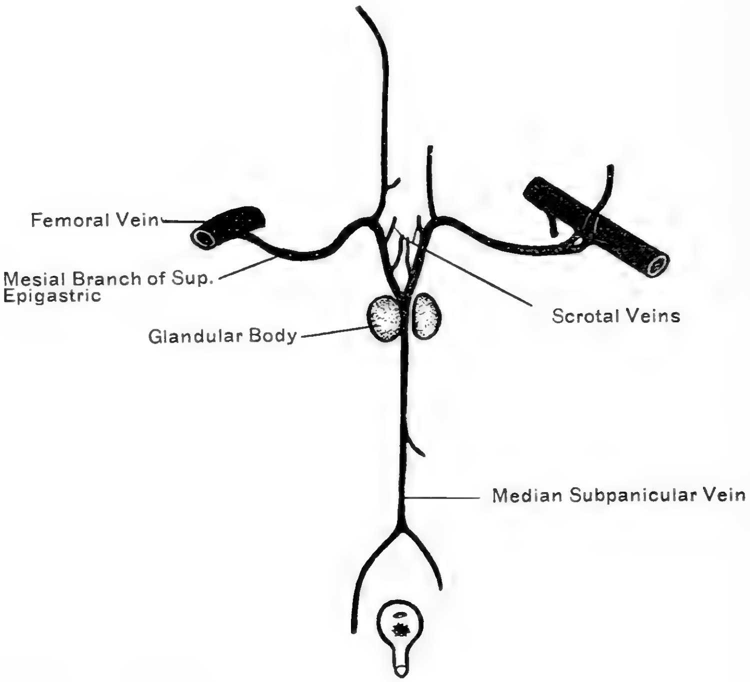


FIG. 2

In a male Dasyurus geoffroyi (Fig. 4) the median subpanicular vessels appear represented only by a transverse anastomosis between the internal branches of the superficial epigastrics; into this open the scrotal veins. The anastomosis is prescrotal in position. The lateral branches of the epigastrics inosculate with the long thoracics, forming a continuous channel along the side of the abdomen between the axillary and femoral veins.

In an adult female Phascolomys (Fig. 5) there is also a precloacal trans-transverse anastomsis, into which open cloacal veins. The ends of this arch are connected with the adductor vein on each side by a small vessel which runs along the pelvic arch to the interval between adductor magnus and gracilis, which it enters after receiving a tributary from the post-axial margin of the thigh. The connection of this transverse precloacal arch with the superficial epigastrics is not direct as in Dasyurus. The epigastrics follow the lateral margin of the mammary



BETTONGIA SPEC. ♂

FIG. 3

glands; mesial to the glands is a second smaller vein which opens caudad into the prepubic arch and is connected with the epigastrics by several cross branches between the mammary glands. This mesial vessel is continuous with the long thoracic.

While the general type of these veins presents a strong resemblance to the abdominal veins of reptiles and urodele amphibians, the precise significance of the various elements is by no means clear. Embryological data are almost wholly lacking.

McClure ('06) has described abdominal veins in the 8 mm. embryo of Didelphys: "These two veins resemble in all their relations the posterior division of the abdominal veins of the embryos of reptiles, since they receive tributaries from the body walls, open cranially into the umbilical veins and connect caudally with the external iliac veins. . . . The

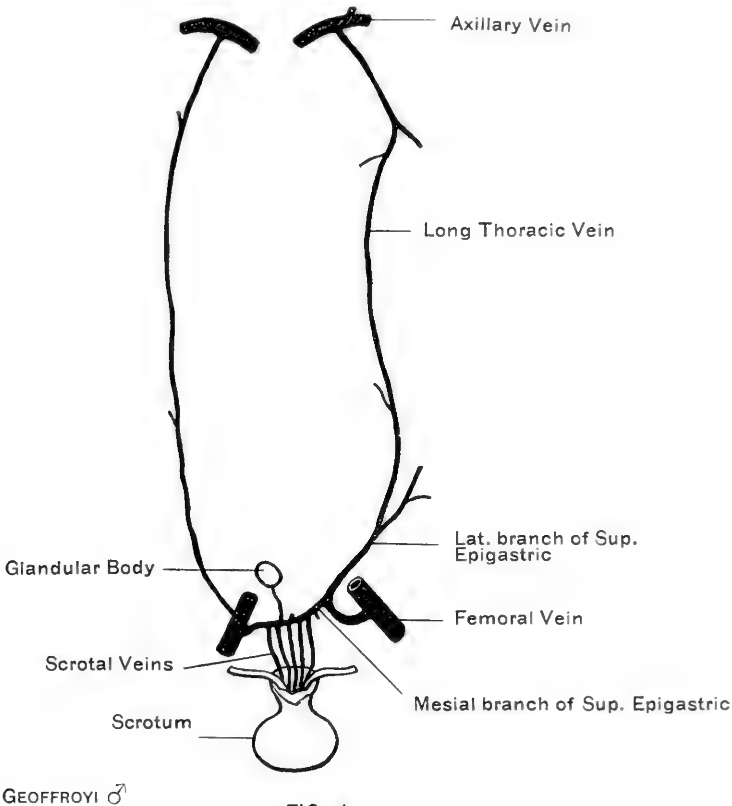
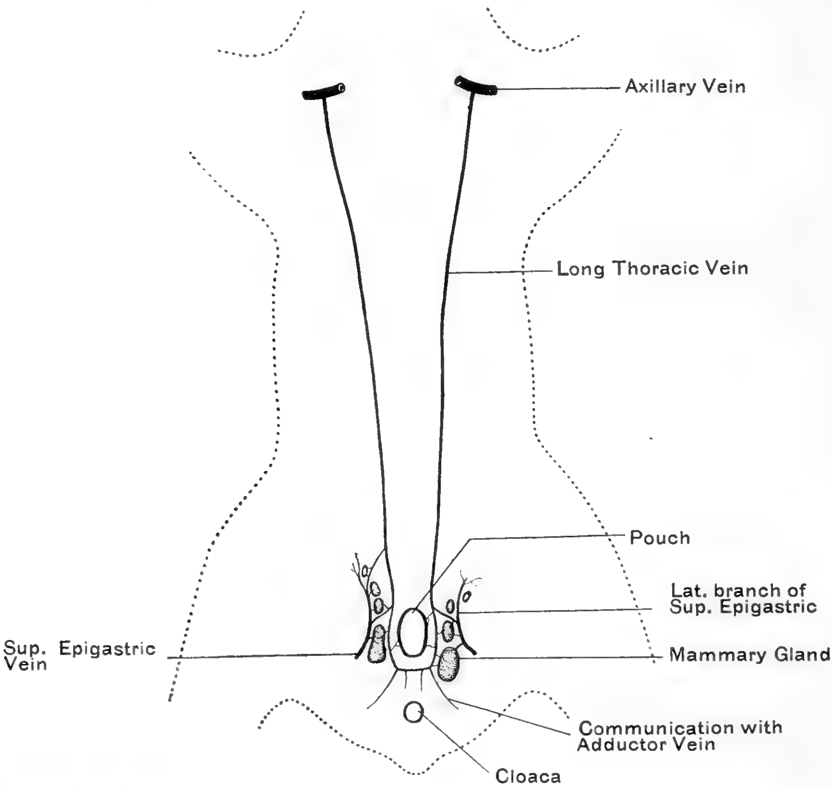


FIG. 4

abdominal veins are undoubtedly transitory in character and confined to the embryo during its uterine existence, since no traces of them were met with in any of the pouch young examined."

These vessels would appear to persist in the Macropodidæ as the mesial branches of the superficial epigastrics, connecting the median subpanicular vein with the external iliacs, and in Dasyurus as the transverse prescrotal vessel.

With regard to what I have termed the "median subpanicular vein," it is to be noted that immediately cephalad of its communication with the epigastrics—post-abdominals—it bifurcates to join the long thoracic of each side. A condition similar to this is present in the 6 mm. cat (Huntington), where the proximal portion of the umbilical, near its



PHASCOLOMYS MITCHELLI ♀

FIG. 5

entrance into the liver, is connected with the "primitive ulnar" by a rich network of small vessels.

The long thoracic would appear to be formed as a longitudinal anastomosis between these. If such a condition may be supposed to occur in the Marsupial embryo, the loss of the hepatic connection would establish the adult condition in Onychogale. The elements in the anastomosis between axillary and femoral would then be long thoracic, umbilical, post-abdominal, *i. e.,* mesial branch of epigastric. The lateral branch of the superficial epigastric draining the caudo-lateral region of the abdomen has here no direct connection with the long thoracic.

In Dasyurus, on the other hand, axillary-femoral anastomosis is formed by the inosculation of the lateral branch of the superficial epigastric, here a true thoracico-epigastric vein being formed, as often in man.

With regard to the medial subpanicular vessel caudad of the post-abdominal tap, two hypotheses offer:

1. It may represent a fusion between the post-abdominals or their cloacal tributaries.

2. It may be a discrete element. In favor of the second alternative may be cited its condition in Phascolomys, where a transverse precloacal arch is present, connected only indirectly with the mesial branches of the epigastrics. Its emergence from a precloacal arch would perhaps render it within the limits of possibility that it was a persistence of the subintestinal line. Unfortunately, no embryological data are available.

The lateral caudal vein also has been little studied. Its connection by a ventro-mesial branch with the cloacal veins in the Macropodidæ would appear to be a retention of primitive conditions, as in Selachians and Teleosts the cutaneous veins of the tail open into a plexus surrounding the cloaca of subintestinal origin. On this assumption the sciatic connections would represent a progressive change, tending ultimately to transfer the subcutaneous caudal to the sciatic system. Here it may be noted that in the Macropus, where the sciatic communications are more direct, there is an interruption in the subcutaneous channels beside the cloaca, the median subpanicular vein being formed of independent radicles and not directly by union of branches of the subcutaneous caudal, as in the Onychogale.

A further problem arises in connection with the topography of the longitudinal axillo-femoral anastomoses and of the prepubic arch. In the Marsupial these channels are subpanicular, in lower forms subperitoneal. The veins are homodynamous, but how far strictly homologous can be determined only by ontological studies in which the embryonic stages of the venous channels are correlated with the developing stratification of the somatopleure.

In conclusion, it is with pleasure that I acknowledge my great indebtedness to Dr. Huntington for his interest and criticism in the preparation of this paper. My thanks are also due to Dr. P. Fiaschi, of Sydney, Australia, who has on several occasions generously supplied this laboratory with most valuable Marsupial and Monotreme material.

DEMONSTRATION OF THE INTERVENTRICULAR MUSCLE BANDS OF THE ADULT HUMAN HEART. By H. McE. Knower. *Anatomical Laboratory, Johns Hopkins University.*

This demonstration is made on a specimen of adult human heart in which the fat, coronary vessels and epicardium have been removed to expose the superficial muscle fibers of the ventricles and of the conus. This superficial sheet is cut on the posterior surface to the left of the posterior interventricular groove (sulcus longitudinalis posterior), and the right ventricle rolled away from the left after the method followed by J. B. Macallum with pig embryos' hearts. The septum is thus split open, exposing the inner terminations of the muscle bands which arise superficially from the right and left atrio-ventricular rings, and from the conus, and end in the papillary muscles of the left ventricle. Deeper fibers are also shown, extending from the left ring to the large papillary muscle of the right ventricle, and from the conus to this papillary muscle. The membranaceous septum is split, showing the position of the atrio-ventricular bundle of His in a novel and striking manner. The septal blood-vessels are also found readily. The right and left ventricles may be thus unrolled further until opened from the septal side, as done by Macallum for young pig hearts. A fair proportion of hearts taken from dissecting-room subjects, preserved by injection of carbolic, glycerin, alcohol solution and afterward kept for a time in cold storage or in vats of weak carbolic, are found to be suitably macerated for this demonstration.

The results of Winkler, Pettigrew, Ludwig, Krehl and Macallum are thus readily examined in the human heart; we believe for the first time.

It is urged that students should be induced to study the heart in this way, after working out the coronary circulation, etc., rather than to simply cut open the ventricles after the method used by the pathologist in autopsy, since these cuts destroy the important muscle connections. The tracing of the muscle bands between the right and left ventricles will furnish a valuable aid to the better appreciation of the action of the heart. The relations of the papillary muscles to the interventricular (and conus) muscle bands can hardly be understood without this dissection.

A more extended illustrated account is now in progress.

An Improved Thermo-Regulator.

BY

WARD J. MacNEAL, Ph.D., M.D.

Assistant Chief in Bacteriology, University of Illinois.

From the Laboratory of Histology and Embryology, University of Michigan, Ann Arbor, Mich.

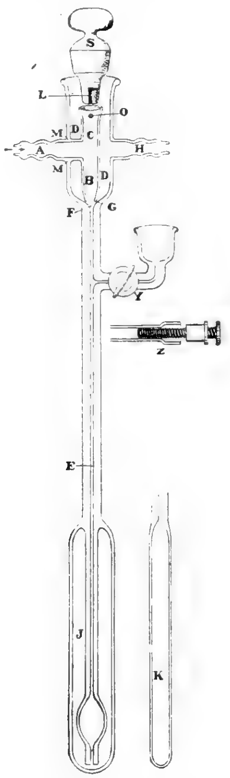
The biologist must have at his disposal some reliable thermo-regulator for maintaining a fairly constant temperature in his various incubators and ovens. The most widely used gas thermo-regulators are made of glass and filled with mercury or with mercury and some lighter liquid, the heavy mercury serving to close the chief source of gas supply at the desired temperature, while a minute opening at another point remains open to furnish sufficient gas to keep the flame burning, but not sufficient to maintain the temperature: with cooling the mercury falls and allows gas to flow through the larger opening. In this way the supply of gas is made large when the temperature is a little below, and very small when it is a little above the desired point, and the variation in temperature is very slight. The instruments on the market rely upon the weight of the mercury to prevent gas from passing through it and are, therefore, insufficient for any but the lowest gas pressure, gas bubbling through the mercury, when it is supposed to be shut off, being a common occurrence unless a gas pressure regulator has been installed.

The thermo-regulator, about to be described, makes use of the property of capillary repulsion between mercury and glass, and when properly made will regulate smoothly and accurately against ordinary gas main pressure (5 mm. mercury). It can be made to hold back with certainty gas at a pressure of twenty millimeters mercury or even more. The mechanism upon which this quality depends is adjusted and permanently sealed in position at the time the instrument is made, and is tested at that time. It cannot get out of adjustment unless the regulator be broken or melted.

The instrument[1] devised (Fig. 1) is very simple in principle and not difficult to make for one with some experience in glass blowing. The inlet tube A leads through the wall of the chamber D, to which it is fused, into an inner upright tube, BC. Near the upper end of this upright is a small opening, O, which allows the minimum supply of gas to pass to the burner to avoid extinction of the flame. The lower end of this upright tube fits quite closely the bottom of the chamber, D,

[1]The thermo-regulator is kept in stock by Eberbach & Son, Ann Arbor, Mich.

around the opening leading into the capillary tube, EF. This end is adjusted so close to the bottom that mercury will not pass through between inner and outer tube at less than twenty millimeters mercury pressure, yet not so close but that an abundant supply of gas may pass. The proper adjustment of this part must be thoroughly tested before the instrument leaves the factory. The upper end of the upright, BC, is closed by a ground glass stopper, which also closes the top of the outer



chamber, D. In the ground surface of this stopper a gamma-shaped (Γ) groove is cut, the vertical limb extending from the lower tip of the stopper to the level of the opening, O. The horizontal limb is deep where it joins the vertical, but gradually becomes shallow and ends about one-quarter the way around the stopper. This groove serves for passage of the gas from the inner tube BC, to the opening O, and thus to the outer chamber D, and by rotating the stopper the amount of gas flowing through this passage may be reduced to any desired point. The outlet tube, H, leads from the chamber D to the burner connection.

The capillary, EF, leads to a bulb of sufficient size; the larger the more sensitive the instrument. Either the large bulb with inside capillary, J, to be filled with mercury and alcohol, or the smaller simple bulb for mercury alone may be used. A side arm is attached to one side of the capillary EF, for conveniently controlling the height of the mercury column. Either the curved capillary tube with stopcock and a cup on the end, or the simple tube with metal screw cemented in, may be used here, according to the purpose which the regulator is to serve. These parts have been previously described by Novy.[2]

The chief advantage of this regulator lies in the fact that the parts upon which the action depends are absolutely fixed in their proper relation. This is not the case in other regulators. The minimum opening is readily adjustable and its mechanism is very simple. Cleaning and refilling the instrument requires care, but presents no great difficulties.

A New and Sensitive Method of Injecting the Vessels of Small Embryos, Etc., Under the Microscope.

BY

H. McE. KNOWER.
Anatomical Laboratory, Johns Hopkins University.

In the course of my studies on the development of the blood-vessels and lymphatics of frog embryos, it was found impossible to secure an injecting needle fine enough or a force sufficiently controllable to drive an injection fluid into the minute vessels of these small bodies, until the following method was devised:

If a gentle warmth is applied to a glass bulb blown on the end of a capillary tube, while the fine point of the tube is held beneath the surface of some fluid, as India ink,[1] air will be driven out of the bulb and ink will run up to replace it as the bulb cools. When the system has come to an equilibrium, the point of the tube is inserted into the desired blood-vessel under a dissecting microscope (binocular if possible), the tube being carried on a holder to avoid warming it or the bulb. India ink is now injected, as desired, by warming the bulb when ready.

[2]Novy, Centralblatt f. Bakt., Bd. XXIII, 1908, p. 1054.
[1]Higgin's waterproof drawing ink is to be recommended.

This method then depends: first, upon the use of glass tubes with the finest possible capillary points, as already recommended by various investigators; secondly, upon my idea of the advantages of a closed system with a sensitive glass bulb serving as a reservoir for the injecting fluid, which is driven out under any degree of pressure desired by heating the bulb.

A few directions should suffice to make the method readily available. A glass tube about 2.5 to 4 mm. in cross section is heated[2] in the flame (Bunsen) of the blow-pipe, until it can be drawn out as in Fig. 1. The tube should be turned while heating. It is then broken across the middle and heated, being turned at the same time, at the point x, Fig. 2, with a fine blue blow-pipe flame, until the larger end is melted through, leaving only a small portion on the tip of the capillary tube (Fig. 2). If the flame be now turned on more fully and the enlarged tip heated still more, until molten, care being taken to apply the heat all around the end (note arrow in Fig. 3) and to avoid melting the adjacent fine tube, a bulb may be readily blown on it, as in Fig. 4. The end is usually removed from the flame when hot enough and blown quickly, but without too great pressure, through the capillary tube. The size and thinness, *i. e.*, sensitiveness, of the bulb may be varied at will to suit special conditions. Large and relátively thick bulbs blown on tubing of 8 mm. cross section are often serviceable.

The tube should generally be given a bend (Fig. 5, a) over a minute gas-jet burning at the end of a glass tube drawn out to a point. A very fine capillary point is now secured by again drawing out the end quickly over, but not too close to, the little gas-jet, c (Fig. 5. b), or near the

Explanation of Figures.

Fig. 1.—Glass tube drawn out after moderate heating near middle (see arrow). Tube should be turned while heating. The capillary tube will usually be three or four times the length of that in the figure.

Fig. 2.—Superfluous tube burned off at x by a fine blow-pipe flame. Tube should be turned while heating.

Fig. 3.— Enlarged end, molten and heated around the end (note arrow) while being turned.

Fig. 4.—Bulb blown as soon as tube in Fig. 3 is molten. The end is usually removed from the flame, when hot enough, and blown quickly but without too great pressure through the capillary tube. Size usually about twice that of figure.

[2]The position of arrows in figures indicates the point of application of heat.

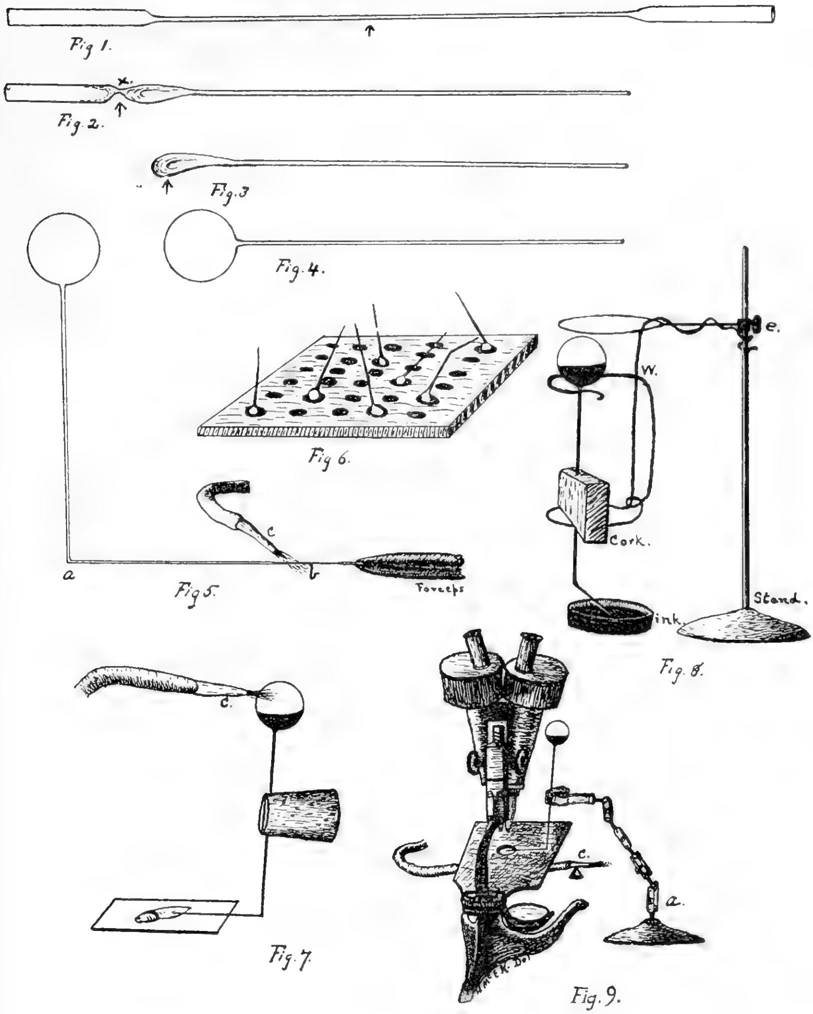


Fig. 5.—The bend at a is given before the fine tip b is drawn out over the gentle heat of c, or near a hot iron. Reduced size.

Fig. 6.—Board with auger holes to hold bulbs. Size much reduced.

Fig. 7.—Method of applying heat and introducing tip with free hand, and simple cork holder. Size reduced.

Fig. 8.—Wire support w, for holding bulb while filling. Reduced size.

Fig. 9.—Method of using jointed holder a, with binocular. The small gas-jet c lies in front ready for heating the bulb. Size greatly reduced.

flame of a small alcohol lamp with a thread wick. To accomplish this the tube should be drawn toward the operator through the heat of the margin of the flame and pulled out at the same time. The flame must be a small one, as small as possible. If the extreme tip fuses solid, it must be clipped with scissors. It is important to obtain a very fine point to insure good results. Most difficulties which arise are to be traced to insufficient fineness of the tip.

My injecting bulbs are kept standing in auger holes driven part way into a board, as in a bottle board (Fig. 6).

When about to inject, the tube of the bulb is wedged into a split in the end of a cork (Fig. 7), and the device is suspended in a rack over the injecting fluid. Any support which will hold the tip just beneath the surface without breaking it will serve. A good rack may be made by bending one end of a piece of heavy wire (Fig. 8, w) into a shape convenient to receive the cork, while the other end is bent on to the sliding arm of a small iron filter-stand (Fig. 8). The bulb may now be raised or lowered on loosening the thumb-screw (c), and when this is tightened the point of the tube may be held beneath the surface of the injecting fluid without danger of breaking. It often suffices to rest the cork holder on the mouth of a vial, allowing the tube to hang down into the fluid, which should stand deep enough to permit granules to settle at the bottom. It is often well to dilute the ink, if this is the fluid used, with a little water. In total mounts, cleared and studied in cedar oil or balsam, injections with diluted ink are apt to show most detail. Sea water tends to precipitate the ink. Hence special care is needed when the specimen must be injected in this solution.

The bulb is now heated with a small gas-jet, or the flame of a small taper, strongly if much ink, gently if little is to be used, or with the warmth of the breath if still less fluid is desired, or a specially delicate bulb is used. It is then allowed to stand until it has filled itself with sufficient fluid and is cold. If the bulb be then touched with the finger to cause a few drops to be expelled a little water may be drawn in at the tip, as this now stands in water. This is not generally necessary, but prevents drying and aids in keeping the point clean at the start.

As soon as the object to be injected is in place (and if necessary anæsthetized) beneath the microscope, binocular if possible, the injecting bulb is removed from the rack and the point carried into the location selected in the specimen. A great advantage of the method is that now the injecting fluid will not run out, if the point be of suitable fineness, until the bulb is warmed and pressure exerted. While the device is now held steadily, the left hand is brought around in front to warm the bulb. The warmth of the fingers is often sufficient to inject limited areas, or to impel the fluid into a vessel to be pumped rapidly throughout the body by the action of the heart. In this way the injection may be very sensitively regulated; if, however, more injecting pressure is desired, a small gas-jet at the end of a glass tube is brought around by the left hand (Fig. 7, c). With care the pressure may be kept well under control. It may be varied at will. When not in use this gas-jet lies ready just in front of the operator, resting on a support (Fig. 9, c). A lighted match or taper may be substituted, or the bulb may be heated by electricity run through a resistance coil of aluminium or copper ribbon attached to the holder and surrounding the bulb and operated by pressing the foot on a push button or switch.

As it is a great advantage for the operator to have both his hands free to manage the specimen and bulb, thus giving his undivided attention to the introduction of the tip into the vessel, a special holder is necessary unless the warmth is applied by an assistant. This need is supplied by a lens-holder on a jointed arm, with joints of the ball-and-socket type (Fig. 9, a). When the cork support of the injecting bulb is fixed in the lens-holder, in place of a lens, the capillary point of the tube may be introduced into the selected vessel with sureness, the ball-and-socket joints allowing it to be carried in regularly by the hand and holding it quite steadily during the process. As soon as the point is securely in position, the holder of itself becomes at once fixed, and permits of its being left sticking there in place, without jerks or vibratory movements, while the hands are freed to aid in the manipulations of heating, etc. After using, the point may be immersed in the injecting fluid, still held by the jointed holder, and allowed to refill until again needed. This holder is a most valuable accessory, and I am indebted to Dr. E. R. Clark, of this laboratory, for suggesting its use with my bulbs. His enthusiastic and skillful adaptations of this method to his own work have been most helpful in perfecting it. Several dealers have offered to improve the lens-holder catalogued as "Ts." by Messrs, Bausch and Lomb, for use with my bulbs by making the terminal joints lighter and adding thumb-screws to the last one or two ball-and-socket joints. The present form is somewhat too clumsy, and not sufficiently sensitive.

Another type of holder which will doubtless be found useful for injecting by this method is furnished by the mechanical contrivance of

Dr. J. F. McClendon described and figured in his "Studies on Protozoa" which will appear in the Journal of Experimental Zoölogy.

Applications.

Fish.—Young shark embryos are readily injected on the yolk through the vitelline vessels and make most interesting specimens.

Amphibia.—I have found it easy to inject, under the Zeiss binocular, the entire vascular system of very young tadpoles of several species of frog from less than 7 mm. up, and the lymphatic system of the same stages, as well as special vessels, were injected at will. Small Amblystoma larvæ have also been similarly injected. The results of these injections will be described in a forthcoming paper. Such specimens are beautiful when fixed, dehydrated and cleared in creosote or cedar oil, and studied in cedar oil or balsam. They may may also be sectioned.

It is necessary to call attention to the importance of some means of keeping the body of the embryo fixed while introducing the injecting point into a vessel. In the case of a tadpole some melted paraffin is dropped on a slide, and when cool a bed is cut down to the glass, of a shape to hold the body, the tail being allowed to lie exposed on the glass where its vessels may be readily seen and entered.

Birds and Reptiles.—Chick and duck embryos of two or three days are injected on the yolk surface and then fixed; or, better, removed into warm salt solution with the vascular area intact, kept alive and injected under the binocular on a large slide, when the blastoderm has well flattened down as soon as the salt solution has run off. The membranes must generally be weighted or given a slight pull against the point of the bulb from behind, in a direction opposed to its movement, so that the wall of the vessel may not be pushed away from it, but ruptured to permit its entrance. A point of sufficient fineness may often be introduced without such extra precautions.

Dr. H. McL. Evans, of this laboratory, has discovered a very important point in injecting bird and mammalian embryos after the heart beat becomes pronounced, which he has kindly allowed me to mention here. He finds that the fluid should be thrown into the vitelline or umbilical artery instead of a vein and forced in against the heart action. The result is a more complete injection than when the vein is used. His remarkably fine injections are made by Popoff's[3] method, which must be mentioned here as a very useful one.

[3]Popoff used a glass tube drawn out to a fine capillary point, and attached

With my method heating must be kept up, but with care, to make the injection complete. Diluted ink often gives more complete injections, better for study in oil.

Such specimens, which may be readily made by this method, should be demonstrated in every elementary course of embryology. (Doubtless embryos of small birds, as sparrows, could be also used, and the method could evidently be applied to lizard, snake and turtle embryos, etc., with ease.) Much younger chick embryos, from 30 to 40 hours, have been injected by this device, showing the great sensitiveness and delicacy of the method. Of course, older embryos of 3 to 7 days are injected without trouble, but embryos of the second, third and fourth days will be most useful for purposes of demonstration. These may be cleared and mounted entire in balsam; or, when the membranes and vitelline vessels have been removed, the embryo may be partially dissected to show the vessels of special regions. Thick sections are also very instructive.

Mammals.—It is not at all difficult to inject young mammalian embryos, as those of the rat or pig. When these are removed from the uterus to a warm slide, with membranes attached, the umbilical arteries are readily exposed and stretched between the embryo and its membranes under the binocular, and it is only necessary to exert slight tension by placing a small weight on the membranes, or catching them by clamp forceps, to insure success in introducing the point of the bulb. I have thus secured good early specimens of both rat and pig.

Miscellaneous.—Dr. Robert Retzer has applied the device to aid in an entirely different technical procedure, by using it to delicately distend a collapsed trophodermic vesicle of a very young mammalian (pig) ovum in the segmentation stage. The point of a bulb, filled with the same oil in which the vesicle lay after dehydration, was introduced into its cavity and a few drops gently expelled within the trophoderm until

to a rubber tube which he held in his mouth. The injecting pressure was obtained by blowing into the rubber tube.

This method has been found very valuable, but it seems probable that the method here described will prove more adaptable and more readily usable to many workers. The superiority of Dr. Evan's injections by Popoff's method or the similar ones which I have made with my own device is probably due largely to the use of diluted India ink.

See: Demetrius Popoff, "Die Dottersack-Gefässe des Huhnes," pp. 15-19. Wiesbaden, C. W. Kreidel's Verlag, 1894.

the creases and wrinkles disappeared with the distension, and thus a fine symmetrical specimen was secured for mounting entire.

Many other applications (to invertebrates, etc.) will doubtless be found for this device, the sensitiveness of which renders it especially adaptable to microscopic technique.

Advantages of the Method.

1. Less manipulative skill is required than with those methods depending on pressure from a column of fluid, a rubber bulb, or from the mouth.

2. No rubber tubes or other appendages interfere with free movement.

3. With the use of the jointed holder the maximum effort may be devoted to introducing the point into a vessel, while a minimum of attention is then demanded to applying the warmth.

4. Pressure is variable at will, and especially sensitively controllable.

5. Fluid does not run out until desired, if a fine point is used.

6. The amount of fluid is easily measured, so that a quantity as small as needed may be introduced into a vessel of a limited area.

7. The bulbs hold fluid well without evaporation, and the quantity is seen at a glance through the glass.

8. The apparatus is simple and easily made.

9. The tubes are very adaptable in size and shape to special conditions.

10. The tips are readily made of any degree of fineness.

BOOK REVIEWS.

Morris's Human Anatomy. Edited by Henry Morris and J. Playfair McMurrich. Fourth edition. P. Blakiston's Son & Co., 1907.

The general arrangement and scope of Morris's Anatomy are so well known, that a detailed account of this text-book is superfluous. It will suffice, therefore, to consider more particularly the new features presented by the latest edition.

The growing prominence of American anatomists as authors is emphasized by the list of colloborators of the work in question. Of the nine English contributors to the third edition, only four participated in the preparation of the present one, these being supplemented by seven new American contributors. The book, therefore, may justly claim an international character.

The influence of the notion held by some English teachers, that histology and embryology find their place with physiology rather than with anatomy—a divorce sanctioned by the original authors of Morris—is still apparent. The evident conviction of the editor and his American colleagues as to the necessity of presenting at least some of the developmental and structural data in the interests of an intelligent discussion of the anatomy of the human body, has led to the inclusion of many more references to embryology and histology than in previous editions. This departure is certainly to be welcomed as aiding to minimize the tendency of the student to regard histology and embryology as distinct branches and not, which they of course are, as integral parts of anatomy.

The editor has tempered the student's initial plunge into the minutiæ of the skeleton by a short introductory section devoted to a sketch of General Morphology, in which Professor McMurrich touches upon the cell and the germ layers, followed by an outline of metamerism and branchiomerism and of the basic plan of the body-tube and the limbs. These pages are full of suggestions for the thoughtful student, the only regret being that the sequence of events is not explained at somewhat greater length, since the tyro, perhaps, will be sometimes at a loss to correlate the several processes.

Section II, devoted to Osteology and revised by Professor Thompson, remains essentially as in the previous edition, with the exception of the changes necessitated by the adoption of the Basle nomenclature. Space for sixteen new illustrations has been made by judicious modification of the text. Further saving might have been secured by the transfer of the teeth and the ear ossicles and bony labyrinth from this section to the oral cavity and the ear respectively, where they belong.

The section dealing with the Articulations is one of the three divisions of the book which still retain the original authors. Mr. Morris is so identified with this special field of anatomy, that his contribution to the text-book bearing his name long ago became authoritative. The section in the new edition contains few changes and remains, as it always has been, one of the best in the book. Should we venture criticism, it would be to protest against the rigid adherence to systematic description, whereby undue prominence as distinct ligaments is given to bands, which sometimes in reality are so illy defined as to be made out only with uncertainty. A new feature in the present edition is the concluding paragraph under each joint, giving a summary of the muscles which act upon the particular articulation under discussion.

The tendencies to found human anatomy upon a sound and broad scientific basis are nowhere more strikingly displayed than in the descriptions of the muscular system as presented in some of the recent text-books. The time-honored topographical or functional grouping has given place to a subdivision more in accord with the relationship established by developmental and comparative studies. The occasional separation of adjacent muscles, or, at times, the association of those topographically remote, resulting from such classification, would be inconvenient for practical work, were it not for the fact that, in most cases, the dissection named, and not the systematic text-book, is the guide followed by the student in his laboratory exercises.

In breaking away from the customary grouping of the muscles followed in previous editions, Professor Bardeen has been influenced by the morphological relationships as revealed by embryonic development. Thus, the muscles of the head are first discussed and next those of the neck, for the reason that the musculature belonging primarily to the head later overlaps that of the neck. Following the latter, the muscles of the arm, of the back, of the thorax and abdomen and of the leg are considered in the foregoing order, since each succeeding group is to a greater or less degree overlaid by the extension of the preceding. Whether this classification is as satisfactory as one following more closely the subdivision of the myomeres, with the branchiomeric musculature recognized as a superimposed group, is debatable. It is, at any rate, a welcome advance over the time-honored arrangement.

While the detailed descriptions of the individual muscles have been retained—thereby continuing one of the excellent features of Morris—Dr. Bardeen has introduced each group with a sketch of its general relations, as to topography, fasciæ and bursæ. These sketches are useful to the student as a preparation for the details of the individual muscles. Another feature of value is the addition of numerous figures representing cross-sections at various levels. It is regrettable that the drawings have been so much reduced, since in some cases, notably in the sections of the forearm, their small size, together with the maze of leaders, is not conducive to clearness. The section closes with a useful exposition, in semi-tabular arrangement, of the muscles grouped according to function.

The section devoted to the Organs of Circulation has been revised, and indeed largely rewritten, by Professor Florence Sabin. This accomplished anatomist has contributed a clear, straightforward account of the heart and the blood-vessels, with due consideration of the more important variations. A somewhat fuller discussion and illustration of the development and fundamental plan of the vessels, especially of those of the limbs, would have afforded important hints as to the significance of the adult vessels and their variations. The illustrations representing the blood-vascular system have been increased by over a third. While the instructive diagrams by Walsham still retain their place, numerous additional figures from various authors supply a more realistic picturing of the blood-vessels. The atlases of Toldt and of Spalteholz have been largely drawn upon for these supplementary figures, which, with few exceptions, have suffered in the reproduction. It seems too bad that so excellent a text should not be honored by illustrations of more originality, or, at least, of greater technical merit.

The description of the lymphatic system in the present volume is a marked contrast to that in former editions, not only in its greater adequacy of text and illustrations, but also in the spirit in which it has been considered. Professor Sabin has been so conspicuously identified with the advances in our knowledge concerning the development of the lymphatics, that one turns with interest to the account of their formation. Having the courage of her convictions, it is natural that the author describes the lymphatics as direct outgrowths from the veins. The fact that the account was written prior to the appearance of the paper of Huntington and McClure explains the absence of reference to the conclusions of these authors.

The section pertaining to the Nervous System, contributed by Professor Hardesty, in one of the most satisfactory in the book. The description of the cerebro-spinal axis in particular exhibits the influence of the developmental and morphological data now dominating our conception, which contrasts so strongly with the view-point of a generation ago.

Following an introductory sketch of the fundamental units and the development of the nervous system, the spinal cord claims attention, excellent drawings of cross-sections at typical levels and a number of instructive diagrams giving additional value to the text. Less satisfactory is the schematic representation of the tracts of the cord, which, if it does not discourage by reason of its small size and complexity, will surely stimulate the application of the student.

The natural subdivision of the encephalon, based upon its general conformation and fibre paths, certainly warrants recognition of the brain-stem as one of the three chief parts of the brain; while, on developmental grounds, there seems no sufficient reason to ignore the independence of the mesencephalon and to include it with the cerebrum. It is to be regretted that Dr. Hardesty has not taken advantage of an opportunity to associate the terms, fore-brain, mid-brain and hind-brain with the primary cerebral vesicles, rather than to perpetuate the use of the awkward and unnecessary series of literally translated synonyms for the secondary vesicles. "Hind-brain," as the equivalent of the rhomencephalon, has much to recommend it over its restricted application to the metencephalon.

The anatomy of the brain-stem is well illustrated, a number of additional figures, based on Quain and Spalteholz, having been introduced by the author. Following the time-honored plan of discussing the central connections of the cranial nerves with the brain-stem, is, we believe, much less instructive for the average student than to impress these relations as an integral part of the description of the nerves themselves. Many will regret that Dr. Hardesty did not substitute some of his own admirable sketches of the cerebral hemispheres in place of those which appear, as, notwithstanding the authoritative endorsement "after Toldt," these leave much to be desired as accurate representations of the convolutions. The text on the brain is excellent and the descriptions of the fibre-tracts clear and up to date. The summary of the conduction paths will be appreciated as a most useful feature, affording, as it does, an instructive survey of the chief neurone-chains. The description of the peripheral nervous system is adequate, a number of illustrations, chiefly from Toldt and from Spalteholz, reinforcing the somewhat meagre series of the former editions.

In the section devoted to the Organs of Special Sense, Mr. Gunn retains the Eye, while Professor Kerr has assumed the revision of the Ear, the Tongue and the Nose. The description of the eye continues to be more from the standpoint of the ophthalmic surgeon, important as that is, than from that of the anatomist, and shows the influence of the tradition that histology has small place in a text-book of anatomy. It is, however, difficult to escape the conviction, that the student, reading for the first time the description of the organ of sight, would welcome a good picture of the retina.

Dr. Kerr contributes a brief but excellent account of the ear, including two interesting views of the tympanic cavity. A fuller description of Corti's organ, with its auditory cells, and an illustration definitely locating this important structure, might have utilized with advantage the blank half-page. The inclusion of the tongue among the sense organs implies emphasis of its relations to taste. It seems not unreasonable, therefore, that the reader should expect to find sufficient information to enable him to comprehend intelligently the structures concerned—the taste-buds and their gustatory cells. In his excellent description of the nose, Dr. Kerr seemingly accepts the assumed limitation of the olfactory area to the superior concha and the adjacent septum—a limitation by no means beyond question. In applying the term, hiatus semilunaris, to the groove, and not merely to the cleft leading into it, the confusion, for which the English anatomists are responsible, is continued.

In his revision of the Organs of Digestion, Professor Huber has supplied a most instructive section, in which developmental data, so necessary for an intelligent understanding of the adult conditions, receive due consideration. Perhaps, after all, the assumed "rotation" of the stomach during distention is not as positive as we once supposed. Notwithstanding the imposed restrictions, Dr. Huber has included sufficient reference to structure to enable the student to understand the organs described.

The section devoted to the Respiratory Organs, rewritten by Professor Terry, is particularly well balanced, the text, while to the point, being sufficiently comprehensive to afford more than a mere outline. The illustrations are well chosen and instructive.

The editor, Professor McMurrich, contributes the Uro-Genital System, and in his revision has exercised a discrimination, as to both text and illustrations, which has produced an admirable chapter. The statement, that during life the empty bladder possesses the T- or Y-shaped cavity, may be questioned; likewise, that the appendix epididymidis is a relic of the Müllerian duct.

The section discussing the Struceures of the Pelvic Floor is from the pen of Professor Thompson. It is, indeed, unusually complete and shows the influence of the elaborate German descriptions, which in many features it follows. The important conception of a pelvic diaphragm is emphasized, and, likewise, the relation of the "white-line" to the origin of the levator ani—a subject greatly confused in English text-books. It does seem regrettable that the term, endopelvic fascia, should be restricted by the BNA and, therefore, not have the wider significance so aptly suggested for it by Merkel.

Dr. Huber also contributes the section on the Ductless Glands, which is clear and conservative and includes enough structural and developmental data to afford a satisfactory account of the spleen, the suprarenal, thyroid, parathyroid and thymus bodies. It may be noted incidentally, that nowhere in the book is mention made of the coccygeal body, and one sentence, in connection with the carotid artery, is the only reference to the carotid body.

The descriptive part of the book is brought to a close by Dr. Kerr's excellent section on the Skin and Mammary Gland.

In accordance with the established plan of Morris, the practical applications are grouped in the final chapter, devoted to Surgical and Topographical Anatomy, by Mr. Jacobson. A number of changes bring the text up to date, which, so far as topographical relations are concerned, is very satisfactory. There are, however, many applications of anatomy to medicine, which, if of less particular concern to the surgeon, are none the less important for the practitioner. More of these might have been included with advantage.

The use of the Basle nomenclature makes this edition of Morris of particular interest. While the use of the terms in an Anglicized form was wise and, in fact, the only practical way of promoting their use by English-speaking students, the almost entire absence of the BNA names in their original form is an omission which seems unpardonable. To compel the student in search of the exact international form of a term to turn to other sources for this information, although possessing a recent text-book of over fifteen hundred pages, the avowed champion of the newer terminology, is certainly inconsistent.

The index is unusually satisfactory and, for the most part, free from the irritating multiplication of references. The possibility of obtaining the work in parts, either singly or as the complete set, will be appreciated by many.

The impressions of the new Morris as a whole may be summarized: As a description of gross anatomy the text is excellent and up to date, but in places too incomplete to afford an adequate presentation of the subject under discussion, unless supplemented by reference to other books. The illustrations are strikingly inharmonious. The numerous cuts copied from other sources, especially those from Toldt and from Spalteholz, have been reproduced, in many cases, with indifferent success and, too often, are distinctly inferior to the originals. Notwithstanding these defects, the editor and his collaborators are to be congratulated on the marked improvement of the new edition over the previous ones. In its revised form Morris will resume its honored place among the foremost text-books of anatomy.

George A. Piersol.

EVOLUTION OF MAMMALIAN MOLAR TEETH to and from the Triangular Type, including collected and revised researches on Trituberculy and new sections on the forms and homologies of the molar teeth in the different orders of mammals. By HENRY FAIRFIELD OSBORN, Sc.D., LL.D., D.Sc., edited by W. K. Gregory, M.A. New York: The Macmillan Company, 1907. Pp. i-ix + 1-250, including bibliography, with 215 figures in the text.

The question of the evolution of the mammalian molar teeth is one which has interested comparative anatomists for many years, and it is with great interest that the present work on this subject has been received. The work is essentially a technical one, intended for the very advanced student or for the specialist, since one who has had no great amount of training would be able to appreciate the book. The author's object in gathering together his scattered essays on the subject of the evolution of teeth is to present the subject more fully to those who do not accept the tritubercular origin for the mammalian molar. He claims that this disbelief is due partly to misunderstanding, but "chiefly to the fact that some of the most decisive and convincing paleontological evidence in support of the theory has not been clearly advanced."

The book is conveniently divided into ten chapters, the first five of which are taken up with quotations and comments by the editor and author from the author's original essays published between 1887 and 1907. The sixth chapter is devoted to a discussion of the geological succession of molar types. Chapter seven gives the types of molars found in the different orders of mammals. Chapter eight deals with the evolution of the premolars, and is in a way a digression from the main object of the book. Chapter nine was written by the editor and is given up to a critical review of the objections to the theory of the tritubercular origin of the mammalian molar and to a discussion of other theories. Chapter ten is another digression entitled "Rectigradations in the Teeth."

The beginning student will find the work of little or no value to him, since there has been no attempt to make the book useful to that class of students. It is intended primarily for the specialist. One searches in vain for a figure to give a definite idea as to what all of the various cones, protocones, metacones, metalophs, etc., really are in the teeth of such an animal as a common dog or the horse. The author has presupposed that his readers are nearly as well acquainted with the subject as he is himself. This will cause the book to be of less value than it might have been.

The theory of the tritubercular origin of the molar teeth of mammals was first proposed by Professor E. D. Cope in 1883, but during the time in which he wrote on the subject he confined himself to a discussion of the early forms from the lower Eocene. Later the subject was taken up by Dr. Osborn, and it was carried by him through successive stages of the geological development of mammals. Cope was first led to a consideration of the theory by observing that in the mammals from the Puerco Eocene the molars almost universally consisted of three cusps. The main cusp Cope postulated as the primitive reptilian cusp, and it has been named by Dr. Osborn the protocone. The lateral cusps arose as outgrowths from the sides of the protocone, and are known respectively as the paracone and the metacone. From this simple three cusped type of molar Dr. Osborn has traced homologies through nearly all of the orders of mammals. Opposed to this theory is the one advanced by Ameghino that the tritubercular tooth arose by the fusion of three reptilian cones. This is known as the concrescence theory.

Students of zoölogy will be grateful to the author of the volume for inserting the outline of the classification of the mammals, which includes the living as well as the extinct forms. The table of classification covers six pages, and it gives the latest results of the work of the author on the relationship of the various orders of mammals. On page 17 is given a diagram showing the stratigraphy of the mammal horizons of North America in their probable relations to each other.

The author was first led to a critical study of the tritubercular theory through his studies on the Mesozoic mammals, which have, for the most part, tritubercular teeth. The first chapter of the book is given up to a discussion of the molars of these Mesozoic mammals, and the original figures published by the author are reproduced here. The next chapter is given up to a general discussion of the development of the mammalian molar from the primitive tritubercular tooth, or, rather, from the primitive single reptilian cone, which is postulated but is not known. A definite system of nomenclature is proposed for the various cones of the teeth. The primitive cone is named the protocone, and additional cusps are given names which distinguish their order of appearance or their position. To the names of the cusps of the teeth of the lower jaw the suffix *id* is attached. For instance, protoconid is the primitive reptilian cone of the lower jaw teeth. The author expresses the hope that the nomenclature will be retained, even if the theory is rejected, since the confusion which would result from another system of names would then be avoided.

In the third chapter the author gives a discussion of the molars of primates, which he has studied from the point of view of the tritubercular theory. He is able to trace definite homologies in the teeth of the primates with the molars of more generalized mammals. The principles of the theory are here repeated in detail and some space is given to a discussion of the manner of origin of the alternate cusps of the upper and lower jaws. In the following chapter a discussion of the molars of ungulates is taken up and new terms are proposed for the various types of ridges and cusps which the molars of these mammals exhibit. The ridges are spoken of as *lophs* and we have the terms protoloph, metaloph, etc., with the same meanings attached to the terms as in the case of the more simple molars. The fifth chapter includes a revised outline of what has been given in the preceding chapters.

In chapter six is given a very interesting and instructive discussion of the chronological distribution of molar types. The author agrees with most paleontologists that the Theriodontia were ancestral, or nearly so, to the mammals, and includes in his discussion of the molars the teeth of the theriodonts. The different reptiles described exhibit molar types which vary from the protodont or single cusp to the multitubercular type in Tritylodon, although Dr. Broom has recently claimed that Tritylodon is a true mammal.

The next ninety-two pages of the book will undoubtedly prove to be of most value to the zoölogical student, since in these pages is given a discussion of the types of molars found in the various orders of mammals with the various cusps and ridges identified according to the tritubercular theory. There is only one thing that can tend to lessen the value of the work, and that is that the forms discussed are extinct. Little or nothing is said about the molars of living mammals. This part of the book is, however, a decided advance over anything we have in the literature on mammals. There is an abundance of good illustrations showing the various types assumed by the different orders of mammals.

The chapter on the evolution of the premolars is based on the work of the author and on that of Dr. W. B. Scott. The evolution of the premolars differs from that of the molars in that the premolars of the upper and lower jaw do not seem to have followed the same line of evolution, although the form of tooth is not greatly different in the upper and the lower jaws. The same terminology may be applied to the cusps of the premolars as to the molars, although this has been disputed by some.

The remainder of the book, with the exception of a very few pages, is taken up by the editor in a discussion of the objections and difficulties in the tritubercular theory and a statement of the other theories for the evolution of the mammalian molar teeth. The editor is quite fair and candid in his statements, and one readily perceives that he has not allowed himself to be prejudiced by his belief in the tritubercular theory. His statement of the other theories is quite fair and just. The theories in opposition to the tritubercular theory which have been advanced are the plexodont or concrescence theory first put forth by Ameghino, the embryological theory advanced by Taeker, Röse and others, and an entirely different interpretation of the elements of the tritubercular teeth of the Jurassic mammals as restudied by Dr. J. W. Gidley. The concresence theory is dismissed at once because there seems to be no basis to support it. The embryological theory is given more consideration, and it differs from the theory outlined by Osborn in the different ages assigned to the various cusps. According to ontogeny, the paracone of the upper molars of Osborn arises earlier than the protocone. Gidley's restudy of the Jurassic mammals would seem to confirm the results obtained by the embryologists, and it may make necessary a revision of the tritubercular theory.

The work as a whole is an excellent one. The illustrations are good, with the exception of those on page 43. The proofreading has been well done, since there are but few typographical errors. The bibliography in the back will be useful. The book is well indexed and it cannot but be of much service to those interested in the development of the higher animals.

Roy L. Moodie.

A TEXT-BOOK OF SURGICAL ANATOMY. BY W. F. CAMPBELL. Octavo of 675 pages and 319 illustrations. $6.00 in cloth, $6.50 in half morocco. W. B. Saunders Company, Philadelphia and London, 1908.

According to the author "the single purpose of this book is to aid the student and practitioner in mastering the essentials of practical anatomy," and in many respects the work is well calculated to accomplish this end. While lacking the cyclopedic fulness of many treatises on the subject, it must, nevertheless, in its own class, take high rank for the amount of valuable material presented and the manner in which it has been treated. Surgically we find it very complete and practical, the exposition clear and to the point, and those for whom it is intended will miss little of practical importance, although a somewhat fuller and more detailed treatment of certain topics, e. g., the eye and particularly central nervous system would have enhanced the value of these important chapters. Fortunately the writer is a teacher of anatomy, and his knowledge of the subject has enabled him to produce a work of corresponding anatomical accuracy upon which the practitioner can rely and in which the treatment of questions of pure anatomy is quite refreshing when compared with that of certain other text-books on the same subject. He has introduced a large amount of descriptive material on the more important regions, to which are added many well-chosen and instructive illustrations. Not only has normal anatomy in so far as it concerns the student been handled most commendably, but those variations and abnormalities which are of surgical or medical interest have received rather extensive attention.

Why he should repeatedly use the expressions "infraorbital notch" and "lymphatic ganglia" we do not understand. He speaks of the posterior border of the lesser wing of the sphenoid as being in relation with the Sylvian fissure where he should have been more explicit as to what part of the fissure was meant. In speaking of the escape of cerebrospinal fluid from the ear he fails to note the character and location of the lesions upon which rests the possibility of such escape. The location given to the Gasserian ganglion is quite conventional if not erroneous, and in this respect he differs in no wise from the majority of the standard works on anatomy. The ganglion in no sense occupies the impressio trigemini which is far smaller than the ganglion, lodging simply the two roots of the nerve as they pass beneath the sup. petrosal sinus. The ganglion itself is roughly crescentic in shape (g. similunare), placed almost in a sagittal plane, being in relation, from behind forward, with the anterior surface of the tip of the petrous portion of the temporal bone, with the internal carotid artery as it leaves the temporal bone to enter the cranial cavity and with the base of the great wing of the sphenoid.

On the whole, there is little to detract from the practical value of the book, while the extent of the field covered, the mass of anatomical and surgical facts brought together in a concise and orderly manner and properly correlated, and the clear and terse treatment accorded each commend it to the profession most favorably.

N. W. Ingalls.

CONTRIBUTIONS FROM THE ANATOMICAL LABORATORY OF THE UNIVERSITY OF WISCONSIN. Volume III, 1906-1907. Madison, 1908.

This volume contains the reprints of eleven papers published by the various members of the Anatomical Staff of the University of Wisconsin during the years 1906-1907. Professor W. S. Miller, whose previous work on the lung has made him an authority upon this subject, contributes four papers dealing chiefly with the bronchial blood-vessels and the vascular supply of the pleura pulmonalis. Dr. B. M. Allen, also continuing the line of his previous investigations, adds three papers on the development of the sex-cells in Chrysemys and Rana pipiens. A paper on the pancreatic ducts in the cat is contributed by G. J. Heuer, and one on the pyloric cæca of the Centrarchidæ by R. H. Johnson. Professor C. R. Bardeen has two papers, the first of which concerns the abnormal development of the toad ova when fertilized by spermatozoa exposed to the Roentgen rays. The second paper is a continuation of his valuable studies in the field of human embryology. It includes a comprehensive and detailed account of the development and variation of the nerves and musculature of the lower extremity. Lack of space prevents an adequate review of the foregoing papers, which constitute an admirable series.

This plan of bringing together into a series of volumes the scattered publications from an individual laboratory is growing in favor and deserves hearty commendation. It demonstrates in a concrete form the work actually accomplished by each laboratory, and encourages the members of the staff to keep up and improve the pace once set. It also acts by example as a wholesome stimulus to other laboratories, and thus tends to increase the amount of productive scholarship.

C. M. Jackson.

NOTES AND APPOINTMENTS.

Professor A. G. Pohlman has been promoted from junior professor to professor of anatomy in the University of Indiana.

Professor H. D. Senior, M.B., F.R.C.S., formerly associate professor of anatomy in the College of Medicine of Syracuse University, has been appointed professor.

Professor Charles Sedgwick Minot, of Harvard University, was elected a corresponding member of the Vienna Physico-Medical Society at its centenary celebration on June 27th.

Dr. Charles V. Morrill, A.M., formerly assistant in zoölogy in Columbia University, New York City, has been appointed lecturer on histology and embryology in Syracuse University.

Mr. Henry Lomb, one of the founders of the Bausch & Lomb Optical Company, died on June 13, at the age of eighty years. Mr. Lomb, through the company, has rendered valuable service to science in this country by the making of scientific instruments.

In the anatomical department of the University of Chicago Professor B. H. Harvey has been promoted from instructor to assistant professor, and Dr. E. G. Kirk has been promoted from associate to instructor. Three assistants in anatomy have also been appointed—Dr. Ralph E. Sheldon, Mr. James Patterson and Mr. Elbert Clark.

Dr. Herbert McLean Evans, S.B. University of California and M.D. Johns Hopkins University, has been appointed assistant in anatomy in the Johns Hopkins Medical School. Dr. Evans has carried on research work as a medical student in connection with vascular problems. He has made extensive studies on the blood-vessels of the intestine; his remarkable injections of embryos have been demonstrated at the recent meetings of the Anatomical Association; he has made valuable studies of the blood supply of the para-thyroid glands, and has contributed to our knowledge of the lymphatic system, both in the normal intestine and especially in connection with the growth of lymphatics in a sarcoma of the intestine.

The facilities for summer work in anatomy at Wood's Hole have attracted a relatively large number of the members of the Association of American Anatomists this year. The following list will give an idea of the variety of workers in this group, and will suggest how stimulating are the associations to be found at this biological center, where members of so many universities are together. At the Marine Biological Laboratory are: Dr. C. M. Jackson, professor of anatomy, University of Missouri; Dr. W. H. Lewis, associate professor of anatomy, Johns Hopkins University; Dr. H. McE. Knower, associate in anatomy, Johns Hopkins University; Dr. H. Mc.L. Evans, assistant in anatomy, Johns Hopkins University; Dr. E. G. Conklin, professor of zoölogy, Princeton University; Dr. T. H. Morgan, professor of experimental zoölogy, Columbia University; Dr. F. R. Lillie, professor of embryology, University of Chicago; Dr. Leo Loeb, assistant professor of experimental pathology, University of Pennsylvania; Dr. H. E. Jordan, adjunct professor in anatomy, University of Virginia; Dr. R. E. Sheldon, assistant in anatomy, University of Chicago.

Besides this list five others should be mentioned because, though not members of the association, they all hold teaching positions in departments of anatomy: Dr. C. R. Stockard of the Cornell Medical School, Dr. O. S. Strong of Columbia University, Dr. A. M. Miller of Syracuse University, Dr. C. V. Morrill, and Dr. G. G. Scott of the College of the City of New York. Messrs. Spencer, Rand and Halsted are at the Marine Biological Laboratory taking courses in comparative embryology and zoölogy supplementary to their medical school work. Dr. G. H. Parker, professor of anatomy at Harvard University, is working at the United States Fish Commission Laboratory.

The establishing of a department in psychiatry at the Johns Hopkins University and the appointment of Professor Adolph Meyer, M.D., LL.D., as its director, is a matter of great importance. The department and the necessary hospital ward have been made possible through the generosity of Mr. Phipps, of Philadelphia.

Professor Meyer, who is well known as the leading psychiatrist in the country, is at present director of the Pathological Institute of the New

York State Hospitals and professor of psychiatry of the Cornell Medical School. He took his medical degree at the University of Zurich in 1892. From 1892 to 1895 he was honorary fellow and docent in the University of Chicago; from 1893 to 1895 pathologist to the Illinois Eastern Hospital, and from 1895 to 1902 pathologist and director of clinical and laboratory work in the Worcester Insane Hospital and docent at Clark University. In 1901 he received the degree of LL.D. from the University of Glasgow. The importance and the great scope of his position in connection with the New York State Hospitals indicate the value of his work, and the Johns Hopkins University is to be congratulated on the addition of Professor Meyer to its faculty.

The establishing of the department of neurology at the Wistar Institute three years ago marked a great advance in neurological research; it was a recognition of the facts, so ably brought out by the late Professor His, of the great difficulty of obtaining and preparing neurological material for investigation, and the imperative need for co-operation in the long and difficult problems. This work could not have received a greater impetus than through the appointment of Professor Meyer in a department where the opportunities for research will be ample. It is needless to say that the connection of psychiatry with the fundamental branches of neurology, neuro-physiology and neuro-pathology is as yet an almost unbroken field. Professor Meyer's conception of the importance of these fundamental branches and his contributions to their development make one sure of a great department under his leadership.

Among the important events of the year is the reorganization of the department of anatomy in the Northwestern Medical School in Chicago. Professor Arthur W. Meyer, S.B. University of Wisconsin and M.D. Johns Hopkins University, has been appointed professor of anatomy, and will have full charge of the department and its reorganization. Professor Meyer was assistant and instructor in anatomy in the Johns Hopkins University during the years 1905 to 1907. For the past year he has been assistant professor of anatomy at the University of Minnesota. His marked ability as a teacher and his success in research work make his appointment a most wise one. Dr. Meyer will himself take charge of the gross anatomy, with assistants who are yet to be appointed.

The histology and embryology will be given by Professor C. W. Prentiss, Ph.D., formerly of Harvard University, now of the Washington

(State) University, who has been appointed assistant professor in anatomy. He will be assisted by Dr. S. Walter Ranson, Ph.D. University of Chicago, and M.D. Rush Medical College, who becomes associate in anatomy. Dr. Ranson will have charge of the neurology. Dr. F. W. Thyng, Ph.D., who has been the Austin teaching fellow at the Harvard Medical School and has had charge of the courses in biology at Tufts College this last year, will go to the Northwestern as an assistant. His research is familiar to the readers of the American Journal of Anatomy. There will be two demonstrators, Mr. M. R. Chase and Mr. N. Alcock, both of whom have taken the Master's degree in biology at the Northwestern University.

Through the influence of Dr. C. A. Wood and Dr. Frank Allport a special laboratory has been established for the study of the histology and pathology of the eye and ear. This laboratory, which marks still another important step, will be under the charge of Dr. E. P. Carlton, a graduate of the University of Wisconsin and of the Northwestern University Medical School. The university has made a liberal appropriation for the department and has been most generous, not only toward the staff, but also in providing adequate equipment and increased library facilities. The appointments to the new department are significant, indicating, as they do, the development of the spirit of research in anatomy in the West. They also show the broadmindedness of those in authority and their desire to place anatomy on a much higher plane. These changes bring the department at the Northwestern University in line with all the leading medical schools where special emphasis is laid on research. Professor Meyer's position at the University of Minnesota has not yet been filled.

THE ANATOMICAL RECORD

Vol. II. SEPTEMBER, 1908 No. 6

A Note on the Presence or Absence of the Glosso-Pharyngeal Nerve in Myxinoids*

BY

J. B. JOHNSTON.

University of Minnesota.

In the course of studies on the morphology of the head in vertebrates I have been much interested in the interpretation of the vagus. The explanation of this as a collection of several true branchial nerves (Johnston, 1905) required some special modification to fit the case of the myxinoids, in which according to earlier writers the IX and X nerves are united. This condition was met by supposing that the process of collecting the branchial nerves, as it proceeded from behind forward, went a step further in myxinoids than it has in gnathostomes, and so carried the whole series of (IX and X) branchial nerves into a single complex.

This view has always seemed to me somewhat strained, but the facts necessary for a more natural explanation were not available until later. The facts referred to concern the disappearance of gills in the cephalic part of the series. This, indeed, was referred to in my paper on the morphology of the head (1905, p. 191), but the meager account by Price (1896) did not lead me to see its bearing on the question of the IX nerve, especially since Price expressed the opinion that as many as twenty-three or twenty-four gills had disappeared.

My remarks on the disappearance of gills in Bdellostoma have been seriously criticised by Stockard (1906, p. 487), who says: "Price, working with a limited supply of material, made the mistake of supposing that a great number of gill pouches appear during development, possibly

*Neurological Studies, University of Minnesota, No. 7.

as many as thirty-five. Of these, he thought the posterior ten or fourteen develop into the gills of the adult, while the others entirely disappear. Dean corrected this statement when he found a shifting and not a closing of the gills to take place; and Price, in a subsequent paper on the development of the excretory organs of Bdellostoma, based on a more complete series of embryos, has corrected his former statement and accepted Dean's interpretation on this point. Notwithstanding these corrections, Price's original idea has since been utilized by Ayers and Jackson, '00, who try to account for the atrophy of the forward gills as due to the enormous development of the 'club-muscle' in that area. Johnston, '05, also quotes Price's earlier conclusion and states his belief that there is a reduction of the anterior gills on account of the parasitic life of this animal. It has been clearly shown, however, by Howes, '91; Ayers, '93; Jordan and Everman, '96, and Worthington, '05, that these animals are not parasitic but predaceous, attacking disabled fishes. Therefore Johnston's explanation will not suffice. Since, also, there are no forward gills lost, we must accept the position that the gills belonged originally to the head region, and owe their extension into the trunk to the shifting forward of trunk myotomes into the occipital region, the view, by the way, which Johnston rejected in favor of his explanation cited above."

With regard to this criticism it may be said, first, that it is by no means clear that Stockard is warranted in invoking the shifting of myotomes to explain the shifting of gills in myxinoids. Because shifting forward of trunk myotomes into the head has been observed in gnathostomes, and because this affects the relative position of gills and other organs, it does not follow that this will explain the position of gills in myxinoids. In gnathostomes the shifting forward of trunk myotomes is largely due to the abortion of head myotomes, due in turn to the formation of a rigid cranium. In myxinoids this cause for shifting forward of trunk myotomes is not present. Until we have positive evidence on this point, we may assume that in myxinoids, as in Petromyzon (Neal, 1897; Koltzoff, 1902), all the cranial myotomes remain throughout life. The postotic myotomes probably reach forward as in Petromyzon above and below the orbit into the wall of the buccal funnel, and on this account there may be some shifting forward of trunk myotomes. But that the shifting due to this could possibly account for the adult position of the gills in Bdellostoma, no one can be asked to believe. The shifting backward of gills with reference to myotomes and spinal nerves amounts to something like fourteen trunk segments and a long prebranchial pharynx is formed between the mouth and gills. Yet there is no shoving together or telescoping in the postotic region such as occurs in gnathostomes, no fusion of vertebræ with the skull, no abortion of postotic myotomes. Neither is there any shifting or loss of dorsal nerve roots such as occurs in gnathostomes (Worthington, 1905a, for Bdellostoma; compare for Petromyzon, Johnston, 1905a). There is a translocation backward of the gills in relation to the myotomes, nerves, etc., without any shortening, crowding or telescoping of the latter structures. Indeed, when Stockard comes to describe the shifting of the gills (p. 510) he says nothing of shifting of myotomes, but describes a region of great growth between the second thyroidean gill (third gill behind the mouth) and the following ones. This great growth affects both dorsal musculature and pharynx. The growth of the dorsal part of the neck carries the head forward around the egg and the growth of the pharynx leaves a space between the third and following gills. In this space ventrally the large club muscle develops, and Stockard admits it as a factor in causing the translocation of the gills.. The shifting of the gills, then, is due to a great growth and extension of the neck which, in Stockard's phrase, "leaves the gills behind" in the trunk. In brief, what Stockard's account of the development shows is that during the ontogeny there occurs a translocation of parts to bring about an adult condition the two main features of which are the position of the gills far back in the body and the presence of the large club muscle in front of the gills. These features, I assume, are adaptations to the mode of life of the animal. The club muscle serves to move the "tongue" in rasping off the flesh of fishes, the gills being placed far back enables the animal to bury its head in a fish and still breathe while eating. In my paper which Stockard criticises I was covering an enormously wide field and making every possible effort to be brief. On that account I attempted to express the above explanation of the position of the gills by referring to the "parasitic life of the animal." The explanation still seems to me wholly just. The use of the word "parasitic" was a slip of the pen, as I was well aware of the habits of these animals. The morphological considerations are in no way affected by substituting the word "predaceous," since it is quite as necessary for a Bdellostoma to breathe while he is eating a "disabled" fish as if he were dining daily at the expense of a permanent host.

Second, Stockard's statement, "since, also, there are no forward gills lost," is inconsistent with his description (p. 498-504) of the growth, reduction and disappearance of the hyomandibular and two post-hyomandibular or thyroidean gills. His concluding paragraph on this point reads: "The three following gills, hyomandibular and the two thyroidean, undergo a distinct retrogressive development; in the young embryo they are the most advanced elements of the entire gill series; they then gradually degenerate and in late stages become entirely lost."

Stockard's excellent work, confirming and supplementing Dean's study of entire embryos, makes clear, therefore, that Bdellostoma stouti has sixteen gills behind the mouth, that the cephalic three of these disappear and that the caudal thirteen are carried back into the trunk region. It has been shown by Ayers (1894) and by Worthington (1905) that the number of gills varies in different species of Bdellostoma between seven and thirteen or fourteen. Miss Worthington has brought out two further important facts with regard to the Californian species, the same as studied by Stockard. In this species the number of gills varies between individuals, and also the rudimentary or missing gills sometimes occur at the cephalic end of the series. From all of which it would appear that Price was wrong chiefly in the large number of gills which he thought disappeared from the cephalic end of the series. That I followed Price's earlier paper was due to the facts that my 1905 paper was sent to the publisher on October 25, 1904, while Price's second paper was not published until December, 1904. While my paper was awaiting publication I was in Europe, where the American Journal of Anatomy was not to be seen.

Since the hyomandibular and two following gills disappear in Bdellostoma it might be expected that their nerves would be greatly reduced or absent. Miss Worthington's (1905a) description of the facial nerve would seem to support this view, since she described the nerve as composed of motor fibers to the muscles of the hyoid arch and of communis components distributed to the skin of the region of the fourth tentacle. We may suppose that these communis fibers supply taste buds. Sensory fibers to the wall of the pharynx are not mentioned.

The main purpose of this note is to point out that the loss of the post-hyomandibular gills has probably resulted in the reduction or disappearance of the IX nerve. If so, the supposition previously made that the process of collecting branchial nerves had gone on forward in the myxinoids until the vagus had joined the glossopharyngeus would be superfluous.

Fürbringer (1897, p. 624) argues that the ramus pharyngeus of the vagus contains the representative of the glossopharyngeus. J. Müller had considered this as the IX nerve and, so far as I know, it is generally so treated.

Miss Worthington (1905a) gives the fullest description of the origin, course and distribution of this nerve that I have seen. In Bdellostoma Dombeyi Loc. it arises by several mixed roots which are the most cephalic of the IX-X series. It passes out of the cranium through a foramen in common with X, undergoes interchange of fibers with X outside the cranium, is bound up in the same sheath with X until it reaches a point opposite the second permanent gill arch, then separates and innervates "the side of the pharynx near the end of the backward position of the second branchial arch." Since two post-hyomandibular gills have disappeared (Miss Worthington and Stockard both worked on the Californian species) the above description shows that the nerve innervates the side of the pharynx three branchial segments caudal to the area of distribution of the post-trematic ramus of the IX nerve in gnathostomes or petromyzonts. This, taken in connection with its intimate relation with the X nerve in its origin and course, can lead to only one plausible conclusion, namely, that this nerve in the Californian species is in reality only a pharyngeal ramus of the X nerve.

The descriptions by Fürbringer seem to show a different condition in some other species. The nerve in question may separate from the X nerve at or soon after its exit from the foramen. In Bdellostoma bischoffi this ramus innervates the greater part of the pre-branchial pharynx and reaches nearly to the first gill sac. In Bdellostoma stouti this ramus extends over only the first half or two-thirds of the pre-branchial pharynx. Since Fürbringer's B. stouti is in all probability the same species as Miss Worthington used, Fürbringer seems to have described a ramus not seen by Miss Worthington. Fürbringer concludes: " . . . , bin ich geneigt, den Ram. pharyngeus Vagi als einen Nerven anzusehen, dessen Grundstock dem N. glossopharyngeus der höheren Wirbelthiere entspricht, dem sich aber auch eine mässige Anzahl von Vaguszweigen einstmals branchialer Natur angeschlossen hat."

After the disappearance of the two post-hyomandibular gills the only visceral structures requiring innervation in the territory of the glossopharyngeus and first division of the vagus are the muscles and mucosa of the slender pre-branchial pharynx. An objection to Fürbringer's conclusion is that one can scarcely see any reason for the union of the rudimentary IX nerve with the X, when at an early stage of development the persistent gills are carried so far apart from the gill of the glossopharyngeal segment, which aborts *in situ.* We should rather expect the IX and X nerves to diverge widely and to maintain their distinct foramina.

Since two gill sacs following the hyomandibular have aborted, the first branchial division of the vagus must be reduced as well as the glossopharyngeus. Therefore, of the "IX-X complex" in myxinoids, the first two segmental units are necessarily very small if not absent. It is very evident from its course and innervation territory that the nerve described by Miss Worthington has no resemblance to a true N. glossopharyngeus. Unless she has overlooked a separate nerve, I am of the opinion that the glossopharyngeus is absent in the animals studied. In the forms described by Fürbringer from dissections we cannot come to a definite conclusion until we have histological and embryological studies, including the tracing of nerve components. In particular it is very desirable to know the facts regarding cutaneous components which are present in both the facialis and glossopharyngeus in petromyzonts (Johnston, 1905a). The most probable view at present is that the pharyngeal ramus in question represents part of the first or second division of the vagus. The visceral sensory component may represent the r. pharyngeus of X1 and possibly X2. The motor component may be the remnant of the post-trematic ramus of X1. The reasons for this may be summarized as follows:

1. The reduction of both IX and X1.

2. The improbability of union of IX and X owing to shifting of the gills.

3. The close union of the pharyngeal ramus in question with the X nerve.

4. The numerous instances in which one nerve has taken over the innervation territory of another; trigeminus, r. palatinus VII, etc.

The bearing of this on the supposition that a gill arch has been lost in the gnathostomes must not be overlooked. I have shown elsewhere (1905) that the arguments formerly made in favor of a lost gill fall to the ground when the question is considered from the standpoint of the nerve relations. Now that it has been clearly shown that gill slits are lost in myxinoids between the mouth and the persistent gills, this fact may be taken by some to support the hypothesis that a gill has been lost in gnathostomes. But the fact that two gills abort in myxinoids is not in itself good evidence that any do so in gnathostomes. The abortion of the forward gills and shifting back of others in myxinoids finds a natural explanation in the habits of the animals. As pointed out above, the most simple and direct conclusion to be drawn from this is that the loss of the gills has been followed by the loss of the IX nerve as well. In all gnathostomes, however, the IX nerve is present. The conditions in myxinoids are, therefore, peculiar and do not lend support to the view that a gill has been lost in the middle of the series in gnathostomes.

It should, of course, be understood that by placing the terms myxinoids and gnathostomes in contrast I do not mean to express any opinion regarding the relations of these groups. I have always regarded the cyclostomes as primitive forms and am in thorough sympathy with the modern view, which compares the so-called tongue with the lower jaw of gnathostomes. On the other hand, although primitive, the cyclostomes do not stand in the direct line of evolution of gnathostomes, and the loss of gills at the cephalic end of the series and of part or all of the IX and first division of the X nerve may prove to be among their most striking peculiarities.

PAPERS CITED.

AYERS, 1894. Bdellostoma Dombeyi Loc. Woods Holl Lectures for 1893.

DEAN, 1899. On the Embryology of Bdellostoma stouti. v. Kupffer's Festschrift.

FÜRBRINGER, M., 1897. Ueber die Spino-occipitalen Nerven, etc. Gegenbaur's Festschrift.

JOHNSTON, 1905. The Morphology of the Vertebrate Head from the Viewpoint of the Functional Divisions of the Nervous System. Jour. Comp. Neurol. and Psychol., Vol. 15.

1905a. The Cranial Nerve Components of Petromyzon. Morph. Jahrb., Bd. 34.

KOLTZOFF, 1902. Entwickelungsgeschichte des Kopfes von Petromyzon Planeri. Bull. Soc. Imp. d. Natural. d. Moscou, Année 1901.

NEAL, 1897. The Development of the Hypoglossus Musculature in Petromyzon and Squalus. Anat. Anz., Bd. 13.

PRICE, 1896. Some Points in the Development of a Myxinoid (Bdellostoma stouti Loc.). Vhdlg. Anat. Ges., 10 Vers., Berlin, 1896.

STOCKARD, 1906. The Development of the Mouth and Gills in Bdellostoma stouti. Amer. Jour. of Anat., Vol. 5.

WORTHINGTON, 1905. Contribution to our Knowledge of the Myxinoids. Amer. Naturalist, Vol. 39.

1905a. The Descriptive Anatomy of the Brain and Cranial Nerves of Bdellostoma Dombeyi. Q. J. M. S., Vol. 49.

A Note on the Occurrence of Mitoses in the Corpus Luteum of the Guinea-Pig.

BY

LEO LOEB.

From the Laboratory of Experimental Pathology, University of Pennsylvania.

According to Sobotta the corpus luteum of the rabbit and of the mouse is produced through an enlargement of the granulosa cells without an increase in the number of these cells. According to this author mitoses are only found in the endothelial cells of the capillaries which invade the granulosa from the theca interna and externa. In the guinea-pig, on the other hand, I described[1] the occurrence of mitoses in granulosa cells 11-18 hours after copulation. Twenty-six hours after copulation and later we see mitoses in spindle cells which immigrate into the granulosa. Between 30 and 40 hours we observe mitoses in the newly formed cell tubes (capillaries) of the corpus luteum; and in spindle-shaped cells which do not distinctly belong to the cell tubes, but are probably immigrated connective tissue cells. Mitoses are also found in cells which lie in close approximation to the cell tubes, and it is quite possible that some of these latter cells are lutein cells, although it cannot be stated with certainty at this stage of the development of the corpus luteum. This is due to the fact that sometimes the endothelial cells change their position somewhat during mitotic division; they may protrude toward the lumen of the cell tubes as well as towards the outer side. But it is at least very likely that the cells which are situated between capillaries and in which mitoses are observed, from the second to the fifth day after copulation, are, in many cases, lutein cells. Since my earlier observations were published I have had the opportunity of examining a large number of

[1]Anatomischer Anzeiger, 28 Band, 1906, and Jour. Amer. Med. Assoc., 1906. Quite recently there appeared a note by Regaud and Debreuil (C. R. Soc. Biol., T. 54, No. 1908), in which these investigators report the occurrence of mitoses in the corpus luteum of the rabbit during the last week of pregnancy, just preceding the degeneration of the corpus luteum. They assume that in this case the mitoses are not a sign of active cell proliferation, but that they represent the first stage of decline of the corpus luteum. As will be shown in this note, the conditions are different in the guinea-pig.

corpora lutea of the guinea-pig at later stages of development; and I found that it is a very common occurrence to find cells which are undoubtedly lutein cells in mitotic division. Ten to twenty-four days after copulation, or even at later periods, it is frequently possible to observe a very large number of mitoses in corpora lutea either with or without a co-existing pregnancy. Monasters are seen in the majority of cases, but often we see well-developed diasters and sometimes we observe the later stages of mitotic division, and there is no doubt that the nuclear division is followed by cell division. That this is always the case cannot be maintained. It occasionally appears as if a dispersion of the chromosomes takes place, leading, perhaps, to a subsequent degeneration of the cells. However this may be, it can be stated that in the corpus luteum of the guinea-pig, with or without an accompanying pregnancy, mitoses are frequently found at various stages of its development, and that in a certain number of cases at least the mitotic nuclear division is followed by multiplication of the lutein cells.

A New Thermo-Regulator.

BY

M. J. GREENMAN.

The Wistar Institute of Anatomy and Biology.

Referring to Fig. 1, A is a steel tube 14″ long and 3/4″ internal diameter, closed at the lower end. This tube is filled with mercury and screwed tightly into the body of the regulator B. The gas passages through the regulator body consist of an inlet C and an outlet D both of which are fitted with 1/8″ (inside diameter) iron pipe. Gas entering at C passes through to outlet D and is conveyed from this outlet through an 1/8″ iron pipe to the Bunsen burner beneath the oven.

Extending vertically through the regulator body B is a passage 3/8″ in diameter from E to F and 1/4″ in diameter from F to G. Within this passage is a float H which carries on a slender rod above a valve which fits a conical valve-seat at G. Extending from inlet C around this valve to outlet D is a by-pass I controlled by a screw valve J. When valve at G is closed, gas may be allowed to pass from inlet C to outlet D by opening screw valve J. This is to supply gas for the pilot light.

The regulator is filled with mercury until the lower end of H is sufficiently submerged to float. The height of the mercury in the passage E-F is regulated by the rod K extending down through the regulator body into the mercury tube A. By forcing down this rod the mercury is displaced and rises in the passage E-F. Float H fits loosely and touches the walls of the passage in which it is contained at four points at F. This float is grooved at its upper end as shown in enlarged section M. These grooves permit any mercury, which may by accident be forced above point F, to fall readily back into passage E-F. Likewise the opening N will permit any mercury, forced by accident into tube C, to fall back into its proper place in passage E-F. On account of the intense surface tension of mercury it is necessary for sensitive operation, that float H be surrounded by a 1/16″ layer of mercury.

It will be seen now, that since H floats in the mercury when about two-thirds submerged, the slightest increase in the volume of the mercury contained in tube A, producing a considerable rise in the much smaller passage E-F, will carry float H upward and close the valve at G. Since these changes in volume are produced by changes in temperature of the medium surrounding tube A it will be seen that the gas valve at G will open or close at the slightest change in temperature. Temperature is fixed by means of rod K. Withdrawing the rod lowers the mercury in passage E-F, opens the gas valve at G and raises the temperature of bath or oven. Screw L by means of a stuffing box at the bottom, holds rod K in place. The pin O prevents the float H from falling too far into the mercury tube.

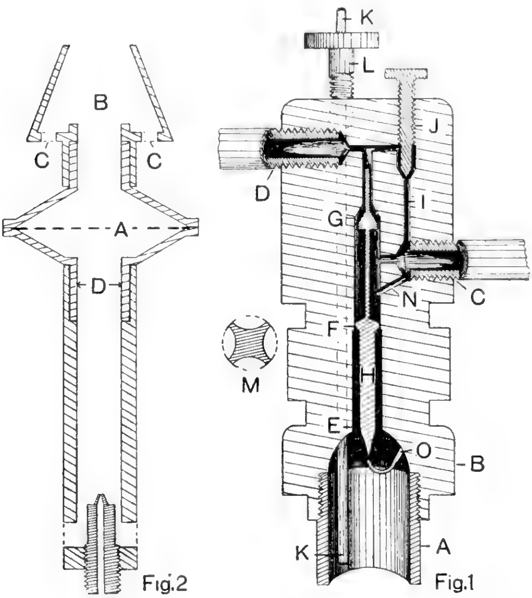


Fig.2 Fig.1

The Bunsen burner which operates best with this regulator is shown in Fig. 2. At A is a copper gauze diaphragm 1½″ in diameter which, on account of size, does not retard the flow of gas, and does prevent the "snapping back," which so often occurs in other burners when the regulator reduces the gas flow to a very small amount.

The hood B is to protect the pilot light which should burn just within this hood. When the gas flows freely, the extra air required is taken in through openings CC. A pilot light burning quite within this hood burns a blue flame, likewise when the burner operates at full capacity it burns a blue flame, thus preventing the troublesome sooting of the oven bottom. The height and bore of these burners must be determined by the maximum temperature required and the insulation of the oven. A burner having a ¼″ bore at D suffices for an oven of 1 cubic foot internal capacity and operating at a temperature of 53° C.

A similar oven operating at a temperature of 38° C. would require a burner of 5/32″ to 3/16″ bore and somewhat shorter than the burner for higher temperatures. A burner of this type and of the proper capacity always burns a blue flame, and gives the greatest satisfaction.

The regulator here described is constructed entirely of steel and is designed for an oven of 1 cubic foot internal capacity. A larger oven requiring more gas would, of course, require a regulator having larger ports.

This regulator was designed to take the place of other thermo-regulators which have proven unsatisfactory and unsafe where gas is used for heating. It controls temperature within one-half of a degree regardless of gas pressure or room temperature.

Four of these regulators have been in successful operation in the laboratories of the Wistar Institute during the past season.

Embalming of Bodies for Teaching Purposes.

BY

EDMOND SOUCHON, M.D.

Professor Emeritus of Anatomy, Tulane University, New Orleans, La.

For some time past, I have been experimenting to improve the dissecting material at Tulane.

The first aim is, of course, thorough and complete preservation; second, the softness of the tissues, as they are found in the unembalmed subjects; third, the color of the muscles and organs, the securing at least of a *brown dark* color for the muscles; fourth, the distention and the coloring of the arteries, without coloring the adjacent tissues.

After many experiments, the following formulæ have been reached by me and give almost perfect satisfaction, meeting the four requirements mentioned above.

Formula for Embalming Bodies for the Dissecting Room.

A.

Water ....one and a half gallons
Arsenious acid (saturated solution)...........one gallon
Formalin (formaldehyd 40%) ....eight ounces

B.

Alcohol ....sixteen ounces
Carbolic acid (liquefied crystals)..............eight ounces
Glycerine ....sixteen ounces
Creosote (Beechwood)..........................two ounces

Dissolve the carbolic acid in the alcohol, etc., then mix B with A. Strain through a towel.

If the injection is made through the femorals, reserve about one half gallon for the two legs. After injecting, stand up the subject, or suspend for two or three days.

The longer the time before dissecting the subject, the better the color.

Formula for Injecting the Arteries.

Hot water (not boiling water) ....one quart
Corn starch (q. s. to make a mixture like thick cream)
about two pounds
Crimson aniline solution (q. s. to give a satisfactory color)
about one and a half ounces.
Tartar emetic solution....................about three drachms

Remarks:—Do not use boiling water, lest it cook the starch.

Practice will teach if one quart is enough. I use Duryea's corn starch in one pound packages, sold by all grocers.

Sift the starch through a sifter. (I use Hunter's.)

Practice will teach the proper amount of starch to use to distend the arteries.

When the piston of the syringe feels a resistance, it is enough. More pressure may cause internal ruptures.

It sets in about one day.

Practice will teach the quantity of crimson aniline solution to use for a satisfactory color.

To prepare the solution of crimson aniline:

Water ....one quart.
Alcohol ....one ounce
Crimson aniline crystals ....one ounce

Practice will teach the proper amount of tartar emetic solution to use. Too much will keep the walls of the arteries from being stained. Too little will allow the aniline to diffuse beyond the walls and color the veins, nerves and connective tissue around the arteries.

To prepare the tartar emetic solution:

Water ....four ounces.
Tartar emetic ....one drachm.

I am indebted to Dr. Philip Asher, of the College of Pharmacy of this city, for the most valuable suggestion of the use of tartar emetic, and for the foregoing formula.

Formula for Embalming Bodies for Operative Surgery.

A.

Arsenious acid (saturated solution)..two and a half gallons.
Potassium nitrate ....two pounds.
Formalin ....four ounces.

B.

Alcohol ....sixteen ounces.
Carbolic acid (liquefied crystals).............eight ounces.
Glycerine ....sixteen ounces.
Creosote (Beechwood).......................two ounces.

Mix B with A.

Formula for Embalming Bodies for Making Museum Preparations.

A.

Water ....one and a quarter gallons.
Arsenious acid (saturated solution) one and a quarter gallons
Potassium nitrate ....one half pound.
Formalin ....two ounces.

B.

Alcohol ....sixteen ounces.
Carbolic acid (liquefied crystals)...............six ounces.
Glycerine ....sixteen ounces.
Creosote (Beechwood).......................two ounces.

Mix B with A.

This is a weaker solution than the foregoing, and the subjects must be worked up without loss of time in warm weather.

Formula for Making Pathologic Preparations for Museums.

The formula written above for making anatomical preparations for museums often gives very good results also for making pathological specimens, but the solution must be injected into the arteries, etc. To immerse simply a pathologic specimen into the solution will seldom give satisfactory results, whereas injected specimens seldom fail. Injection and immersion with the same solution are not the same thing at all. However, the formula recommended will often change the color of the stomach and intestines into a dull gray, and harden them.

The following will not do that.

A.

Arsenic (saturated solution)	one and a half gallons.
Potassium nitrate	one-half pound.
Formalin	two ounces.

B.

Alcohol	sixteen ounces.
Carbolic acid (liquefied crystals)	four ounces.
Glycerine	sixteen ounces.
Creosote	two ounces.

Mix B with A.

This solution is very weak. The embalming will often escape notice. It will very material assist, though, in making good pathological preparations. It will often delay decomposition for a few days even in a warm climate. It is best to work up the subject at once in warm weather.

By saying that subject must be worked at once, we mean that the parts to be preserved must be cut out within twenty-four hours and placed at once in a weak solution of carbolic acid (one ounce to the gallon of water), or in alcohol (ten ounces) with carbolic acid (one-half ounce) to one gallon of water.

The solutions must be changed as soon, and as often, as they become cloudy or discolored. This is very important, lest the impurities in the solutions will affect the color of the tissues.

BOOK REVIEWS.

"A Text-Book of the Principles of Animal Histology." By Ulric Dahlgren, M.S., and William A. Kepner, A.B. New York: The Macmillan Company, 1908.

The biological sciences, at their beginnings, were largely under the fostering care of medicine, and this relationship has had an interesting bearing upon their development. At a comparatively early period zoölogy cut the apron strings that bound it to medicine and asserted its right to be considered an independent science, whereupon its morphological side, cultivated for itself, became known as comparative anatomy. Human anatomy, however, retaining for itself the designation of anatomy, without any qualifying adjective, continued to be regarded as a part of medicine, and, indeed, is so yet, it being difficult for one unfamiliar with the scope of modern anatomy to understand that human anatomy is properly a science apart from medicine, although in its practical applications it must necessarily play an important part in medical training.

But while the morphological side of zoölogy thus gained an independent status, the study of function held to its association with medicine, and physiology, until within recent years, was almost exclusively confined to the investigation of the organic functions of vertebrates; that it wandered afield so far as the Amphibia was due rather to the exigencies of the conditions than to the recognition of the desirability of a comparative physiology. As specialization arose the new subdivisions of the sciences in question, according to the influences under which they developed, were either regarded as forming a part of the medical curriculum or were held to be more or less foreign to it. Embryology, for instance, had its origin outside the medical fold, arising as it did in connection with zoölogy, and only to-day is it beginning to find a proper recognition as a part of the medical discipline. Histology, on the other hand, was a development from anatomy, using that term in its usual sense, and its growth has largely been in relation to its application to medicine, while cytology again was primarily cultivated by zoölogists and embryologists, and, like embryology, is even yet too scantily recognized as a part of the medical curriculum.

All these subdivisions of animal morphology have, however, strong claims to a place among the studies preparatory to medicine, and, at the same time, have a rank as sciences independent of medicine; that is to say, independent of their immediate applications. And with this double rôle there is a necessity for a double mode of presentation. With the serious demands which all are making upon the medical curriculum it is evident that time cannot be spared for their presentation as pure sciences to the already overburdened medical student. He needs his embryology mainly for the proper understanding of his anatomy, histology and pathology, and he needs his histology mainly for its bearings upon physiology and pathology. He cannot study embryology *quâ* embryology, nor histology *quâ* histology, but he should be well grounded in such facts and theories of both these sciences as have a bearing on medicine. On the other hand, in the non-professional school these subjects should be studied as pure sciences; embryology is now and it is time histology was sharing its advantages. The trouble that afflicts us at present is that embryology when presented to the medical student at all is too frequently presented as a pure science, while the histology of the scientific non-professional courses is essentially human histology.

An attempt to remedy this defect, so far as histology is concerned, is to be found in the volume under review, and a perusal of it will certainly suffice to broaden the conception of histology usually held. For the material is arranged so as to show as far as possible the adaptation of form to function, and many such adaptations unknown in mammalian histology, such as those concerned in the production of light and electricity, are described and illustrated. The various functions, and their classification is much more detailed than in the ordinary histological text-books, are considered in succession, and the minute anatomy of the organs by which they are performed is described and figured, not by taking a single organ as a type but by presenting a series of pictures showing modifications of structure which may produce similar results. It is impossible, of course, within the limits of a text-book to give an account of all modifications of any type of organ occurring throughout the animal kingdom, but the authors have been generous within their limits, and one may find within the covers of their book enough to furnish a striking picture of the possibilities of adaptation possessed by protoplasm; and it must be added to the credit of the authors that by far the greater part of what they give is based upon their own observations, a large majority of the 470 figures being original.

The laudable purpose which inspired the book and the rich supply of material which it contains make one hesitate in fault finding, and yet it must be admitted that faults exist to which attention should be drawn. And perhaps the most significant of these is the outcome of the plan of presentation which the authors have selected. The general impression one receives from a perusal of the book is of a somewhat disconnected series of illustrations of adaptation to various functions rather than a coherent treatment of the manner in which the more extreme adaptations have arisen. The principal aim of comparative anatomy is to reach conclusions as to the phylogeny of parts, and that should be an important aim in a comparative histology also. We are not yet, it is true, in a position to deduce as many conclusions from the latter as from the former, the field has not been sufficiently gleaned; and, further, it must be noted that the authors have in certain sections so arranged their illustrative examples as to indicate their probable phylogenetic succession. But much is lacking in this particular. In the chapter on the contractile tissues, for example, one looks in vain for some clew to the evolution of the striation of so-called voluntary muscle, and the marked distinction which histological text-books are accustomed to draw between the striated and unstriated types is maintained, although the distinction seems to have its origin in physiological rather than in morphological conditions.

Another failing is a somewhat insufficient treatment of certain tissues, pardonable to an extent in view of the enormous field which the authors have attempted to cover. But one finishes the section on the blood with a good deal of disappointment, finding therein but scant treatment of the red corpuscles, with no mention of recent observations on their form, while the blood plaques and various other forms of blood elements are completely ignored. These are, of course, best known in the vertebrates and are fully treated in several text-books of human histology, but there are important observations on the blood elements of various invertebrates from which material might with advantage have been secured. The nervous tissues, too, are hardly as fully considered as their importance and complexity demand, and one reads with astonishment, in view of the beautiful experimental observations of Harrison, that "it has been proved, however, that they (the sheath of Schwann cells) are true connective-tissue cells from the locality through which the nerve fiber has passed in its development." Surely it would have been well in discussing the neurofibrils to have made some mention of the observations of

Bethe, Cajal and other recent investigators, and one misses some account of the interesting sense organs of the leeches and chitons and of the lateral line organs of the lower vertebrates.

Finally, it must be said that there is room for much improvement in the style in which the book is written. It lacks continuity in places and is occasionally altogether obscure. Thus on page 10 one reads that the centrosome "consists of a number of radiating fibers, which may be absent when the centrosome is quiet," and, indeed, it is difficult to get an idea of what the authors understand by the word centrosome, it being employed sometimes as equivalent to centriole (pages 57 and 186) and at other times with a much wider significance. In the proof-reading, too, there are many indications of insufficient care, especially noticeable in the case of proper names, Leidig, for instance, being frequently repeated, as is also Harversian, and Conheim. Haidenhain and plecypod look peculiar. But it is in the bibliographic references that the orthographic enormities are most abundant, few of the lists given at the ends of the sections being free from them.

But these may to some seem minor faults, and in spite of all unfavorable criticism that might be made the authors deserve great credit for having furnished the first English book treating histology as histology. In considering so large a field errors of omission and commission are unavoidable, and it is sincerely to be hoped that the book will be received as its merits deserve, and be the means of establishing in our biological courses the too much neglected study of comparative histology.

J. P. McMurrich.

"Principles of Breeding, A Treatise on Thremmatology," by E. Davenport, with appendix by H. L. Rietz. Ginn & Co.

Thremmatology, according to Dr. Eugene Davenport, author of a 700-page text-book on the subject, considers "the principles and practices concerned in the improvement of domesticated animals and plants." It "seeks to answer this one question, How can they be made still more useful and better adapted to the purposes of an advancing civilization." In this search the reader is led by an easy path through most of the fields of biology.

It is recognized by the author that some will differ from him as to the relative stresses to be laid upon the various points which are discussed; but it does seem strange to the reviewer that in a book upon the "Principles of Breeding" nearly twice as much space should be given to regeneration as to Mendel's "Law of Hybrids." Even in the space devoted to the latter it is not accorded perfectly fair treatment. Thus a page, mostly fine print, is given to Darbishire's early paper (Biometrika III) on inheritance in mice which is hostile to Mendelism and no mention is made of Darbishire's reconsideration of his own experiments which supports Mendelism.

The book is to be recommended to those who wish a readable and fairly accurate abstract of Bateson's "Materials," Morgan's "Regeneration," Loeb's "Physiologies," C. B. Davenport's "Experimental Morphology" and "Statistical Methods," Wilson's "Cell," and Pearson's essays, in addition to numerous agricultural experiment station bulletins and general works on evolution.

The most unique part of the work is a clear presentation of the more simple of the biometric methods. Relatively a large amount of space is justly devoted to biometry, in order "to encourage, and if possible induce, more exact methods of study and practice than have hitherto characterized this branch of agricultural science." Nothing is clearer than that *the successful breeder of the future must be a bookkeeper and a statistician.*

Frank E. Lutz.

THE ANATOMICAL RECORD

Vol. II. OCTOBER, 1908 No. 7

Note on Pathological Changes Found in the Embryo Pig and its Membranes.

BY

HENRY S. DENISON.

From the Anatomical Laboratory of Johns Hopkins University.

Several years ago Dr. Mall placed at my disposal the uterus of a pig containing three normal and six pathological embryos which in general appeared to be much alike. The normal ones measured 15 mm. from crown to rump, and the pathological ones were somewhat less than half as long.

It had been my intention to investigate the frequency of pathological embryos in the pig and to ascertain whether they are associated with constant changes in the membranes or in the walls of the uterus, and towards this study fifty-seven uteri were examined which gave promising results. Circumstances have prevented me from carrying the work to a satisfactory conclusion, but the results obtained are perhaps worthy of record.

The six pathological embryos are quite characteristic, resembling very much some of those described by Dr. Mall in his recent article on pathological embryos. There is, however, a tendency towards the formation of vesicles along the line of the umbilical cord, as is shown in the accompanying figure. In this specimen there are several vesicles apparently constricted off by twisting and others show secondary constrictions, making them appear like a string of sausages. There is also a thick antenna-shaped tag hanging from the amnion. This tag repeats itself a number of times in the other specimens. The umbilical cord is also generally twisted more or less in all of the specimens, making it appear as if the pathological embryo rotated within the amnion. The walls of the amnion are thickened, and at first sight amniotic bands appear to be present, but more careful observation shows that they are only the more thickened walls which do not press upon the embryo, for there is hydramnios in all of the specimens.[1]

Sections of the embryos show a marked destruction and dissociation of the tissues with general dropsy and hydrocephalus. The development is very irregular, but the myotomes, eye vesicles and dorsal ganglia can be recognized. In general the spinal cord is partly filled with round cells which at points obscure its borders entirely. In all the specimens the heart is nearly destroyed, being replaced by a mass of round cells.

In order to determine the frequency of pathological embryos in the pig fifty-seven uteri in various stages of pregnancy were examined, and the results are given in the following table. It is seen that as pregnancy progresses the number of normal embryos diminishes and the number of dead and macerated embryos increases. In these uteri 361 embryos were found, of which 332 are normal, 19 macerated and 10 pathological.

The pathological, excluding one cyclops, are 9 in number, and were found in 7 uteri, that is, in about 12 per cent; in each of two uteri two pathological embryos were found, thus indicating that there is a tendency for them to recur in the same uterus.

The pathological ova show changes in the membranes that may briefly be designated "fibro-cystic." By this type of change I mean a fibrous modification and thickening of the pericœlomic mesenchyme between interspersed cyst-like spaces filled with clear material. Such fibro-cystic

	Crown-Rump Length of the Normal Embryos in Centimeters				
	2 to 3.9	4 to 7.9	8 to 11.9	12 to 15.9	16 to 21.
Number of uteri examined	11	15	14	7	10
Number of normal embryos found	76	94	79	38	45
Number of macerated embryos found	4	3	0	1	2
Number of pathological embryos found	1	2	3	4	9
Number of chorion with hemorrhagic patches	69	18	14	7	5
Number with chalky patches	18	37	22	6	11
Number with epithelial proliferation	0	11	20	16	6
Number with cysts at the junction of the cord with the chorion	0	2	9	14	9

[1]Mall, Journal of Morphology, xix, 1908.

alteration may attack any number of the ova in a single uterus, and when marked causes degeneration of the embryo, probably from strangulation of the cord. The chorion immediately adjoining the base of the cord appears to be the seat of election for this disease and is often thickened by a fluffy mass of fibro-cystic mesenchyme. The cord may be twisted and knotted by fibrous bands which, closing also around the cysts, produce pedunculated vesicles of various sizes—bizarre shapes that

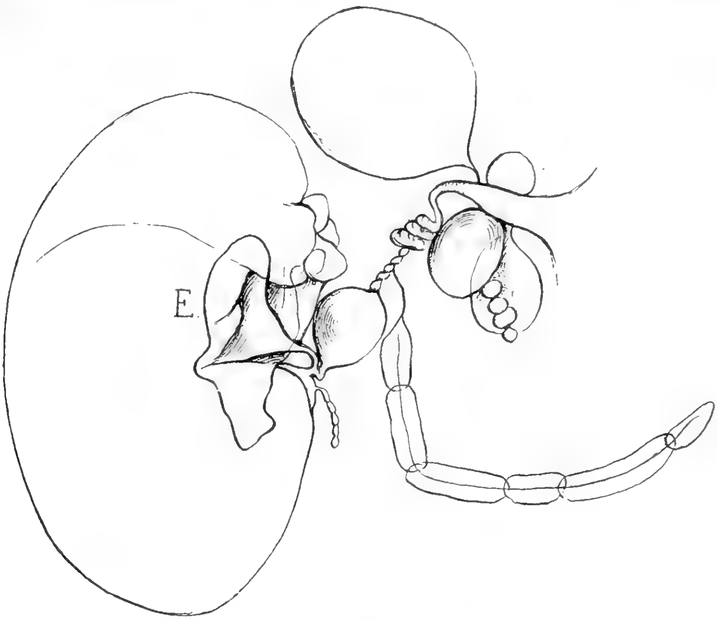


Fig. 1.—Semidiagrammatic outline of one of the pathological embryos within the amnion. The cord is twisted and numerous vesicular tags are attached to it. There is hydramnios; within the outline of the embryo, *E*, is shown.

hang out in the cœlom. The amnion is often thickened, rough and smaller than normal. More often, however, there is hydramnios. Fibro-cystic tags project from its outer surface into the exocœlom which contains considerable magma. Constrictions may form about the embryo dividing it more or less completely into segments. The embryo is degenerated and friable, and the tissues are invaded by wandering blood cells. The fibro-cystic change just described occurs early in pregnancy. After the death of the embryo the ova quickly degenerate and are not found in later stages.

There is, however, an analogous change in older specimens. A few clear cysts are frequently found at the base of the cord in embryos longer than 9 cm. An extensive, rough, fibro-cystic thickening is occasionally present. In one case the embryo with such changes measured 3 cm. less than others of the same uterus. The cysts are often spread over the chorion, forming a thick mass around the attachment of the umbilical cord to it. Sometimes there are many hundred cysts forming a mass 1.5 cm. thick and 10 cm. in diameter.

In the younger specimens hemorrhages are nearly always present in the chorion as the table shows. At first I was of the opinion that they were due to rough handling, but their constancy and their tendency to diminish in number as pregnancy progresses makes me doubt this view of their cause. The older ones show signs of organization with chalky patches which increase as the hemorrhagic patches diminish in number. Chalky changes are very common, especially in the later months. There are three chief forms. One, the commonest, is a white, chalky-streaked succulent polyp involving only the innermost layer of the chorion and flabbily projecting from that surface. Such polyps may occur singly or in great profusion and vary much in size, sometimes being as large as 10 cm. in diameter. At the center, on section, there is a considerable infiltration of large round cells surrounded by deeply blue-staining granules arranged on a fine reticular net-work. The peripheral tissue is œdematous mesenchyme. A second form is the "plaque," that is, a dense whitish plane of chalky deposit situated deeply in the chorion. The third form is a diffuse milky infiltration occurring over the whole chorionic surface.

The chalky mass is imbedded in gelatinous tissue which often forms a transparent mound by itself. In general these masses form individual islands from 2 to 20 mm. in diameter, but they may form narrow streaks fully 10 cm. long.

Epithelial proliferations of the chorion frequently occur in the later months and form wart-like projections which are prone to degenerate in the center. Neither the occurrence of these warts nor of chalky changes appears to bear any relation to production of those fibro-cystic changes described above. The warts are generally quite small, 2-5 mm. in diameter, and contain a core of fibrous tissue which later on undergoes hyaline degeneration in patches with mucoid tissue between them. In some instances the hyaline masses coalesce to form droplets and the mucoid tissue disintegrates.

An Abnormal Human Fœtus.

BY

FLOYD E. CHIDESTER.

From the Biological Laboratory, Clark University.

With Nine Figures.

Through the kindness of Prof. C. F. Hodge, I was permitted during the past winter to dissect an interesting seven months' fœtus presented to him by Mr. W. B. Fox, of the Harvard Medical School. Deformities of the limbs are quite common in human embryos, but complete absence of one leg is not so frequent.

Fig. 1

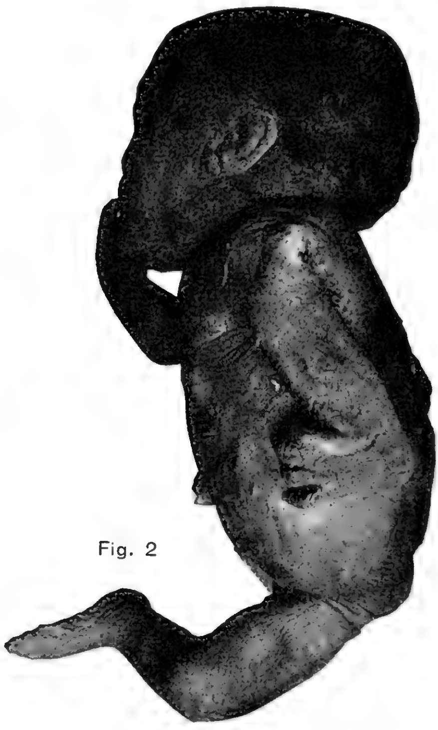


Fig. 2

FIG. 1. View from the front, showing the single lower extremity.

FIG. 2. View from the side, showing the peculiar shape of the left hand.

For the benefit of those who might be interested from an obstetrical point of view, I give the following history of the case:

Mother, housewife; general physical condition, good; number of pregnancies, two; labor began, October 24, 1907; first visit, 1.15 P. M., same day; presentation, vertex; position, occiput left anterior; cervix, taken up; os uteri, wholly dilated; fœtal heart, could not be heard; pulse of mother before, 86; after, 76; temperature before, 98.8; after, 99.2°; membranes ruptured, 9 A. M., October 24, 1907; child born, 1.30 P. M., October 24, 1907; placenta delivered, 3.10 P. M., October 24, 1907; condition of placenta when delivered, intact; perineum, intact; length of

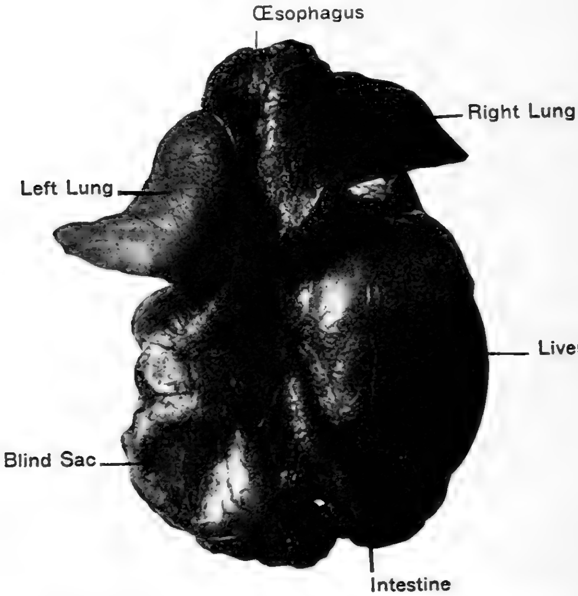


FIG. 3. Rear view, showing the lungs and the (slit) œsophagus, etc.

cord, twenty inches; duration of labor, seven hours; sex, male; age, seventh fœtal month; weight, 3¾ pounds; length, fourteen inches.

The right leg was absent, the left leg being almost a continuation of the spinal column. As can be seen from Fig. 1, the penis was turned a little to the right. The left hand was singularly foot-like in appearance, and the left thumb was attached only to the first finger by a flap of skin.

On receiving the specimen in weak formalin about a week after delivery, I injected the brain and spinal canal and the body cavity with 10 per cent formalin.

At the end of about two weeks I opened the skull and examined the brain, hoping to find it well enough preserved for study. Unfortunately, in the few days elapsing between birth and its receipt and injection, decomposition had rendered any neurological study impracticable. Though kept in strong formalin for over six weeks afterward, the brain did not harden.

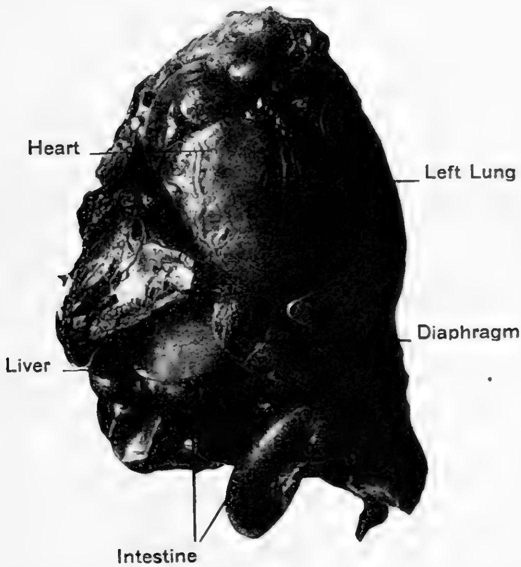


Fig. 4. Front view, showing the heart, liver, left lung, and coiled intestine.

My attention was next turned to the internal organs, which were singularly undeveloped. Fig. 3 shows the lungs, which, instead of being three-lobed and two-lobed respectively, have but a single lobe each.

It is interesting to note that, not only was there no stomach, but that on cutting open the œsophagus, no thickening of the walls was found in the region normally occupied by the stomach. A blind sac, indicated in the preceding figure, occupied a position just below the left lung. This was opened and found to be empty, and to have no opening to the exterior. It was attached by mesentery to the intestine

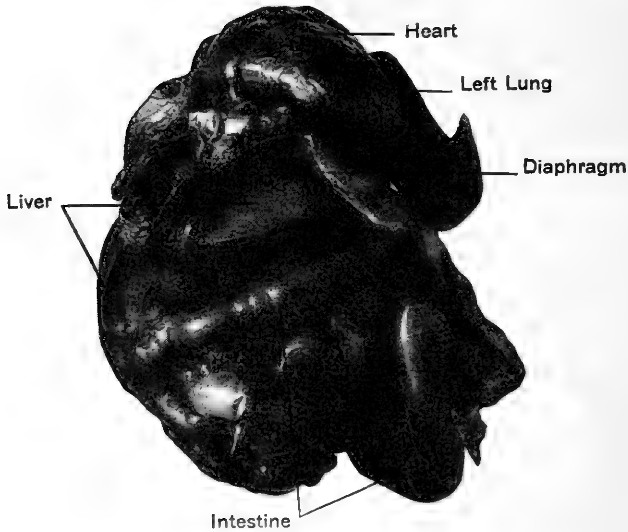


Fig. 5. View of the viscera from below.

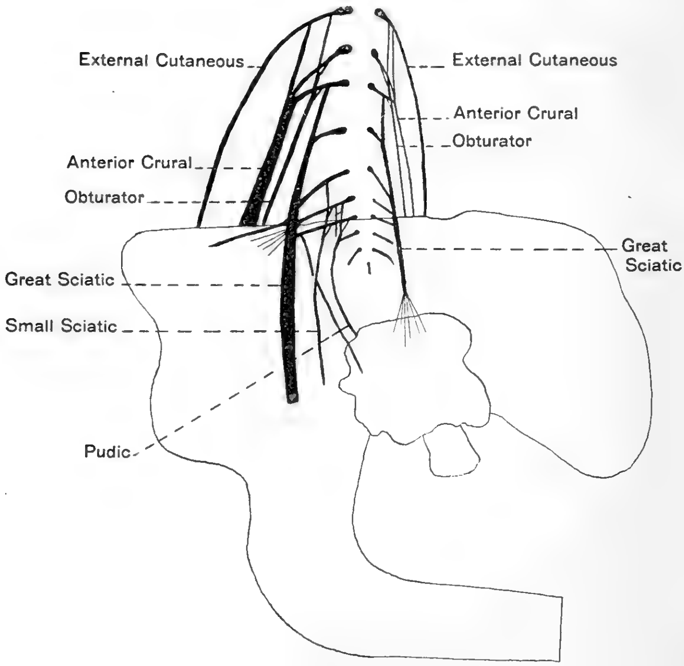


Fig. 6. Rear view of the lumbar and sacral nerves.

Examination of the wall of the sac revealed the presence of the characteristic mucous, sub-mucous, muscular and serous coats of the digestive tract. This sac, or pouch, may have started as the stomach.

The heart was about one-fourth larger than normal. The liver was rather large, but normal in position. There were no kidneys, no spleen, no pancreas, and no appendix vermiformis. The intestine was otherwise normal, except that, as before stated, it was continuous with the œsophagus. The anus, however, was imperforate for about one and a half inches. The right testis was undescended.

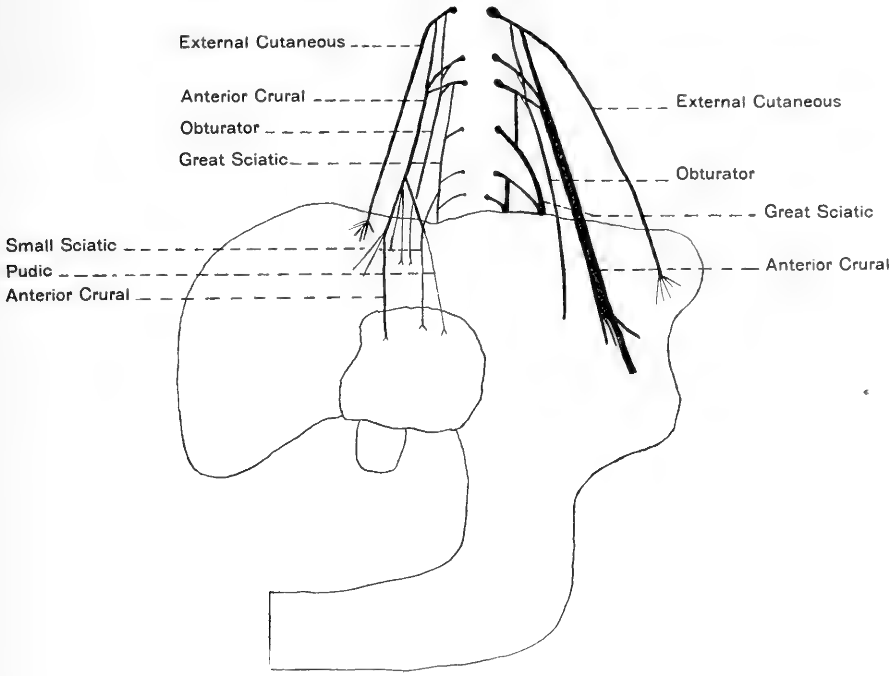


FIG. 7. Front view of the lumbar and sacral nerves.

Since preparation of the brain was impossible, I proceeded to dissect the spinal nerves, and while doing so discovered the absence on the right side of the body of not only the femur, but also the ilium and ischium. This will be mentioned later.

The spinal ganglia were all present on both sides of the cord, but, beginning with the first lumbar, the ganglia on the right side were much smaller than those on the left.

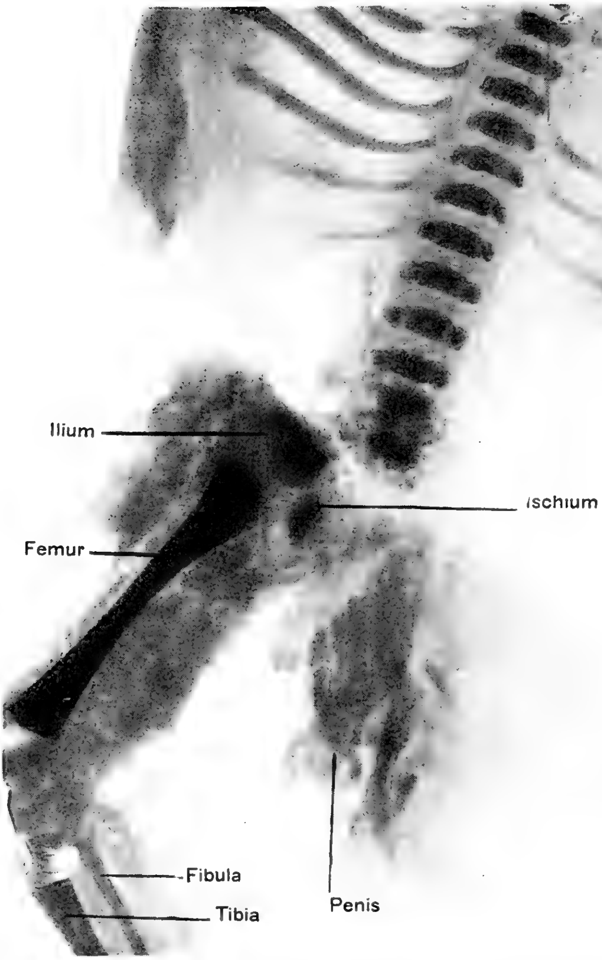


FIG. 8. Skiagraph of the pelvic region, rear view.

The great sciatic nerve on the right side (Fig. 6) passed down into the scrotum and ramified as fine nervelets. All the lumbar and sacral nerves on the right side were distinctly smaller than the corresponding ones on the left side.

The anterior crural nerve on the right side (Fig. 7) sent off five branches, the main trunk continuing into the scrotal tissue, where it, like the great sciatic, ramified cutaneously.

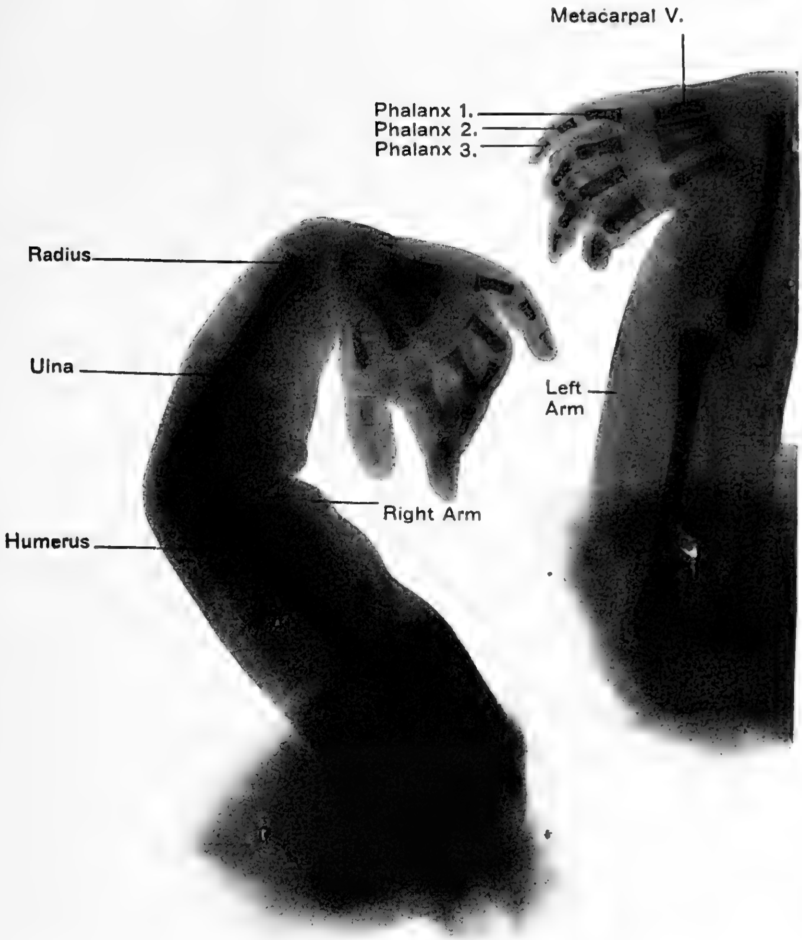


Fig. 9. Skiagraph of the arms.

The small sciatic nerve and the proportionately large pudendic nerves also ramified in the scrotum.

One of the most interesting features of the anatomy of this fœtus was the fact that the bones of the pelvis, as well as those of the extremity, were completely absent on the right side. The accompanying skiagraph (Fig. 8) indicates this clearly.

Careful dissection of the pelvic region confirmed the idea that there was not even cartilage in the place of these bones. The skiagraph shows plainly that the ilium and ischium on the left side are separate in this seven months' fœtus.

The right arm and hand were perfectly normal. The left arm was normal down to the elbow. This was stiff. Fig. 9 indicates the deformity there present. The ulna was completely absent, and the radius and humerus formed a large, stiff joint.

The carpal bones of both hands do not show in the skiagraph, but dissection disclosed the fact that although unossified they were present as very soft cartilage. The left first metacarpal bone was absent.

The thumb was not in its normal position on the left hand. Instead, a ball of flesh containing one cartilaginous phalanx lay in the palm between the first and second fingers. It was attached by a small flap of skin to the second phalanx of the first finger. A nail was present on the dorsal aspect of this "thumb" as it lay in the palm.

I wish to acknowledge my indebtedness to Prof. C. F. Hodge for the opportunity to work on this interesting specimen and for his many helpful suggestions concerning it. The photographic plates were made by Mr. Newton Miller, Clark University, and the skiagraph plates by Dr. Philip Cook, City Hospital, Worcester, Mass.

Summary.

The following abnormalities were discovered:

1. Lungs uni-lobed.
2. Heart one-fourth larger than normal.
3. Kidneys absent.
4. Vermiform appendix absent.
5. Pancreas absent.
6. Spleen absent.
7. Stomach, as such, absent; a blind sac not in the normal position of the stomach may have originated as a stomach.
8. Anus imperforate for one and a half inches.
9. One testis undescended.
10. Bony structure which might be interpreted as belonging to a right leg completely absent.
11. Left thumb misplaced, with no first metacarpal bone on the left hand.
12. Ulna of the left forearm absent.

BOOK REVIEWS.*

"Contributions to the Study of the Early Development and Imbedding of the Human Ovum." I. An Early Ovum Imbedded in the Decidua. By Thomas H. Bryce, M.A., M.D., Lecturer in Anatomy, University of Glasgow, and John H. Teacher, M.A., M.D., Lecturer on Pathological Histology, University of Glasgow. With ten plates and twelve figures in the text. Glasgow: James Maclehose & Sons, Publishers to the University, 1908. Price, 12s. 6d. net.

About ten years ago Peters of Vienna described a human ovum measuring 2.4 mm. by 1.8 mm., which was obtained from the uterus a few hours after death. In all probability the specimen is normal, and until recently was the youngest specimen seen. Now Bryce and Teacher have found a still younger specimen in a piece of decidua sent to them for examination in a mixture of urine and blood-clots. The membrane had been expelled by a young woman who had been married for about two years, but who had not before been pregnant. The physician had recognized a piece of fawn-colored membrane among the blood-clots which he considered to be probably a portion of the decidua of pregnancy as the woman had passed her period by almost ten days. The specimen was cut into serial sections 7 microns thick and was found to contain a beautiful and probably normal ovum whose dimensions, including the syncytium, were 1.95 x 1.10 x .95 millimeters, that is, about as large as a fairly good-sized pin's head. It has thus been demonstrated that a young human ovum can be obtained in a satisfactory state of preservation in a fragment of endometrium, and from now on it will be necessary to examine with care all shreds of membrane which are shed a few days after the omission of a period as recommended by the late Professor His.

It is fortunate for the science of human embryology that this rare specimen has been studied carefully by Dr. Bryce, to whom we also owe a debt of gratitude for his excellent volume on human embryology in the recent edition (XI) of Quain's Anatomy. It could not have fallen into better hands.

The results of this study are given in the form of a superb publication made possible by a grant from the Carnegie Trust of the Scottish

*All correspondence regarding Book Reviews should be addressed to Dr. George L. Streeter, Ann Arbor, Mich.

Universities. The plates are by the three-color process, which are so well done that they equal in many respects the best lithographs. The paper is composed of two parts, the first giving an excellent description of the specimen and the second giving a masterly discussion of its age. No doubt this permanent contribution to human embryology will soon be read by all who are interested in this subject, and in order to hasten the circulation of this volume I cordially recommend it.

The following summary is given by Bryce and Teacher:

A study of the sections shows that the ovum is completely enclosed in decidua except at one point, where there is a small gap closed by a mass of leucocytes and fibrin. The wide gap, closed by a blood-clot as seen in Peter's ovum, is entirely absent.

The ovum lies bathed in blood in a relatively large implantation chamber, with the walls of which it is not united. There is no interlocking or mixing of maternal and fœtal tissues. The innermost layer of decidua lining the cavity is in a state of advanced coagulation necrosis, and this, together with a certain amount of fibrinous deposit, forms a layer of dead material which is practically complete except at one or two points where blood-vessels have opened up, and at one end where hemorrhage has broken into the implantation chamber.

The wall of the ovum consists of an inner lamella (cyto-trophoblast or Langhans' layer) composed of cells rather ill-defined from one another, and continuous externally with an extremely irregular formation which has definitely plasmodial character (plasmodi-trophoblast or syncytium). This forms a straggling reticulum, the meshes of which are filled with maternal blood, forming primitive blood lacunæ. The villi, if such they may be called, are formed wholly by the reticulum of syncytium, there being no protusions of Langhans' cells nor mesoderm into it.

The cavity of the ovum is filled by a delicate tissue having the characters of mesenchyme. There is no cleavage of the early mesoderm into a parietal and a visceral layer with an exocœlom between them. It does not form a distinct lamella round the wall of the cavity and there are no protrusions from it representing future mesodermic villi.

The embryonic rudiment is represented by two eccentrically placed vesicles slung in the mesenchyme by fine protoplasmic threads. They are quite separated from the walls of the ovum by mesenchyme, and the cells forming the two sacs have definite and different characters, but *inter se* shown no differentiation. The cells of the larger (ectodermic) vesicle are cubical; those of the smaller (entodermic) vesicle are flattened.

Remarkable as some of these features of this new ovum are, there is no reason to suppose that it is in any way abnormal or pathological. Every one of its characters, as is shown in the memoir, harmonizes admirably with known later stages. It is in no way contradictory or bizarre. It is not only consistent in itself, but it is also consistent both with admitted facts and with inferences founded upon these facts.

In the second part of the paper the age of young ova is discussed, and Bryce and Teacher reach the conclusion that they are considerably older than is generally believed, that is, when the convention of His is followed. According to this convention fertilization usually takes place just before the first omitted period, and the time between this and the abortion is the age of the ovum. In this case there was a single coitus on October 19th. Menstruation did not follow on October 25th, when it was due, and the abortion occurred on November 4th. Computing from the last period the specimen would be ten days old, and from the time of coitus sixteen days. Taking all of the factors into account they estimate its age at from thirteen to fourteen days.

In the mouse, rabbit and guinea-pig the implantation takes place on the sixth or seventh day, and it is improbable that it takes place earlier than this in man; and until it takes place it is difficult to believe that menstruation will cease. They therefore conclude that seven days must be allowed for segmentation and the early phases of implantation, and another seven days does not seem too much to allow for the growth and development of the ovum up to the stage presented in their case, when we consider the rate of growth in the mouse and guinea-pig and allow for the much longer gestation period in the human subject.

This conclusion is of especial interest to me as it confirms my own, which will be published in the new Human Embryology. Mine was obtained by extending the curve of growth back to the earliest stages which then become fully two weeks older than they are according to the convention of His. (See foot-note in the Jour. Morph., Vol. XIX, page 73.)

It is probable that fertilization usually takes place shortly after the last menstrual period, and as soon as the ovum is well implanted in the uterus the periods do not recur. For this reason ova and embryos of the same stage are often nearly a month apart in age when it is computed from the last period. This is especially marked in young specimen, for in them a few weeks' growth is very apparent.

The whole argument of Bryce and Teacher and myself is too long and too complicated to be given in a brief review, and those who are interested in this question are referred to the fuller accounts. The conclusion is that all of the ova believed to be of the first and second weeks are really of the third and fourth weeks, and that Peters' ovum is fifteen days old instead of four days as Peters believed it to be. Only the study of more very young stages which have complete histories, as have Eternod's and Bryce and Teacher's, with more careful study of the corpus luteum will fully settle this much-discussed question. For the present the evidence obtained from comparative studies, as first pointed out by von Baer and as again emphasized by Bryce and Teacher, proves to be the most valuable control in the solution of this perplexing problem. The necessary records are very difficult to obtain, are usually not reliable and are often marred by disease.

Franklin P. Mall.

"Atlas and Text-Book of Human Anatomy." Volumes I, II and III. By Professor J. Sobotta, of Würzburg. Edited, with additions, by J. Playfair McMurrich, A.M., Ph.D., Professor of Anatomy at the University of Toronto, Canada. Quarto volumes of a total of 794 pages, containing 850 illustrations, mostly in colors. Philadelphia and London: W. B. Saunders Company, 1906. Cloth, $6.00 net, per volume. Half Morocco, $7.00 net.

This atlas with text is quite an exceptional production and worthy of very special consideration. A year's use in the dissecting-room has aroused much enthusiasm in the reviewer.

The illustrations of the work are, on the whole, the most artistic to be found in any text-book or atlas commonly available; while at the same time they are quite accurate, originally conceived and judiciously selected. The text is very clear, succinct and direct; yet withal sufficiently extensive for the field chosen. The description is very well adjusted to the figures constituting the atlas, and the editor's arrangement of matter and use of headings and of type to facilitate reference, or to produce emphasis, is very successful.

The atlas consists of three bulky volumes. Vol. I, 258 pages, with 320 illustrations, includes the bones, ligaments, joints and muscles. Vol. II, 194 pages, with 215 illustrations, treats of the viscera and cavities of the body, and the heart. Vol. III, 342 pages, with 297 illustrations, forms the largest volume, and takes up the vascular system, lymphatic system, nervous system and sense organs. There are then, in all, 794 pages of text, with a few scattered explanatory figures and diagrams. It is exceptionally well printed, in clear type, on large size pages. In addition there are 335 large handsome plates, on heavy paper, bearing most of the 832 illustrations, one or several to a plate and mostly in colors. Dr. Sobotta has selected his figures and had them drawn to show all essentials with the maximum sharpness, yet without becoming diagrammatic. A text has been added to supplement the pictures, by referring the student to all the figures which show a given structure from various points of view; thus bringing together for him all that is needed to form a clear idea of a given region. The text is almost purely descriptive, and very concise. It does not wander into embryological, histological or surgical relations, but confines the account to what may be made out in the dissecting-room. There are frequent references to "Sobotta's Atlas and Epitomé of Histology," and numerous paragraphs in small type giving embryological information, functions of muscles, general relations, etc.; but every effort is made to keep the descriptive account simple and free from digressions. If the title read "Atlas with descriptive text" the scope of the work would be indicated better than by the more ambitious term "text-book," which implies a more comprehensive treatment.

The following quotation from his preface gives the author's idea: "My first thought was to produce an atlas which would supply the practical wants of both the student and physician. It is not an atlas for the finished anatomist. The admirable atlas of Toldt contains a vast number of well-chosen illustrations; but it is so comprehensive that it is difficult for the student to pick out what he actually needs, and owing to its high price and the fact that many of its illustrations are not true to nature, it has not met with great favor from the student body. In the present atlas the aim has been to limit the material to what is absolutely necessary." . . . "The fundamental principle of the work has been to avoid any unusual presentation of the subject which would make the recognition of well-known relations more difficult for the beginner."

In justice to Toldt we are obliged to record our disagreement from this view of his magnificent work. We have used Toldt's atlas (German edition) in the dissecting-rooms for several years, with ever-increasing admiration. It is certainly a masterpiece, produced by an anatomist with very great talent for dissection, and with remarkable artistic ability of the right type. He has secured pictures which represent the best possible points of view, and has exhibited such a thorough grasp of the problems involved, and so great originality in solving them, as to succeed in furnishing us with a set of illustrations which leave very little to be desired. We may grant that a little more color here and there would improve some of Toldt's figures, but we entirely fail to understand how any of them can be characterized as "not true to nature."

Though perfection is not to be expected in anatomical atlases, an experience of several years has led us always to refer to Toldt where there is a complicated region to explain, or an obscurity to clear up, and we cannot remember a time when those vigorous and completely worked out figures have failed us or proved inaccurate. It is true that Toldt's illustrations are very numerous and often special in nature, but most of us would not regret this wealth of choice. It is surprising how many variations he succeeds in working in. His selection of embryological figures is especially good, and a valuable feature of his atlas. It is a great shame that the English edition of Toldt is so complete a failure, the cheap paper and travesties of the excellent German figures, with the crude lettering have robbed this edition of any right to success.

The German edition, however, deserves a wide circulation. It remains the most comprehensive, accurate, original and least diagrammatic atlas now published.

Having said so much for Toldt we still find Sobotta's atlas a remarkably fine production, with original and valuable features of its own.

In such complicated figures colors are almost necessary, but until recent years the cost has been almost prohibitive. Now, however, Sobotta's use of this valuable accessory is especially happy. His plates are striking examples of a most successful application of the modern photographic processes of illustrating which he describes briefly in the preface. The German author and publisher have agreed on the use of the less expensive methods, but they have shown that cheap processes need not produce cheap looking pictures. They have insisted upon care and clearness in the working out of details in both dissections and drawings, and the plates are printed with equal skill. The result is an atlas with plates in several colors, even more satisfactory than the costly engraved plates of old atlases; and yet obtainable at a price within reach of most students.

Here is an example of the importance of a knowledge of processes of reproduction in illustrating, and of a proper understanding of the type of artistic work best suited to the representation of anatomical structures. By using photography as a basis for his figures, Sobotta has saved much time and labor, and has preserved correct proportions. He has not been satisfied with copying, in a superficial manner, merely general appearances; but has had the photographs worked over to secure contrast and emphasis in suitable places, so that the resulting figures exhibit great vigor and sharpness.

The free use of color has made it possible to bring out details in the background, without confusing the picture. This has resulted in satisfactory figures of a complexity rarely attempted before in this field. Very considerable artistic skill and understanding has been required to do this work, and for this the author thanks the artists who have assisted.

The figures may be criticized, as compared with Toldt's, for instance, as somewhat too plastic, as if drawn from models rather than specimens; structures are so extremely clean, and stand out so boldly; but it must be remembered that this is a part of the author's scheme. We think the slight exaggeration of relief and color and definiteness has not introduced any distortion of the facts of anatomy. The effect is to aid the student wonderfully to grasp the correct relations and to pick out special structures with ease. It is also certain that many of the effects which at first appear almost too clean and sharp in the atlas, can be reproduced in the actual dissections of good students with good material. The truth is, indefinite drawings are apt to be due to incompletely worked out dissections, and lack of accurate knowledge. With the pictures of this atlas before them students should be stimulated to dissect with a special degree of finish and thoroughness, and to carry away clear impressions.

After comparing the figures of Sobotta's atlas with those of recent American text-books of anatomy, it is evident that much unnecessary expense might have been avoided in these, by a simple reference to the beautiful figures of the atlas, or to those of Toldt or Spalteholz. It seems probable that for some time to come authors of such text-books will feel relieved of the burden and expense of constructing more figures like those of the atlases, and will turn their energies to more effective and discriminating treatment of the subject matter in their texts. The atlases will furnish students all necessary pictures for aid in their dissections, pictures far better than in the text-books. From time to time new figures of an elaborate character will be introduced into the atlases. These may take up special fields. The text-books may then refer to the standard figures of the atlases for descriptive purposes, and illustrate other aspects of the subject by original figures of less elaborate character. This will do away with much duplication, promote more individuality in the texts, and lead to more originality in the supplementary illustration of special phases of anatomy. Such figures as Corning has given for topographical relations are admirable for this purpose, and they are very helpful to students, on account of the insistence upon only those particular characters necessary to enforce the argument of the text. They furnish a good type of drawing for the student's own sketches.

By using colors lavishly Sobotta has been able to make several departures in presenting his subject. An examination of the figures of the skull in the first volume would suffice to show how wonderfully its complexities are simplified. The same color is used for a given bone whenever it is shown in combination with others, where the relations are complicated. Difficulties disappear at once, relieving the text of much explanation. All through the atlas the colors are combined very harmoniously. The same advantages are secured for the representation of ligaments and tendons ending in bone, or in differentiating muscles from tendons. Here we have a definiteness which stops short of becoming diagrammatic. The same is true in the plates showing muscles, fascia, etc. The red color selected for muscles is in good taste, and makes a fine contrast with the other tissues.

The lettering is exceptionally well done all through the atlas, and will serve as a model for future authors. Guide lines are kept inconspicuous and the italicized type is never over prominent. The lettering is written directly on the structures indicated in many places, yet in a style to avoid marring the figures.

Vol. II contains some effective figures of the teeth, where the deciduous set is colored white and the permanent blue. The peritoneum, mediastinum and cavities of the body are well treated. A number of colored sections of the trunk, showing the relations of the viscera, are especially to be noticed, as well as a number of good explanatory diagrams in the text.

It is in Vol. III perhaps that the author carries out his program to the best effect. The possibility of using a variety of colors has enabled him to show the arteries, veins and nerves of various regions all in the same picture, while the muscles, bones, tendons, fat, etc., are also clearly represented in appropriate colors; so that every structure stands out very sharply. The result is quite wonderful, even the finer plexuses and ramifications of vessels and nerves being easily identified at a glance. Refer for instance to the figures showing the terminal vessels and nerves of the hand or foot, or of the orbit. This feature of the atlas is quite original and will enable students to verify the details of their own dissections directly; without turning so frequently from plate to plate to identify nerves, arteries or veins, as is necessary in other atlases, to secure an idea of the relations in a given region. A much needed plate is one showing the superficial blood-vessels and nerves of the front of the thorax and abdomen. There should be a more complete figure of the cardiac plexus.

The figures of the brain are quite adequate with some good diagrams and sections; the cerebral sinuses are very well done in Figs. 589 and 679; and there are many beautiful figures of both eye and ear where the colors are of great service.

The character of the text has already been considered and does not require further notice here; though a few general sections, as those on the peritoneum and brain, are worthy of special attention. A prominent feature is the very systematic manner in which the matter is presented. Numerous references throughout the text to figures in works on embryology, as has been well done for histological details, are much to be desired. These could be placed in foot notes and would enable the student to find illustrations for many interesting relations merely suggested in this text. Reference to figures of Kollmann's atlas might suffice.

In the index, reference numbers should be given to the different figures in which each structure appears. This would be helpful, since the plates are not arranged in the order followed by the student in his dissection.

There should also be a short carefully classified list of references to a few journals, books and articles treating of the various aspects of anatomy; as variations, comparative anatomy, neurology, embryology, topographical anatomy, applied anatomy, etc.

It is a pleasure to congratulate Dr. McMurrich on providing American students and teachers with this book, and the publishers for the admirable manner in which they have done their work.

H. McE. Knower.

"EDINGER'S LECTURES ON THE CENTRAL NERVOUS SYSTEM, SEVENTH EDITION." [1]

The first edition of this work was based on a course of lectures delivered in 1883-84 and designed to present the more important architectural

[1]Edinger, L. Vorlesungen über den Bau der Nervösen Zentralorgane des Menschen und der Tiere. Seventh Edition. Band I, Das Zentralnervensystem der Menschen und der Säugetiere, 1904. Band II, Vergleichende Anatomie des Gehirns, 1908. Leipzig, F. C. W. Vogel.

features of the human brain to a medical audience presumably already familiar with the gross anatomy of the brain. The fifth edition (1896) included about 150 pages of systematic comparative neurology of lower vertebrates in addition to a considerably fuller treatment of the mammalian brain. The fifth edition differed from the earlier ones in that especial attention was devoted to the functional significance of the parts described, and the further development of this treatment in the seventh edition constitutes perhaps its most valuable feature. In the seventh edition both parts are still further enlarged and published in separate volumes, of which the first devoted to man and other mammals appeared in 1904, and the second devoted to lower vertebrates in 1908.

The first volume of the seventh edition is designed to serve as a textbook for medical students and practitioners and includes concise and very valuable summaries of the more important results of pathological and experimental anatomy as well as the normal functions of the parts. It includes also many new and very helpful illustrations.

The first four chapters are devoted to general neurological questions,—history and general methods of investigation of the nervous system, the anatomical and pathological consideration of ganglion cell and nerve in general and the neurone doctrine. Then follows a brief chapter on the development of the brain, after which the systematic treatment of the structure of the human spinal cord and brain is begun.

Emphasis is laid throughout on the conduction paths as giving the key to structure. In view of the functional standpoint chosen, it is surprising that the cranial nerve components are not grouped into functional systems and each of these co-ordinated with its cerebral center as an introduction to the anatomy of the medulla oblongata. Such a treatment is simple and didactically much preferable to the traditional method of describing successive levels as if these were natural segmental units. In fact the real morphological units tend to show longitudinal arrangements, as Edinger's numerous synthetic diagrams make very plain. The chief value of a series of figures of successive cross-sections through the oblongata (which is very great indeed) is in giving the orientation of these units and their peripheral connections.

This standpoint is in fact adopted in the second volume. The value of these concepts in the elucidation of the human medulla oblongata is quite as great as in the case of the lower vertebrates, upon which most of the literature on this subject has hitherto been based; and it is to be regretted that the author did not avail himself of his unique opportunity of giving his wider circle of medical readers the benefits of the same functional analysis which he has himself used in writing for the smaller circle of comparative anatomists in the second volume.

The gustatory system is treated (p. 146) in the way suggested; but not altogether satisfactorily. The common center of this system is the nucleus of the fasciculus solitarius (designated nucleus terminalis on Fig. 82). The facial and glossopharyngeal components of this system are correctly drawn. The vagal component which undoubtedly exists in man as in lower vertebrates (from taste buds in the pharynx and epiglottis) is mentioned in the text but not included in the figure. The fasciculus solitarius and its nucleus are figured as extending forward in undiminished volume from the facial level to that of the trigeminus, where they receive a gustatory component from the ramus lingualis trigemini. The prefacial fasciculus solitarius probably does not exist; if it does occur in man, it is certainly very much smaller than the postfacial portion. Fascicles of fibers have several times been described passing from the trigeminus root to the fasciculus solitarius. These, in my opinion, are fibers of tactile sense, probably concerned with the correlation of tactile and gustatory impressions from the mouth. I have described such a connection in fishes where a prefacial fasciculus solitarius is certainly absent. That gustatory impressions do not enter the brain by the trigeminus root is supported by the whole weight of comparative anatomy and by the best clinical and pathological observations on man after the destruction of the Gasserian ganglion.

Turning now to the second volume, we find that nearly one-half of its pages are devoted to the rhombencephalon and its peripheral connections. The treatment of these subjects has been revolutionized as compared with previous editions and even with the first volume of this edition. The first three chapters, devoted to the peripheral nerves and their development, were elaborated especially for this edition by Professor Froriep.

This discussion takes its departure from the now classic fourfold subdivision of the peripheral nervous system into somatic afferent and efferent and visceral afferent and efferent systems. The branchial nerves are classed with the visceral systems. Aside from the first and second nerves, two special sensory systems are also recognized, the acustico-lateral and gustatory. The morphological association of the nerves of the lateral lines with the VIII cranial nerve is on p. 11 incorrectly credited to the present writer, whereas the principle had been clearly stated many times before both by students of the peripheral and central connections of the cranial nerves. Mayser, in 1882, even went so far as to call these lateral line roots anterior and posterior auditory roots, on the basis of their central connections alone. Edinger recognizes that the acustico-lateral system stands in close relations with the somatic afferent system (p. 13); nevertheless he is unwilling to admit the genetic connection of the two systems of nerves (p. 11), thus ignoring or rejecting a large body of recent work both physiological (Parker) and anatomical (Johnston and others).

On page 12 the gustatory organs are classified as visceral receptors in conformity with recent American writers, and the cutaneous taste buds of certain teleosts are definitely mentioned as belonging to this system. But on page 90 the only physiological evidence known to me that these cutaneous organs of fishes have a gustatory function (my paper on the organ and sense of taste in fishes published in the Bulletin of the U. S. Fish Commission in 1904) is rejected.

The eye-muscle nerves are regarded as somatic motor and the evidence for this, we are told (p. 13), lies exclusively in their central relations—a remarkable statement in view of the fact that the eye-muscles are the only muscles of the head, except the hypoglossus musculature, which arise from typical somites, or segmented dorsal mesoderm, like the somatic muscles of the trunk.

The statement (p. 64) that in cyclostomes the vagus contains somatic motor elements which in higher animals are represented in the hypoglossus; ascribed to Johnston, does not accurately represent his position. On page 90 it is said that the IX cranial is a well-defined separate nerve only above the fishes. That it is quite as distinct in fishes as in higher animals is shown by the work of many anatomists from the days of Stannius until now. In the carp the terminal nucleus of its sensory root has, moreover, a special lobe, the lobus glossopharyngei, situated between the lobus vagi and the lobus facialis.

The various functional systems of components of the cranial nerves are clearly recognized and their embryological development sketched, but no satisfactory figure of their mutual relations is given. The diagram of the selachian nerves (Fig. 5) is very schematic and incomplete; and in fact the exact composition of the selachian nerves is less accurately known (pending the completion of Strong's examination) than that of several other species of fishes and amphibians (Petromyzon, Gadus, Pleuronectes, Menidia, Rana, Amblystoma, etc.), of which good figures are available.

The medulla oblongata is divided into functional regions or zones corresponding with the functional systems of peripheral nerve components and the fundamental value of these central functional units is clearly recognized (pp. 82 to 90), in this following the pioneer work of Strong, Kingsbury and later American students. This treatment is totally different from that of the earlier editions, and marks an advance which puts this part of Edinger's book ten years ahead of any other European work on the central nervous system. We have reached the point in cerebral anatomy where the medulla oblongata of vertebrates can be given a tolerably clear-cut morphological analysis based on functional relations. Much remains to be done here; but the general morphological plan of the rhombencephalon can be laid down more precisely than that of any other part of the brain.

Edinger's papers contain frequent references to the ganglion isthmi, but nowhere has he given a clear account of its structure and connections. The present work is even less satisfactory in this matter; several different structures in different animals are included under the name, with no adequate description of any one of them. On page 111 it is described in general and regarded as an association apparatus. The structure identified as ganglion isthmi in Petromyzon Professor Johnston informs me is an integral part of the tuberculum acusticum, being present in the whole length of that organ, and its efferent tract is a part of the primitive lemniscus system. In teleosts it is said (p. 135) to be feebly developed and to lie caudad of the "Rindenknoten" of Mayser (nucleus visceralis cerebelli of Johnston, superior secondary gustatory nucleus of Herrick). The latter structure is said to be totally lacking in most other vertebrates, and to be a differentiation from the frontal pole of the sensory trigeminus nucleus (p. 111). Accordingly, Edinger does not accept the conclusion of the American writers that the Rindenknoten is a secondary visceral nucleus, though he describes (p. 91) and figures its broad connection with the visceral centers of the oblongata through the "secondary vagus bundle" of Mayser and gives no precise account of any trigeminus connection whatever. As a matter of fact, the sensory trigeminus connections are very small or absent in all forms, though the connection with the motor V nucleus is always extensive. Furthermore, the size of the Rindenknoten varies directly with the size of the primary visceral sensory nuclei of the oblongata (and the range of this variation is extremely wide in teleosts), whereas it is independent of similar variations in the size of the primary trigeminal centers. This evidence, while greatly strengthened by recent American work, goes back to the time of Mayser in 1882, and is in fact mentioned by Edinger himself (p. 91).

Throughout the description of the brain Edinger makes the valuable distinction between the structures which are indigenous to the several regions (*Eigenapparat*) and the conducting elements which come into them from without (*Verbindungs-apparat*). This distinction might advantageously be more generally emphasized, both in research and instruction. Critical examination reveals many cases of loose description and confused terminology which sometimes baffle the experienced neurologist and make the work unnecessarily difficult for a beginner. Edinger's neglect of the BNA terms, even in the mammalian volume, gives the impression that it arises not so much from a desire to correct evident defects in that system as from mere carelessness. Failure to redraw old figures so as to bring their terminology into harmony with that of the newer ones and the text is also a source of much confusion, and sometimes of positive error.

For instance, in the description of the olfactory apparatus there are many inconsistencies. On page 252 of Vol. 2 the name lobus olfactorius is applied to the whole evagination surrounding the rhinocœle, and the name lobus parolfactorius to the whole basal olfactory area caudad of this. The term bulbus olfactorius is applied on page 253 only to the superficial formatio bulbaris (glomerular formation), but on the same page the tractus olfactorius is said to arise from the caudal and lateral pole of the round bulbus, so that one must infer that here the author includes the mitral and granular cell layers in addition to the glomerular layer in his bulbus, *i. e.,* the whole primary olfactory center. On page 255 the lobus olfactorius is defined as the terminal station of the olfactory tracts of the second order. But in a half-dozen or more of the figures the bulbus, or primary olfactory center, is marked lobus olfactorius. The lobus olfactorius as a secondary olfactory center would seem to be the same as the lobus parolfactorius, as defined above. But later the lobus parolfactorius of birds, reptiles and mammals (also called tuberculum olfactorium) is located behind the lobus olfactorius and given a very special interpretation.

After many fluctuations of usage, the author now divides the olfactory fibers of the second order into two groups (p. 266), one of which he designates tr. bulbo-epistratici, the other tr. bulbo-corticales (dorsales, ventrales et laterales). Since the secondary olfactory centers in which the latter fibers end should not all be called cortex, as we shall see beyond, it is preferable to retain the old usage and call all olfactory fibers of the second order tractus olfactorius (lateralis, medialis, epistriaticus, etc.), thus avoiding also the confusion of "bulbus" olfactorius in these compounds with "bulbus" as a synonym of medulla oblongata in similar compound names of tracts. Olfactory tracts of the third order arising in the secondary olfactory area may then be named in accordance with the usual custom after their terminal nuclei, such as tractus olfacto-habenularis, tr. olfacto-corticalis, etc.

Edinger in all of his writings has laid great stress on the constancy of the structure and fiber connections of the habenula throughout the whole vertebrate series. The forebrain connections of the habenula of reptiles and amphibians are in reality more nearly like those of mammals than Edinger's own acount would indicate. He applies the name tænia thalami to the stria medullaris, not adopting the recommendation of the BNA that the word tænia be applied to the line of union of the membranous roof with the massive side wall of the brain and never to a tract. In Vol. 1 he describes in the mammalian nervous system a "nucleus tæniæ" as a part of the secondary olfactory area between the bulbus olfactorius and the optic chiasma which he terms in different places variously, basal grey, baso-medial grey, area olfactoria, spatium olfactorium, lobus olfactorius, lobus parolfactorius and tuberculum olfactorium. The figures show that this nucleus lies really behind the lamina terminalis in the grey surrounding the preoptic recess and dorsally of the optic chiasma and is the same as the nucleus supraopticus of Kölliker's precise descriptions. From it arises the ventral component of the stria medullaris, or tr. olfacto-habenularis. This tract is in mammals always designated by Edinger as a part of the tænia thalami and in the lower vertebrates sometimes in this way and sometimes as tr. olfacto-habenularis. In mammals the stria medullaris is joined by a tract from the cerebral cortex via the columna fornicis (tr. cortico-habenularis) and by fibers connecting with the middle part of the thalamus (tr. habenulo-diencephalicus), and both of these tracts are present in reptiles and amphibians. In the frog my own examination shows that the tr. cortico-habenularis arises in two places, one part from the dorso-medial cortex and a much larger part from the occipital pole of the hemisphere. Edinger has incorrectly designated the latter part tr. olfacto-habenularis ("tænia") and its place of origin nucleus tæniæ (Fig. 189 of Vol. 2), notwithstanding the fact that it lies far laterally in the pallial part of the hemisphere and not in the basal grey about the preoptic recess. The presence of a true nucleus tæniæ in the frog in the typical position in the baso-medial grey is ignored by Edinger, which is the more surprising in view of the fact that this nucleus has been correctly described in the frog by Kappers, working in Edinger's own laboratory. Kappers, however, follows Edinger in placing the nucleus tæniæ in the occipital pole of the hemisphere, while he designates the true tr. olfacto-habenularis by the new and unnecessary name, tr. area-habenularis. On page 267 the same confusion of the ventro-medial nucleus tæniæ with a nucleus in the ventro-lateral wall of the hemisphere is made by Edinger in the description of the reptile brain.

In the analysis of the forebrain, like that of the medulla oblongata, the first and second volumes are so different in both nomenclature and fundamental principles that one has difficulty in correlating them. Since it is here that the comparative method should be expected to yield its most valuable results, we shall examine these chapters of both volumes in some detail.

In the subdivision of the cerebral hemisphere as given in Vol. 1 (p. 286) some radical departures from common usage are noted. There are three primary subdivisions: (1) baso-medial grey, closely associated with the lamina terminalis and extending both forward to include parts adjacent to the lamina terminalis (paraterminal body of Elliot Smith) and backward to the anterior wall of the infundibulum; (2) basal ganglion, or corpus striatum; (3) pallium, or the "whole wall of the hemisphere vesicle." "Pallium" as thus defined is divided into two fundamental divisions. The pallium basale is the oldest part of the forebrain. Just what this includes is nowhere clearly stated. It is said in front to receive the olfactory nerves, and in the same paragraph it is identified with the "lobi olfactorii." From the figures and context I assume it to include the olfactory bulb and the parts of the ventral wall of the hemisphere immediately adjacent, perhaps as far back as the optic chiasma. It thus covers ventrally the baso-medial grey and the corpus striatum. Dorsally of the basal pallium, in mammals forming the margin of the overlying roof of the forebrain and in some lower vertebrates forming the whole roof, is the pallium marginale, or hippocampal formation. The remainder of the wall of the forebrain vesicle is formed by neopallium. Elsewhere the term cortex is used apparently as synonymous with pallium in all of the senses given above.

Edinger adds, "Pallium basale (lobus olfactorius) and pallium marginale (formatio hippocampi) together have been called archipallium by Elliot Smith." This is a misquotation of Elliot Smith's writings so far as they are known to me. He applies the word rhinencephalon to the combined basal olfactory centers and hippocampus and limits the word archipallium to the hippocampus. Edinger's use of the terms pallium and cortex in Vol. 1, as applied to basal structures (in the olfactory bulb, "cortex olfactoria" over the lobus parolfactorius, etc.), is confusing and unfortunate, and it is to be hoped that it will not be generally adopted.

In Vol. 2 the most fundamental division of the brain separates the palæencephalon from the neencephalon. The latter includes what is generally designated pallium or cerebral cortex. It increases in amount as we ascend the vertebrate series and progressively effects more extensive connections with other parts of the brain. The palæencephalon is the basal mechanism of the brain and is relatively constant from the lowest to the highest vertebrates. The author even goes so far as to state in his introduction that from the most primitive vertebrates upward the palæencephalic parts of the brain are quite as highly developed as are the corresponding parts in mammals. This statement as it stands is manifestly incorrect. What he intends us to understand is probably that, if we abstract from the brain the cortex cerebri *and its dependencies,* the remainder is relatively constant. But these cortical dependencies, such as the pyramidal tracts, cerebellar hemispheres, pars optica of the thalamus, etc., are not included in his topographic definition of the neencephalon, as might very advantageously be done.

The precise limits of the palæencephalon are variously given in different places. Confusion is produced at the start by the obscure statement (p. 242), "From the purely palæencephalic anterior cerebral vesicle, the proencephalon, the neencephalic hemispheres evaginate, chiefly somewhat dorsally. The primitive anterior wall persists between them as the lamina terminalis." If this means that the lamina terminalis marks the boundary between the palæencephalon and the neencephalon, it would exclude the basal olfactory centers from the former. This, however, is clearly not the intent, for on page 249 the hemisphere in front of the lamina terminalis is divided into, (1) hyposphærium, or palæencephalic portion containing the olfactory bulb, olfactory lobe (secondary olfactory centers) and corpus striatum, and (2) episphærium. The latter appears first in well-defined form in the Amphibia, and here in its simplest form is defined as a new formation which receives olfactory fibers of the third order from the lobus olfactorius, and not secondary olfactory fibers like the hyposphærium. This criterion is of small value, for in all vertebrates there are numerous undoubtedly palæencephalic centers which receive olfactory tracts of the third order, and on the other hand, there is good authority for the belief that some olfactory fibers of the second order reach the hippocampal formation, even in the higher vertebrates, including man. We read further, "The episphærium is identical with the neencephalon" (p. 251), and "from the Reptilia onwards the expressions episphærium and pallium are employed as identical" (p. 295).

This definition of pallium is quite different from that employed in the description of the mammalian brain in Vol. 1, where the whole wall of the forebrain was called pallium; but the reader is not advised of this fact. The usage of Vol. 2 is certainly preferable; for it accords with general practice and, though we have as yet no thoroughly satisfactory morphological definition of pallium, nevertheless in mammals, at least, it can be tolerably well described anatomically as the free part of the forebrain wall dorsally of the massive basal part, which was, I believe, the original use of the term. Pallium may be applied to the whole thickness of this dorsal wall, whether massive or membranous; cortex, on the other hand, should be applied only to the grey superficial layer of the massive wall. It might perhaps be permissible to speak of a cortex of the bulbus olfactorius, tuberculum olfactorium or other basal structures, but certainly the name pallium should not be applied to these basal structures. And I think it preferable on account of the traditional associations of the word to limit the application of the term cortex cerebri to the pallium.

The relations of the epistriatum of amphibians, reptiles and birds to the structure so named in fishes is obscure. It receives as we pass up the series from fishes to mammals fewer secondary olfactory fibers from the olfactory bulb and progressively more olfactory fibers of the third order from the "cortex olfactoria" covering the olfactory lobe and parolfactory lobe, tr. olfacto-epistriaticus (cortico-epistriaticus of Edinger). In mammals its shrunken vestige is seen in the nucleus amygdalæ, the tænia semicircularis containing the tr. olfacto-epistriaticus.

The lobus parolfactorius, like the epistriatum, has evidently been differentiated phylogenetically within the secondary olfactory area, but it receives in addition to the olfactory tracts other important tracts from the lower brain regions, of which one of the most characteristic is the tr. quinto-frontalis from the terminal nucleus of the nervus trigeminus.

The lobus parolfactorius is a center of correlation for all of the sensory functions associated with the snout or muzzle, a combination of diverse sensory impressions which Edinger calls in the aggregate "oral sense." In birds it attains its greatest dimensions, and the tract from it to the epistriatum (tr. fronto-epistriaticus) is very large. In this tract functions other than olfactory evidently predominate, for the olfactory system is greatly reduced in birds. Since, then, the lobus parolfactorius is a correlation center for all of the senses connected with the snout and the act of mastication, this connection with the epistriatum suggests that the latter participates in the same functions.

The most important original contributions contained in this edition in my opinion are found in the chapters on the forebrain in the second volume. The problem of the phylogeny of the cortex cerebri is given a new phase by the suggestion that the archipallium arose, not as a purely olfactory center, but as an outgrowth of a center of correlation between olfactory and other afferent impressions from the snout in the parolfactory lobe and epistriatum. The penetration of secondary tactile, somæsthetic and other sensory systems into the forebrain for ease of correlation with the secondary olfactory centers was, accordingly, the point of departure for the evolution of the cerebral cortex. The author's studies on the phylogeny of the cortex and some interesting applications to comparative psychology with which the second volume closes are developed more at length in an address recently delivered and about to appear in English translation in the Journal of Comparative Neurology and Psychology.

This work, particularly the second volume, represents very largely the work of Edinger's own laboratory, and the breadth of the field covered and great mass of detail presented give testimony to the immense labor involved. His figures are nearly all original, and the facts presented are mostly either new or personally verified by the author or his staff. This, which is the pre-eminent merit of the work, is at the same time the source of its greatest weakness, chief of which is, perhaps, a fondness for loose generalizations of an impressionistic sort which give the reader a broad view over the subject, but require so much qualification as soon as attention is directed to details as seriously to impair their value. The loose and variable use of descriptive names brings this defect into unfortunate prominence.

These defects are, it is true, to a large extent inherent in the nature of the subject. Comparative neurology has been and is extremely difficult because of the fragmentary nature of the mass of intricate detail and the lack of co-ordinating principles. At the present moment the science is in a transitional state growing out of the rapid elaboration of functional units in morphology, and the reformulation of old static anatomical elements in terms of these units must necessarily be a slow process. But this reformulation is well under way and the renaissance of comparative neurology has already come.

One should also bear in mind that in the preface of the first edition of his lectures Professor Edinger forewarned his readers that statements might sometimes be made in more dogmatic form than the facts at hand fully justify. No doubt too great advantage has at times been taken of this liberty. It is, however, true that this is one of the elements of Edinger's brilliant literary style which has had no small influence in popularizing the concepts of comparative neurology and emphasizing their great value to human neurologists. Because of the far-reaching influence which Edinger as a pioneer and notable exponent of the comparative point of view has exerted and will continue to exert I have chosen in this review to point out some of the imperfections of this book rather than to dwell exclusively on its obvious excellences, thus hoping to do a service to both reader and author, for Edinger's lectures will long continue to be, as they have been, a standard reference work for all neurologists.

C. Judson Herrick.

"Human Anatomy, including Structure and Development and Practical Considerations," by Thomas Dwight, Carl A. Hamann, J. Playfair McMurrich, George A. Piersol and J. William White. With 1734 illustrations, of which 1522 are original and largely from dissections by John C. Heisler. Edited by George A. Piersol. Philadelphia and London: J. B. Lippincott Company, 1907. Price, $7.50. 2088 pages.

In this, the first complete text-book of human anatomy of any considerable importance written and produced in this country entirely by American authors, a distinct step in advance has been attained that must be gratifying to all American anatomists. We are no longer dependent upon England or Germany for a text-book of the first rank. Quain's Anatomy has been for many years the best standard work in English, and to equal or excel it is indeed a difficult task, yet we feel that this new work approaches its excellence in many respects. Piersol's Anatomy is the only American work which covers the same ground as does the Quain, including descriptive anatomy, histology, embryology, neurology and practical anatomy. The two anatomies are of about the same length, the Piersol containing a few more pages. In general arrangement, however, they differ in that in Quain the embryology, histology, descriptive anatomy and practical considerations are in separate volumes, while in the Piersol these subjects are treated for the most part in the sections devoted to the various systems of the body, and the whole bound in one volume. There are certain advantages and disadvantages in this scheme, but it serves the purpose somewhat needed in this country of emphasizing the fact that the field of anatomy is not limited merely to the dissection of the human body. Students in embryology or histology, however, may find it rather inconvenient to carry about such a large book when using only a small part.

In reviewing a book of this size, some 2088 pages, the reviewer can scarcely be expected to read every page, much less attempt to indicate either all its virtues or defects. But during the past winter I have had frequent occasion to consult the text, which has proved excellent and concise, while its use by a number of my students to their entire satisfaction indicates that it will soon be widely and extensively used in this country.

The editor points out in his preface that three chief considerations were in mind in the preparation of the work. (1) "The presentation of the essential facts of human anatomy in its broadest sense by a descriptive text which while concise should be sufficiently comprehensive to include all that is necessary for a thorough understanding not only of the gross appearances and relations of the various parts of the human body, but also of their structure and development." In this he has been assisted by several distinguished American teachers. Dr. Thomas Dwight has written the description of the skeleton including, along with the various bones, the joints and ligaments, certain anthropological data and statistics of sex differences. Prof. Dwight's numerous osteological contributions render him especially suited to deal with this section, which is quite complete, covering some 350 pages of carefully prepared text and clear-cut illustrations. Professor Dwight has also contributed the account of the gastro-pulmonary system and of the accessory organs of nutrition.

Prof. J. Playfair McMurrich in his treatment of the muscular system has classified them upon a morphological basis; their embryological significance forming the guide for the arrangement in the following groups: I. The branchiometric muscles arising from the mesoderm of the branchial arches, including (a) trigeminal, (b) the facial, and (c) the vago-accessory with the trapezius and sterno-mastoid muscles. II. The metameric muscles, divided into two main groups, the axial and appendicular. The inclusion of the orbital muscles with the metameric axial musculature has not at present sufficient embryological support nor is there direct evidence that the hypoglossal musculature is metameric in origin. This classification is the most logical and satisfactory for a systematic text. The blood- and lymph-vascular systems were written by the same author.

Prof. Carl A. Hamann contributed the account of the cerebro-spinal nerves and sympathetic system. Dr. George A. Piersol has written the introduction, the histological and embryological paragraphs, as well as the account of the central nervous system.

There is thus combined in this one carefully written volume sufficient histology, embryology, neurology and gross anatomy to carry the medical student through these subjects. It is quite remarkable that the publishers are able to sell the volume for $7.50, which is less than one-half the cost of Quain's Anatomy. This very remarkable price will contribute much to the success of the book.

The second consideration, "adequate emphasis and explanation of the many and varied relations of anatomical details to the conditions claiming the attention of the physician and surgeon," has been adequately treated by Dr. J. William White, a surgeon and teacher of anatomy. The various sections dealing with these practical applications of anatomy are scattered in their appropriate places throughout the book and are both helpful and valuable to the student, diverting to a certain extent his attention to that side of anatomy with which he must become more familiar later on in his medical course.

The great number of original illustrations gives distinct character to the book. It must have been an enormous task to have executed such a large number of drawings, and one wonders if it would not have been better to have drawn more upon those already in existence, of which there are many of equal excellence. To one familiar with the wonderful illustrations in the atlases of Sobotta, Toldt and Spalteholz there is a feeling of disappointment that the figures in Piersol have not greater clearness and depth. This is possible even in text figures, and that, too, without departing from faithful records of actual dissections. The details in many of the figures, especially at the periphery, are not carefully worked out and often are mere smudges, as in Figs. 506, 507, 570, 590, 598, 619, and many others. Again, in many of the figures illustrating the blood vessels the muscular and skeletal background lacks the clearness and detail to enable one easily to recognize the relations. The figures of the peripheral nerves are subject to even greater criticism. The diagrams of the plexuses and anastomoses are quite too crude, while the nerves in many of the more elaborate figures are so indistinct that often only by very close and careful attention can one identify the smaller branches (Figs. 1082, 1079, 1084, 1087, 1088, 1090, 1137, 1138, etc.), while the background and relations are often miserable. One depends greatly on figures when looking hastily for small points, and I have often found it necessary to turn to figures in other books, not because the views are not well chosen, but because the artist has often failed to draw with the eye of an anatomist.

The day has come, I think, when American anatomists can no longer neglect the BNA terminology. Its partial use in the last edition of Morris by McMurrich is a step in the right direction, but would have been more effective had it been used as completely as in Barker's translation of Spalteholz. The question of the Latin or of the English translation is perhaps unimportant, but as the BNA is international, it would seem advisable to adhere strictly to the Latin terms. The editor in his preface states that he gave very earnest consideration to the question of terminology, and concluded that the retention for the most part of the terms in use by the English-speaking anatomists and surgeons would best contribute to the usefulness of the book. Many of the BNA terms appear in the text as synonyms having a special type. The changes from our English terminology to the BNA are neither so great nor so numerous as to introduce much confusion, and as the BNA norm is used it would have added to the book had this terminology also been used throughout with the occasional use of the English synonym in parenthesis. The use of anterior for ventral and posterior for dorsal, for example, has led to much confusion and should be discarded.

We regret that more references to the literature have not been added. Such references are extremely valuable to the student, and as an introductory method into the literature serve as a distinct educational feature. The anatomy as a whole is a decided success, and the editor and his collaborators are to be congratulated for giving us a truly first-class text-book. *W. H. Lewis.*

NOTES AND APPOINTMENTS.

Retirement of Professor Simon Henry Gage from the Chair of Histology and Embryology in Cornell University.

At the end of the academic year, June, 1908, Professor S. H. Gage of Cornell University took advantage of the provision in the Carnegie Foundation for the Advancement of Teaching, which gives a retiring allowance after 25 years of professorial service. He was appointed instructor in Histology and Embryology at Cornell in 1878, assistant professor in 1881, associate in 1889, and full professor in 1895; he has thus been actively engaged in university instruction for 30 years. As this is, as far as we know, the first instance of a retirement under the Carnegie Foundation, by a man in the prime of life for the purpose of scientific research, it is an event of importance not exclusively for the development of anatomy in this country, but in the wider field of the development of scientific medicine. The establishment of the system and its use for the sake of research represent a real demand for more opportunities for scientific investigation.

It seemed to Professor Gage that perhaps he could be of greater service to his institution and to others by giving up teaching and devoting himself for the remaining years of active life to the completion of some of the investigations begun during his teaching career; for, as teachers well appreciate, the time for working out difficult investigations is altogether inadequate in the college vacations and during an occasional sabbatical leave. It can be readily seen that the retirement of a teacher in charge of a department at the age of 57 for the purposes of investigation might give rise to an attitude of disapproval on the part of the institution with which he was connected. But far from this, the President and Trustees of Cornell University, while they express great regret at the loss of an efficient teacher in the regular instruction of the university, showed their sympathy and hearty appreciation of the value of Professor Gage's work for the university in a most substantial form.

He was made Professor of Histology and Embryology, Emeritus, and there was placed under his sole charge for the purposes of his investigations a fully equipped, well lighted laboratory. The equipment includes microscopes, microtomes, and the apparatus needed for work in histology and embryology; a full outfit for gross- and micro-photography; a projection microscope, a dark room for drawing and photography; and also about 15,000 slides of serial sections, histologic and embryologic material which he has been collecting for the last ten years for the purposes of investigation. However, space and means for instruction and investigation in the teaching department remained intact and included among other things an abundance of microscopes and microtomes, a photographic room with full outfit, a projection microscope for class-room demonstrations and another in a special room for study and drawing. Also over 28,000 permanent microscopic preparations in histology and serial sections of the central nervous system and of embryos.

The University Trustees also promised an annual appropriation for the purchase of apparatus and specimens and for the ordinary running expenses of a laboratory; and granted him the privilege of occupying his house on the campus under the same conditions as an active teaching professor. These substantial grants were accompanied by a note stating that "it is the ardent desire of the university to encourage investigation," and while regret was expressed that the instructing staff of the University was to lose a devoted teacher, gratification was felt that Professor Gage was to retain his connection with the university and carry on investigations within its walls.

In making the retiring allowance the Carnegie Foundation showed its liberal spirit in the following communication from President Pritchett: "In communicating this action the Executive Committee desires that you [President Schurman] will extend to Professor Gage the assurance of the high esteem which the Executive Committee has of his work in research and their best wishes for many years of fruitful work in his chosen field."

As Professor Gage is giving up active teaching it will not be out of place to mention his great success as a teacher. During the past 30 years, he has personally instructed in the laboratory about 2,000 students. Many of these students have continued their scientific activity and have published scientific papers. To illustrate the wide scope of the students who have come under Professor Gage's influence, or, as he would put it, whom he has had the good fortune to instruct, the following list is added:

Dr. Hermann M. Biggs.—University and Bellevue Medical College. On Board of Directors of the Rockefeller Institute for Medical Research.

Donaldson Bodine, Ph.D.—Professor of Zoölogy, Wabash College.

Samuel H. Burnett, M.S., D.V.M.—Assistant Professor in Comparative Pathology in the New York State Veterinary College.

Dr. Fred C. Bush.—Professor of Physiology, University of Buffalo, N. Y.

Ralph V. Chamberlain, Ph.D.—Professor of Biology, University of Utah.

E. M. Chamot, Ph.D.—Assistant Professor of Sanitary Chemistry, Cornell University.

Mrs. Anna Botsford Comstock, B.S.—Lecturer in Cornell University; Artist and Author, Ithaca.

Dr. Henry P. De Forest.—Professor in Post-Graduate Medical College, New York.

E. J. Durand, Ph.D.—Instructor in Botany, Cornell University.

E. P. Felt, Ph.D.—State Entomologist, Albany, N. Y.

Margaret C. Ferguson, Ph.D.—Professor of Botany, Wellesley College, Mass.

Dr. Pierre A. Fish, D.Sc., D.V.M.—Professor of Physiology and Pharmacology, New York State Veterinary College, Ithaca, N. Y.

Louis Agassiz Fuertes, A.B.—Scientific Artist, especially birds.

Mrs. Susanna Phelps Gage, Ph.B.—Investigator, Ithaca, N. Y.

William A. Hilton, Ph.D.—Pomona College, Cornell University, Histology and Embryology.

Prof. J. A. Holmes.—University of North Carolina; State Geologist North Carolina; in charge of U. S. Geological Survey for testing fuels and structural materials.

Grant S. Hopkins, B.S., D.V.M., Ph.D.—Professor of Anatomy in New York State Veterinary College, Ithaca.

L. O. Howard, Ph.D.—United States Entomologist, Washington, D. C.

Ida H. Hyde, Ph.D.—Professor of Physiology, University of Kansas.

Dr. W. H. Jordan.—Director of the New York State Agricultural Experiment Station, Geneva, N. Y.

Dr. A. T. Kerr.—Professor of Anatomy, Cornell University Medical College, Ithaca, N. Y.

B. F. Kingsbury, Ph.D., M.D.—Professor of Histology and Embryology, Cornell University, Ithaca, N. Y. Professor Gage's successor.

William C. Krauss, B.S., M.D.—Physician and Scientific Writer.

S. E. Meek, Ph.D.—Investigator in Field Museum of Natural History, Chicago, Ill.

A. D. Macgallivray, Ph.D.—Assistant Professor of Entomology, Cornell University.

Dr. Robert O. Moody.—Associate Professor of Anatomy, University of California.

Mrs. Agnes Claypole Moody, Ph.D.—University of California (Wife of Dr. Moody).

Dr. V. A. Moore.—Director of New York State Veterinary College, Ithaca, N. Y.

Dr. Burton D. Myers.—Professor of Anatomy, University of Indiana.

J. G. Needham, Ph.D.—Assistant Professor of Limnology, Cornell University.

H. W. Norris, Ph.D.—Professor of Zoölogy, Iowa College, Grinnell, Iowa.

Dr. Leonard Pearson.—State Veterinarian of Pennsylvania; Professor of Medicine and Dean of the Veterinary Department of Pennsylvania.

Effie A. Read, Ph.D.—Author of Olfactory Apparatus, Journal of Anatomy, Washington.

J. E. Rice, B. S.—Professor of Poultry Husbandry, New York State College of Agriculture, Cornell University.

W. W. Rowlee.—Professor of Botany, Cornell University.

Prof. M. V. Slingerland.—Entomologist, Cornell Experimental Station.

Theobald Smith, M.D., LL.D.—Professor of Comparative Pathology, Harvard.

Prof. H. E. Summers.—Entomologist, Ames, Ia.

Dr. R. J. Terry.—Professor of Anatomy, Washington University, St. Louis.

Prof. M. B. Thomas.—Professor of Botany, Wabash College, Ind.

William Trelease, S.D., LL.D.—Director of Missouri Botanical Garden.

Dr. Charles G. Wagner.—Superintendent of the State Hospital for the Insane, Binghamton, N. Y.

L. B. Walton, Ph.D.—Professor of Biology, Kenyon College, Ohio.

C. D. White.—Paleobotanist, United States Geological Survey.

Dr. Wm. A. White.—Superintendent United States Insane Hospital, Washington.

Dr. J. M. Wilson.—Histology and Embryology in St. Louis University.

H. H. Wing, M.S.—Professor of Animal Husbandry, New York State College of Agriculture, Cornell University.

One especial feature of Professor Gage's class work came from his thorough understanding of optical apparatus, which made it very natural that he should begin his course with a few periods devoted to a study of the principles involved in the construction of the microscope and the character of the image secured by it. It also made it very natural that he should develop the use of the projection apparatus in his lectures in a most effective manner. He has the reputation of being a very pleasing lecturer. Professor Gage has seen the development of microscopic technique; he began his work without paraffin or celloidin sections, or microtomes or aniline dyes. He has not only made himself a master of technique, but, what is quite different, has the power of training the men about him to become excellent technicians. This skill has brought to him many special students; for example, teachers of biology, physicians, Government employees, specialists in botany, chemistry, entomology, medicine, nature study, veterinary medicine and zoölogy, all of whom came because they could get training in microscopic work. Everyone who has taught histology is indebted to Professor Gage for his publications on technique. His suggestions for class work are always feasible, and are so carefully worked out that they can be readily followed.

The following is a list of Professor Gage's contributions and addresses. It makes one wish to extend congratulations to Professor Gage and to Cornell University that he has now a full opportunity for research while yet in the prime of life.

With Dr. Wilder, anatomical technology.

The microscope, and introduction to microscope methods, and to histology, 1st ed., 1881, 10th ed., 1908. Comstock Publishing Company, Ithaca, N. Y.

Muscular tissue in Buck's Ref. Hand Book Med. Sciences.

The lymphatic system. Buck's Ref. Hand Book Med. Sciences.

The lake and brook lampreys of New York. The Wilder Book.

Life history of the toad. New York State Nature Study Leaflets, 1898-1900.

With Dr. Kingsbury, vertebrate histology. 1899. Comstock Publishing Company, Ithaca, N. Y.

1878-1879. The ampulla of Vater and the pancreatic ducts in the cat. *Amer. Quart. Micr. Journal,* vol. i.

1879. The inter-articular ligaments of the head of the ribs in the cat. Proc. Amer. Assoc. Adv. Sc., vol. xxviii.

1882. Observations on the fat-cells and connective-tissue corpuscles of Necturus. Amer. Soc. Micr. Proc., vol. iv.

1883. Pharyngeal respiration in the soft-shelled turtles. Proc. Amer. Assoc. Adv. Sci., vol. xxxii; and in W. K. Parker's Mammalian Descent.

1885. The limitations and value of histological investigation. Address Amer. Assoc. Adv. Sci. Section of Microscopy and Histology, 1.

1886. Amœboid movement in the nucleus of the white blood corpuscles of Necturus. *Science,* vol. vii, p. 146.

1887. Microscopical tube-length. Information from manufacturers which has led to the adoption of a nearly uniform tube-length.

1888. The form and size of the red blood corpuscles of adult and larval lamprey eels. *N. Y. Med. Jour.,* xlviii, Proc. Amer Micr. Soc., x, 1889.

1889. With S. P. Gage. Staining and permanent preservation of histological elements isolated by means of caustic potash and nitric acid. First publication of a method for permanent preservation of caustic potash preparations. Proc. Amer. Micr. Soc., xi.

1891. Life history of the vermillion spotted newt, Diemyctylus, This paper demonstrated that the red form was simply a stage, not a variation. *Amer. Naturalist,* vol. xxv.

1892. Comparative physiology of respiration. Address before the section of Biology, Amer. Assoc. Proceedings, xli.

It was shown in this that in combined respiration, *i. e.,* part aquatic, part aerial, the aquatic serves mainly to rid the organism of CO_2 and the aerial to supply O.

1895. The processes of life revealed by the microscope, a plea for physiological histology. Address as President Amer. Micr. Soc., Proceedings, vol. xvii, and Report of Smithsonian Institution, 1896.

1896. Zoölogy as a factor in mental culture. National Ed. Assoc., 35th annual meeting.

1898. Transformation of the brook lamprey (Lampetra wilderi) and parasitism among lampreys.

In this paper it was shown that the brook lampreys are never parasitic, although having all the structures therefor the same as the lake or sea lamprey. It was suggested that they have "reformed," ceased to be parasitic. Proc. Amer. Adv. Sc.

1898. Relation of the ureters and the great veins in the cat. Proc. Amer. Anatomists.

1899. The importance and the promise in the study of the domestic animals. Address Amer. Assoc. Adv. Sc. Section of Zoölogy.

1899. Some laboratory apparatus. Proc. Amer. Micr. Soc. (xxi).

In this paper are figured and described the trays for ribbons of sections and for slides devised in 1897.

1900. Development of the lungs in the toad and tree-toads. It was shown that the lungs develop as a single solid proton, becoming forked and hollow in larval life, but not opening into the pharynx till during the transformation period. Proc. Amer. Assoc. Adv. Sc., xlix.

1904, 5, 6, 7, 8. Glycogen in the nervous system. Proceedings of the Association of American Anatomists.

1906. The origin and development of the projection microscope. Proceedings of the Amer. Micr. Soc., Presidential address.

Besides the above there are forty to fifty small papers on various subjects, many of them methods in microscopy and histology.

Announcement of the Twenty-fourth Session of the Association of American Anatomists.

The twenty-fourth session of the Association of American Anatomists will be held in the Anatomical Laboratory of Johns Hopkins University during the week beginning December 27, 1908, and ending January 2, 1909, in affiliation with the American Association for the Advancement of Science and other Affiliated Scientific Societies. The definite dates for this meeting, details concerning rates, headquarters for the Association, etc., will be given in the preliminary program.

Members of this Association desiring to present papers or give demonstrations should notify the Secretary at a date as early as possible, in any event, not later than December 15th. A prompt reply will enable the Secretary to print and distribute a preliminary program some days before the meeting, and to comply with a request received from Dr. L. O. Howard, to have the program of this Association printed in the general program of all the societies meeting at this time and place. Demonstrations have, for a number of years, formed so prominent a part of the program that their desirability has been well established. It is thought that they might be made more effective if a definite program of demonstrations could be arranged, and a definite hour assigned to each demonstration. This cannot be done unless members will notify the Secretary at an early date of their desire to give a demonstration, giving title, and mentioning space and apparatus needed.

The limited time at the disposal of the Association for the reading of papers and the usual fullness of the program make it desirable that the papers presented be abridged as much as possible. With the ready means now at the disposal of this Association for the publication of papers, it would seem desirable that, so far as possible, the communication be given in the form of full abstracts, the members relying on an early publication for the full papers. Members are urged to bear this in mind in preparing communications.

It is hoped that a general discussion may be arranged for this meeting. The reading of papers will begin promptly after the first meeting is called to order. The business meeting will be held the second afternoon of the session, otherwise the afternoons are reserved for demonstrations.

Members are invited to propose for membership in this Association persons eligible thereto. The necessary information regarding eligibility and the manner of proposing members is contained in Article V of the constitution, which reads: "Candidates for membership must be persons engaged in the investigation of anatomical or cognate sciences and shall be proposed in writing to the Executive Committee by two members, who shall accompany the recommendation by a list of the candidate's publications, together with references. The election shall take place in open meeting, a two-thirds vote being necessary." Application blanks may be obtained from the Secretary, and when filled out may be returned to him, who will present the same to the Executive Committee for consideration.

Members with dues in arrears are requested to meet their obligations at an early date. In view of the fact that annual dues of members of this Association include subscription to The American Journal of Anatomy and to The Anatomical Record, now published by the Wistar Institute of Anatomy, it becomes eminently desirable that members in arrears pay their dues, in order that the account of this Association with the Wistar Institute, for the present fiscal year, may be closed.

Members are requested to consult the list of members with titles and addresses found in this issue of The Anatomical Record to see whether their name, title, and address are correctly given. If not, the Secretary requests that he be communicated with at an early date, and the necessary correction indicated.

G. Carl Huber, *Secretary-Treasurer,*
1330 Hill Street,
Ann Arbor, Mich.

ASSOCIATION OF AMERICAN ANATOMISTS

Constitution, Officers and List of Members

Constitution.

ARTICLE I.

Section 1. The name of the Society shall be the "Association of American Anatomists."

Section 2. The purpose of the Association shall be the advancement of anatomical science.

ARTICLE II.

The officers of the Association shall consist of a President, two Vice-Presidents, and a Secretary, who shall also act as Treasurer. The officers shall be elected by ballot every two years.

ARTICLE III.

The management of the affairs of the Association shall be delegated to an Executive Committee, consisting of seven members, including the President and Secretary, ex-officio. One member of the Executive Committee shall be elected annually.

ARTICLE IV.

The Association shall meet annually, the time and place to be determined by the Executive Committee.

ARTICLE V.

Section 1. Candidates for membership must be persons engaged in the investigation of anatomical or cognate sciences and shall be proposed in writing to the Executive Committee by two members, who shall accompany the recommendation by a list of the candidate's publications, together with the references. The election shall take place in open meeting, a two-thirds vote being necessary.

Section 2. Honorary members may be elected from those not American who have distinguished themselves in anatomical research.

ARTICLE VI.

The annual dues shall be five dollars. A member in arrears for dues for two years shall be dropped by the Secretary at the next meeting of the Association, but may be reinstated, at the discretion of the Executive Committee, on payment of arrears.

ARTICLE VII.

Section 1. Five members shall constitute a quorum for the transaction of business.

Section 2. Any change in the constitution of the Association must be presented in writing at one meeting in order to receive consideration and be acted upon at the next meeting; due notice of the proposed change to be sent to each member at least one month in advance of the meeting at which such action is to be taken.

Section 3. The ruling of the Chairman shall be in accordance with "Roberts' Rules of Order."

Orders Adopted by the Association.

Newly elected members must qualify by payment of dues for one year within thirty days after election.

The maximum limit of time for the reading of papers shall be twenty minutes.

The Secretary and Treasurer shall be allowed his traveling expenses and the sum of $10 toward the payment of his hotel bill, at each session of the Association.

That the Association discontinue the separate publication of its proceedings, and that the American Journal of Anatomy be sent to each member of the Association, on payment of his annual dues, this journal to publish the proceedings of the Association, including an abstract of the papers read.

Contributors of papers are requested to furnish the Secretary with abstracts within a fortnight after the meeting.

OFFICERS.

President................James Playfair McMurrich.
First Vice-President...............William S. Miller.
Second Vice-President..............Florence R. Sabin.
Secretary and Treasurer...............G. Carl Huber.

Executive Committee.

Charles S. Minot..........For term expiring in 1908.
Charles R. Bardeen.........For term expiring in 1909.
Thomas G. Lee.............For term expiring in 1910.
Simon H. Gage..............For term expiring in 1911.
Robert R. Bensley..........For term expiring in 1912.

Committees.

Member of the Committee of Arrangements of the International Congress of Anatomy for 1910.

Charles S. Minot, with Franklin P. Mall, *alternate.*

American Members of the International Committee on Reformation of the Myological Nomenclature.

J. Playfair McMurrich, Ross G. Harrison.

Delegate to the Council of the American Association for the Advancement of Science.

Simon H. Gage.

Member of Smithsonian Committee on the Table at Naples.

George S. Huntington.

On Revision of the Constitution.

G. Carl Huber, Henry H. Donaldson, Robert R. Bensley.

Honorary Members.

S. Ramón y Cajal....................*Madrid, Spain.*
John Cleland......................*Glasgow, Scotland.*
John Daniel Cunningham.......*Edinburgh, Scotland.*
Camillo Golgi..........................*Pavia, Italy.*
Oscar Hertwig.......................*Berlin, Germany.*
Alexander Macallister..........*Cambridge, England.*
A. Nicolas.............................*Paris, France.*
L. Ranvier.............................*Paris, France.*
Gustav Retzius..................*Stockholm, Sweden.*
Carl Toldt..........................*Vienna, Austria.*
Sir William Turner..............*Edinburgh, Scotland.*
Wilhelm Waldeyer.................*Berlin, Germany.*

MEMBERS.

Addison, William Henry Fitzgerald, B. A., M. B., Demonstrator of Histology and Embryology, Medical Department, University of Pennsylvania, *3928 Pine Street, Philadelphia, Pa.*

Allen, Bennet Mills, Ph. D., Instructor in Anatomy, University of Wisconsin, *310 Muray Street, Madison, Wis.*

Allen, William F., A. M., *Pacific Grove, California.*

ALLIS, EDWARD PHELPS, JR., LL. D., Associate Editor of Journal of Morphology, Milwaukee, Wis., *Palais de Carnoles, Mentone, France.*

ALLISON, NATHANIEL, M. D., Instructor in Orthopedic Surgery, Washington University, *Linmar Building, St. Louis, Mo.*

BAETJER, WALTER ALBERT, A. B., Johns Hopkins Medical School, *Baltimore, Md.*

BAKER, FRANK, A. M., M. D., Ph. D., Professor of Anatomy, Medical Department, University of Georgetown, *1728 Columbia Road, Washington, D. C.*

BALDWIN, WESLEY MANNING, Instructor in Anatomy, Cornell University Medical School, *Stimson Hall, Ithaca, N. Y.*

BARDEEN, CHARLES RUSSELL, A. B., M. D., Professor of Anatomy, University of Wisconsin, *Science Hall, Madison, Wis.*

BARKER, LEWELLYS FRANKLIN, M. D., Professor of Medicine, Johns Hopkins University, *6 E. Franklin Street, Baltimore, Md.*

BATES, GEORGE ANDREW, M. S., Professor of Histology, Tufts College, Tufts College Medical School, *Huntington Avenue, Boston, Mass.*

BAUMGARTNER, WILLIAM J., A. M., Assistant Professor of Histology and Zoölogy, University of Kansas, *Lawrence, Kan.*

BEAN, ROBERT BENNETT, B. S., M. D., Professor of Anatomy, Medical School, *Manila, P. I.*

BELL, ELEXIOUS THOMPSON, B. S., M. D., Assistant Professor of Anatomy, University of Missouri, *Columbia Club, Columbia, Mo.*

BENSLEY, BENJAMIN ARTHUR, Ph. D., Associate Professor of Zoölogy, University of Toronto, *316 Brunswick Avenue, Toronto, Canada.*

BENSLEY, ROBERT RUSSELL, A. B., M. B., Professor of Anatomy, University of Chicago, *Chicago, Ill.*

BEVAN, ARTHUR DEAN, M. D., Professor of Surgery, Rush Medical College, University of Chicago, *100 State Street, Chicago, Ill.*

BIGELOW, HENRY B., A. M., Ph. D., Assistant in Museum of Comparative Zoölogy, *Cambridge, Mass.*

BLAIR, VILRAY PAPIN, A. M., M. D., Lecturer on Descriptive Anatomy and Demonstrator of Anatomy, Medical Department, Washington University, *3729 Delmar Boulevard, St. Louis, Mo.*

BLAKE, JOSEPH AUGUSTUS, A. B., M. D., Professor of Surgery, College of Physicians and Surgeons, Columbia University, *601 Madison Avenue, New York City, N. Y.*

BONNOT, EDMOND, A. B., Assistant in Anatomy, University of St. Louis, *Corner Grand and Caroline Streets, St. Louis, Mo.*

BREMER, JOHN LEWIS, M. D., Harvard Medical School, *416 Beacon Street, Boston, Mass.*

BRICKNER, SAMUEL MAX, A. M., M. D., Gynecologist to Mt. Sinai Hospital Dispensary (N. Y.); Special Student in Anatomy, College of Physicians and Surgeons, Columbia University, *136 W. 85th Street, New York City, N. Y.*

BRIGHT, J. FULMER, M. D., Professor of Anatomy, Medical College of Virginia, *408 W. Grace Street, Richmond, Va.*

BRÖDEL, MAX, Associate Professor of Art as Applied to Medicine, Johns Hopkins Hospital, *Baltimore, Md.*

BROOKS, WILLIAM ALLEN, M. D., *167 Beacon Street, Boston, Mass.*

BROWNING, WILLIAM, Ph. B., M. D., Professor of Diseases of the Mind and Nervous System, Long Island College Hospital, *54 Lefferts Place, Brooklyn, N. Y.*

BRUNER, HENRY LANE, Ph. D., Professor of Biology, Butler College, *360 South Ritter Avenue, Indianapolis, Ind.*

BUNTING, CHARLES HENRY, B. S., M. D., Professor of Pathology, University of Wisconsin, *Madison, Wis.*

BURROWS, MONTROSE I., *1408 E. Biddle Street, Baltimore, Md.*

CAMPBELL, WILLIAM FRANCIS, A. B., M. D., Professor of Anatomy and Histology, Long Island College Hospital, *86 Green Avenue, Brooklyn, N. Y.*

CARPENTER, FREDERIC WALTON, Ph. D., Instructor in Zoölogy, University of Illinois, *1013 West California Avenue, Urbana, Ill.*

CARR, WILLIAM PHILLIPS, M. D., Professor of Physiology, Medical Department, Columbian University, *1418 L Street, N. W., Washington, D. C.*

CHILD, CHARLES MANNING, Ph. D., Assistant Professor of Zoölogy, Hull Zoölogical Laboratory, University of Chicago, *Chicago, Ill.*

CLAPP, CORNELIA MARIA, Ph. D., Professor Zoölogy, Mount Holyoke College, *South Hadley, Mass.*

CLARKE, ELIOT ROUND, M. D., Assistant in Anatomy, Johns Hopkins Medical School, *1537 North Broadway, Baltimore, Md.*

COHOE, BENSON A., A. B., M. D., Assistant Resident Physician, Johns Hopkins Hospital, *Baltimore, Md.*

COGHILL, GEORGE E., Ph. D., Professor of Zoölogy, Denison University, *Granville, Ohio.*

CONANT, WILLIAM MERRITT, M. D., Instructor in Anatomy in Harvard Medical School, *486 Commonwealth Avenue, Boston, Mass.*

CONKLIN, EDWIN GRANT, A. M., Ph. D., Professor of Zoölogy, Princeton University, *Princeton, N. J.*

CORSON, EUGENE ROLLIN, B. S., M. D., *11 Jones Street, East Savannah, Ga.*

CRAIG, JOSEPH DAVIS, A. M., M. D., Professor of Anatomy, Albany Medical College, *12 Ten Broeck Street, Albany, N. Y.*

DANDY, WALTER E., A. B., Johns Hopkins Medical School, *141 Jackson Place, Baltimore, Md.*

DARRACH, WILLIAM, A. M., M. D., Demonstrator of Anatomy and Instructor in Surgery, Columbia University, *107 West 55th Street, New York City, N. Y.*

DAVIDSON, ALVIN, M. A., Ph. D., Professor of Biology, Lafayette College, *Easton, Pa.*

Dawburn, Robert H. Mackay, M. D., Professor of Surgery and Anatomy, New York Polyclinic Medical School and Hospital, *105 W. 74th Street, New York City, N. Y.*

Dean, Bashford, Ph. D., Professor of Vertebrate Zoölogy, Columbia University, New York City, Honorary Curator of Fishes, American Museum of Natural History, *20 W. 82nd Street, New York City, N. Y.*

DeWitt, Lydia M., M. D., B. S., Instructor in Histology, Department of Medicine and Surgery, University of Michigan, *Ann Arbor, Mich.*

Dexter, Franklin, M. D., *148 Marlborough Street, Boston, Mass.*

Dodson, John Milton, A. M., M. D., Professor of Medicine, Rush Medical College, *568 Washington Boulevard, Chicago, Ill.*

Donaldson, Henry Herbert, Ph. D., D. Sc., Professor of Neurology, The Wistar Institute of Anatomy, *Philadelphia, Pa.*

Dunn, Elizabeth Hopkins, A. M., M. D., Associate in Anatomy, University of Chicago, *Hull Anatomical Laboratory, Chicago, Ill.*

Du Pree, Dan Hughes, B. S., *1717 Fairmount Avenue, Baltimore, Md.*

Dwight, Thomas, M. D., LL. D., Parkman Professor of Anatomy, Harvard Medical School, *Boston, Mass.*

Eccles, Robert G., M. D., Professor Organic Chemistry, Brooklyn College of Pharmacy, *191 Dean Street, Brooklyn, N. Y.*

Edwards, Charles Lincoln, Ph. D., Professor of Natural History, Trinity College, *89 Buckingham Street, Hartford, Conn.*

Eigenmann, Carl H., Ph. D., Professor of Zoölogy, Indiana University, Director of the Indiana University Biological Station, *Bloomington, Ind.*

Elliot, Gilbert M., A. M., M. D., Assistant Demonstrator of Anatomy, Medical School of Maine, *152 Main Street, Brunswick, Me.*

Erdman, Charles Andrew, M. D., Professor of Anatomy, Medical Department, University of Minnesota, *Minneapolis, Minn.*

Essick, Charles Rhein, B.A., *1731 N. Broadway, Baltimore, Md.*

Evans, Herbert McLean, B. S., Johns Hopkins Medical School, *Baltimore, Md.*

Eycleshymer, Albert Chauncy, B. S., Ph. D., Professor of Anatomy, Medical Department, University of St. Louis, *St. Louis, Mo.*

Ferris, Harry Burr, A. B., M. D., Professor of Anatomy, Medical Department, Yale University, *395 Saint Ronan, New Haven, Conn.*

Fischelis, Philipp, M. D., Demonstrator of Histology and Embryology, Medico-Chirurgical College, *828 N. 5th Street, Philadelphia, Pa.*

Flint, Joseph Marshall, B. S., A. M., M. D., Professor of Surgery, Yale University, *311 Temple Street, New Haven, Conn.*

Fox, Henry, Ph. D., Professor of Biology, Temple College, Philadelphia, *4440 N. 19th Street, Germantown, Pa.*

FROST, GILMAN DUBOIS, A. M., M. D., Professor of Anatomy, Dartmouth Medical School, *Hanover, N. H.*

FERGUSON, JEREMIAH SWEETSER, M. Sc., M. D., Instructor in Histology, Cornell University Medical College, New York City, *330 W. 28th Street, New York City, N. Y.*

GAGE, SIMON HENRY, B. S., Professor of Histology and Embryology, Cornell University, *Ithaca, N. Y.*

GAGE, MRS. SUSANNAH PHELPS, B. Ph., *4 South Avenue, Ithaca, N. Y.*

GALLAUDET, BERN BUDD, A. M., M. D., Demonstrator of Anatomy and Instructor of Surgery, College of Physicians and Surgeons, Columbia University, *Hotel Westminster, 115 E. 16th Street, New York City, N. Y.*

GEHRING, NORMAN J., A. B., M. D., *616 N. Aurora Street, Ithaca, N. Y.*

GERRISH, FREDERICK HENRY, A. M., M. D., LL. D., Professor of Surgery, Bowdoin College, *675 Congress Street, Portland, Me.*

GILMAN, PHILIP KINGSWORTH, B. A., M. D., Assistant in Operative Surgery, Medical School, *Manila, P. I.*

GOETTSCH, EMIL, B. S., Assistant in Anatomy, University of Chicago, *118 Maroon Heights, Chicago, Ill.*

GOODALE, GEORGE LINCOLN, A. M., M. D., Professor of Botany, Director of Botanic Gardens, Harvard University, *5 Berkeley Street, Cambridge, Mass.*

GOWANS, EPHRAIM G., M. D., Professor of Anatomy, University of Utah, *Salt Lake City, Utah.*

GREENMAN, MILTON J., Ph. B., M. D., Director of the Wistar Institute of Anatomy, *36th Street and Woodland Avenue, Philadelphia, Pa.*

GUYER, MICHAEL F., Ph. D., Professor of Zoölogy, University of Cincinnati, Ohio, *564 Evanswood, Clifton, Cincinnati, Ohio.*

HAMANN, CARL A., M. D., Professor of Anatomy, Medical Department, Western Reserve University, *404 Osborne Building, Cleveland, Ohio.*

HARE, EARL R., A. B., M. D., Instructor in Anatomy, University of Minnesota, *327 14th Avenue, Minneapolis, Minn.*

HARDESTY, IRVING, A. B., Ph. D., Assistant Professor of Anatomy, University of California, *2320 Hilgard Avenue, Berkeley, Cal.*

HARPER, EUGENE HOWARD, Ph. D., Instructor in Zoölogy, Northwestern University, *839 Milburn Street, Evanston, Ill.*

HARRISON, ROSS GRANVILLE, Ph. D., M. D., Professor of Comparative Anatomy, Yale University, Managing Editor of the Journal of Experimental Zoölogy, *2 Hillhouse Avenue, New Haven, Conn.*

HARVEY, BASIL COLEMAN HYATT, A. B., M. B., Instructor in Anatomy, Hull Anatomical Laboratory, University of Chicago, *454 E. 60th Street, Chicago, Ill.*

HATAI, SHINKISHI, Ph. D., Associate in Neurology, Wistar Institute of Anatomy, *Philadelphia, Pa.*

Hathaway, Joseph H., A. M., M. D., Instructor in Anatomy, Cornell University Medical College, *420 Eddy Street, Ithaca, N. Y.*

Haynes, Irving Samuel, Ph. B., M. D., Professor of Practical Anatomy, Cornell University Medical College, *1125 Madison Avenue, New York City.*

Hazen, Charles Morse, A. M., M. D., Professor of Physiology, Medical College of Virginia, Richmond, *Bon Air, Va.*

Heisler, John C., M. D., Professor of Anatomy, Medico-Chirurgical College, Philadelphia, Pa., *3829 Walnut Street, Philadelphia, Pa.*

Herrick, Charles Judson, Ph. D., Professor of Neurology, University of Chicago (Co-Editor of Journal of Comparative Neurology), Laboratory of Anatomy, University of Chicago, *Chicago, Ill.*

Hertzler, Arthur E., A. M., M. D., Ph. D., Professor of General and Surgical Pathology and Experimental Surgery, University Medical College. Kansas City, Mo., *425 Argyle Building, Kansas City, Mo.*

Heuer, George Julius, B. S., Johns Hopkins Medical School, *1524 N. Broadway, Baltimore, Md.*

Hewson, Addinell, A. M., M. D., Professor of Anatomy of Philadelphia Polyclinic for Graduates of Medicine; Secretary of Pennsylvania State Anatomical Board, *2120 Spruce Street, Philadelphia, Pa.*

Hill, Eben Clayton, A. B., M. D., Assistant in Anatomy, Johns Hopkins Medical School, *2120 N. Charles Street, Baltimore, Md.*

Hill, Howard, M. D., Professor of Anatomy, University Medical College, Kansas City, Mo., *425 Argyle Building, Kansas City, Mo.*

Hopkins, Grant Sherman, D. Sc., D. V. M., Professor of Veterinary Anatomy, Cornell University, *125 Dryden Road, Ithaca, N. Y.*

Hodge, C. F., Ph. D., Professor of Biology, Clark University, *Worcester, Mass.*

Howard, Wm, T., M. D., Professor of Pathology, Western Reserve University, *Cleveland, Ohio.*

Hrdlicka, Ales, M. D., Curator of the Division of Physical Anthropology, Washington, D. C., United States National Museum, *Washington, D. C.*

Huber, G. Carl, M. D., Professor of Histology and Embryology, University of Michigan, *1330 Hill Street, Ann Arbor, Mich.*

Huntington, George S., A. M., M. D., D. Sc., LL. D., Professor of Anatomy, Columbia University, *437 W. 59th Street, New York City, N. Y.*

Ingalls, N. William, M. D., Instructor in Anatomy, Medical College, Western Reserve University, *St. Clair Avenue and East 9th Street, Cleveland, Ohio.*

Jackson, Clarence M., M.S., M. D., Professor of Anatomy and Histology, University of Missouri, *1201 Paquin Street, Columbia, Mo.*

Jayne, Horace, M. D., Ph. D., The Wistar Institute of Anatomy and Biology, *36th Street and Woodland Avenue, Philadelphia, Pa.*

Johnston, John B., Ph. D., Assistant Professor of Anatomy of the Nervous System, University of Minnesota, *Minneapolis, Minn.*

JORDAN, HARVEY ERNEST, Ph. D., Adjunct Professor of Anatomy (Histology and Embryology), University of Virginia, *Charlottesville, Va.*

KEILLER, WILLIAM, L. R. C. P., and F. R. C. S. Ed., Professor of Anatomy, Department of Medicine, University of Texas, *Galveston, Tex.*

KELLY, HOWARD ATWOOD, A. B., M. D., LL. D., Professor of Gynecological Surgery, Johns Hopkins Hospital, *1418 Eutaw Place, Baltimore, Md.*

KEMP, GEORGE T. M. D., Ph. D., Professor of Physiology, University of Illinois, *Hotel Beardsley, Champaign, Ill.*

KERR, ABRAM T., B. S., M. D., Professor of Anatomy, Cornell University Medical College, *Ithaca, N. Y.*

KINGSBURY, B. F., Ph. D., Assistant Professor of Physiology, Cornell University, *Ithaca, N. Y.*

KINGSLEY, J. S., Sc. D., Professor of Biology, *Tufts College, Mass.*

KIRK, EDWIN GARVEY, B. S., Associate Instructor in Anatomy, University of Chicago, Hull Laboratory of Anatomy, *637 Jackson Boulevard, Chicago, Ill.*

KNOWER, HENRY McE., A. B., Ph. D., Instructor in Anatomy, Johns Hopkins University Medical Department (Co-Editor and Secretary of the American Journal of Anatomy), *Baltimore, Md.*

KOFOID, CHARLES ATWOOD, Ph. D., Associate Professor of Histology and Embryology, University of California, *Berkeley, Cal.*

KUTCHIN, HARRIET LEHMANN, A. M., Assistant in Biology, University of Montana, *Missoula, Mont.*

KYES, PRESTON, A. M., M. D., Assistant Professor of Experimental Pathology, University of Chicago, *Chicago, Ill.*

LAMB, DANIEL SMITH, A. M., M. D., Pathologist Army Medical Museum, Professor of Anatomy, Howard University, Medical Department, *2114 18th Street, N. W., Washington, D. C.*

LAMBERT, ADRIAN V. S., A. B., M. D., Instructor in Surgery, College of Physicians and Surgeons, Columbia University, *29 W. 36th Street, New York City, N. Y.*

LANDACRE, FRANCIS LEROY, A. B., Associate Professor of Zoölogy, Ohio State University, *Columbus, Ohio.*

LANE, MICHAEL ANDREW, B. S., First Assistant, Department of Histology and Embryology, Cornell University, Ithaca, N. Y., *451 Jackson Boulevard, Chicago, Ill.*

LFCRON, WILBUR L., A. B., *1410 Mt. Royal Avenue, Baltimore, Md.*

LEE, THOMAS G., M. D., B. S., Professor of Histology and Embryology, University of Minnesota, *Minneapolis, Minn.*

LEFEVRE, GEORGE, Ph. D., Professor of Zoölogy, University of Missouri, *763 Maryland Place, Columbia, Mo.*

LEIDY, JOSEPH, JR., A. M., M. D., Late Assistant Demonstrator of Anatomy and Pathologic Histology, University of Pennsylvania, *1319 Locust Street, Philadelphia, Pa.*

LEMPE, GEORGE GUSTAVE, A. B., M. D., Lecturer on Anatomy, Albany Medical College, *42 Eagle Street, Albany, N. Y.*

LEWIS, DEAN D., M. D., Associate in Anatomy, Hull Anatomical Laboratory, Chicago University, *Chicago, Ill.*

LEWIS, FREDERICK T., A. M., M. D., Assistant Professor of Embryology, Harvard Medical School (Editor of the American Naturalist), *2 Ellsworth Avenue, Cambridge, Mass.*

LEWIS, WARREN HARMON, B. S., M. D., Associate Professor in Anatomy, Johns Hopkins University, *Baltimore, Md.*

LEWIS, WILLIAM EVAN, M. D., Professor of Anatomy, Miami Medical College, *409 E. 5th Street, Cincinnati, Ohio.*

LILLIE, FRANK RATHAY, Ph. D., Associate Professor of Zoölogy and Embryology, University of Chicago, Assistant Director of the Marine Biological Laboratory (Editor of the Zoölogical Bulletin), University of Chicago, *Chicago, Ill.*

LOCY, WILLIAM A., Ph. D., Sc. D., Professor of Zoölogy and Director of the Zoölogical Laboratory, Northwestern University, *Evanston, Ill.*

LOEB, HANAU WOLF, A. M., M. D., Professor of Nose and Throat Diseases, St. Louis University, *537 N. Grand Avenue, St. Louis, Mo.*

LOEB, LEO, M. D., Assistant Professor of Experimental Pathology, University of Pennsylvania, *Philadelphia, Pa.*

MCCARTHY, JOHN GEORGE, M. D., Lecturer and Senior Demonstrator of Anatomy, McGill University, *61 Drummond Street, Montreal, Canada.*

MCCLELLAN, GEORGE, M. D., Professor of Applied Anatomy, Jefferson Medical College, *1116 Spruce Street, Philadelphia, Pa.*

MCCLURE, CHARLES FREEMAN WILLIAMS, A. M., Professor of Comparative Anatomy, Princeton University, *Princeton, N. J.*

MCDONALD, ARCHIBALD L., A. B., M. D., Professor of Anatomy and Physiology, Medical Department, University of North Dakota, *Grand Forks, N. Dak.*

MCDONOUGH, EDWARD JOSEPH, A. B., M. D., Instructor in Histology, Medical School of Maine, *624 Congress Street, Portland, Me.*

MCGILL, CAROLINE, A. M., Instructor in Anatomy, University of Missouri, *Columbia, Mo.*

MCMURRICH, JAMES PLAYFAIR, A. M., Ph. D., Professor of Anatomy, University of Toronto, *Toronto, Canada.*

MCNEAL, WARD J., Ph. D., M. D., Assistant Chief in Bacteriology, Department of Animal Husbandry, University of Illinois, *1005 W. Oregon Street, Urbana, Ill.*

MAJOR, RALPH HERMANN, A. B., Johns Hopkins Medical School, *1222 North Broadway, Baltimore, Md.*

MALL, FRANKLIN P., A. M., M. D., LL. D., D. Sc., Professor of Anatomy, Johns Hopkins University, *Baltimore, Md.*

MARK, EDWARD LAURENS, Ph. D., LL. D., Hersey Professor of Anatomy and Director of the Zoölogical Laboratory, Harvard University, *109 Irving Street, Cambridge, Mass.*

MARTIN, WALTON, Ph. B., M. B., Instructor in Surgery, College of Physicians and Surgeons, Columbia University, *68 E. 56th Street, New York City, N. Y.*

MATAS, RUDOLPH, M. D., Professor of Surgery, Medical Department of Tulane University, *2255 St. Charles Avenue, New Orleans, La.*

MERCER, WILLIAM F., Ph. D., Professor of Biology, Ohio University, *200 E. State Street, Athens, Ohio.*

MELLUS, EDWARD LINDON, M. D., Anatomical Laboratory, Johns Hopkins Medical School, *Baltimore, Md.*

MEYER, ADOLF, M. D., LL. D., Director of the Pathological Institute of the New York State Hospitals, Ward's Island; Professor of Psychiatry, Cornell Medical School, *Ward's Island, New York City, N. Y.*

MEYER, ARTHUR W., S. B., M. D., Professor of Anatomy, Medical Department, Northwestern University, *Chicago, Ill.*

MILLER, WALTER MCNAT, B. Sc., M. D., Professor of Pathology and Bacteriology, University of Missouri, *801 Virginia Avenue, Columbia, Mo.*

MILLER, WILLIAM SNOW, M. D., Associate Professor of Anatomy, University of Wisconsin, *University Club, Madison, Wis.*

MINOT, CHARLES SEDGEWICK, S. B. (Chem.), S. D., LL. D., D. Sc., Professor of Comparative Anatomy, Harvard Medical School, *Boston, Mass.*

MIXTER, SAMUEL JASON, B. S., M. D., Instructor of Surgery, Harvard Medical School, *180 Marlborough Street, Boston, Mass.*

MOODY, MARY BLAIR, M. D., *165 S. Marengo Avenue, Pasadena, Cal.*

MOODY, ROBERT ORTON, B. S., M. D., Assistant Professor of Anatomy, University of California, *Berkeley, Cal.*

MORGAN, JAMES DUDLEY, A. B., M. D., Clinical Professor, Georgetown University Hospital and Medical School, Physician to Garfield Memorial Hospital, *919 5th Street, McPherson Square, Washington, D. C.*

MUNROE, JOHN CUMMINGS, A. B., M. D., Surgeon in Chief, Carney Hospital, *173 Beacon Street, Boston, Mass.*

MUNSON, JOHN P., Ph. D., Head of the Department of Biology, Washington State Normal School, *Ellensburg, Washington.*

MURPHY, JAMES, B. S., Johns Hopkins Medical School, *Baltimore, Md.*

MYERS, BURTON D., A. M., M. D., Professor of Anatomy, Indiana University, *Bloomington, Ind.*

NACHTRIEB, HENRY FRANCIS, B. S., Professor of Animal Biology, University of Minnesota, *905 S. E. 6th Street, Minneapolis, Minn.*

NEAL, HERBERT VINCENT, Ph. D., Professor of Biology, Knox College, *750 N. Academy Street, Galesburg, Ill.*

Noble, Harriet Isabel, M. D., Demonstrator of Anatomy, Presector and Curator of the Department of Anatomy, Woman's Medical College of Pennsylvania, *Noble, Pa.*

Osborn, Henry Fairchild, Sc. D., LL. D., Da Costa Professor of Zoölogy in Columbia University; Curator of Vertebrate Paleontology, American Museum of Natural History, *77th Street and 8th Avenue, New York City, N. Y.*

Parker, Charles, Aubrey, M. D., Instructor in Anatomy and Instructor in Surgery, Rush Medical College, University of Chicago, *1660 Fulton Street, Chicago, Ill.*

Parker, George Howard, D. Sc., Professor of Zoölogy, Harvard University, *16 Berkeley Street, Cambridge, Mass.*

Paton, Stewart, A. B., M. D., *Room 30, 22 William Street, New York City, N. Y.*

Patten, William, Ph. D., Professor of Zoölogy, Dartmouth College, *Hanover, N. H.*

Patterson, James, B. S., Assistant in Anatomy, University of Chicago, Hull Laboratory of Anatomy, University of Chicago, *Chicago, Ill.*

Piersol, George L., M. D., Sc. D., Professor of Anatomy, University of Pennsylvania, *4724 Chester Avenue, Philadelphia, Pa.*

Pohlman, August G., M. D., Junior Professor of Anatomy, Indiana University, *411 Fess Avenue, Bloomington, Ind.*

Potter, Peter, M. S., M. D., Associate Professor of Anatomy, St. Louis University, Marion-Sims-Beaumont Medical College, *Grand Avenue and Caroline Street, St. Louis, Mo.*

Prentiss, H. J., M. D., M. E., Professor of Anatomy, University of Iowa, *Iowa City, Ia.*

Primrose, Alexander, M. B., C. M. Ed., M. R. C. S. Eng., Professor of Surgery, University of Toronto, *100 College Street, Toronto, Canada.*

Pryor, Joseph William, M. D., Professor of Anatomy and Physiology, State College of Kentucky, *261 N. Broadway, Lexington, Ky.*

Radasch, Henry E., M. S., M. D., Associate in Histology and Embryology, Assistant Demonstrator of Anatomy (Department of General Anatomy), Jefferson Medical College, Lecturer on General and Dental Histology, Pennsylvania College of Dental Surgery, *914 S. 47th Street, Philadelphia.*

Reese, Albert Moore, A. B., Ph. D., Professor of Zoölogy, West Virginia University, *Morgantown, W. Va.*

Reford, L. L., B. A., M. D., *803 Cathedral Street, Baltimore, Md.*

Reisinger, Emory William, M. D., Assistant in Anatomy at the Georgetown Medical and Dental Schools, *1424 K Street, N. W., Washington, D. C.*

Retzer, Robert, M. D., Instructor in Anatomy, Johns Hopkins University, *227 W. Monument Street, Baltimore, Md.*

Revell, Daniel Graisberry, A. B., M. B., Department of Public Health, *Edmonton, Alberta, Canada.*

Rice, Edward Loramus, Ph. D., Professor of Zoölogy, Ohio Wesleyan University, *134 W. Lincoln Avenue, Delaware, Ohio.*

Russell, Nelson G., M. D., Assistant in Anatomy, Medical Department, University of Buffalo, *475 Franklin Street, Buffalo, N. Y.*

Sabin, Florence R., B. S., M. D., Associate Professor of Anatomy, Johns Hopkins University, *Baltimore, Md.*

Sampson, John Albertson, A. B., M. D., *180 Washington Avenue, Albany, N. Y.*

Santee, Harris E., Ph. D., M. D., Professor of Anatomy in the College of Physicians and Surgeons, University of Illinois and in the Jenner Medical College, *770 Warren Avenue, Chicago, Ill.*

Scannon, Richard E., A. B., Austin Teaching Fellow in Histology and Embryology, Harvard Medical School, *Boston, Mass.*

Schaeffer, Marie Charlotte, M. D., Lecturer and Demonstrator of Biology and Normal Histology, Medical Department, University of Texas, *Galveston, Texas.*

Schulte, Herman Von W., A. B., M. D., Adjunct Professor of Anatomy, College of Physicians and Surgeons, Columbia University, *176 W. 87th Street, New York City, N. Y.*

Schmitter, Ferdinand, A. B., M. D., First Lieutenant, Assistant Surgeon, U. S. Army, *Fort Egbert, Alaska.*

Seelig, Major G., A. B., M. D., Assistant in Anatomy, Medical Department of St. Louis University, Humboldt Building, *537 N. Grand Avenue, St. Louis, Mo.*

Selling, Lawrence, A. B., *810 N. Broadway, Baltimore, Md.*

Senior, Harold D., M. B., F. R. C. S., Associate Professor of Anatomy, College of Medicine, Syracuse University, *Orange Street, Syracuse, N. Y.*

Shambaugh, George E., Ph. B., M. D., Instructor in the Anatomy of the Ear, Nose and Throat, University of Chicago; Associate in Osteology, Rush Medical College, *100 State Street, Chicago, Ill.*

Sheldon, Ralph Edward, A. M., M. S., Assistant in Anatomy, University of Chicago, Hull Laboratory of Anatomy, *Chicago, Ill.*

Shepherd, Francis John, M. D., C. M., M. R. C. S., Eng., LL. D., Professor of Anatomy, McGill University, *152 Mansfield Street, Montreal, Canada.*

Shute, Daniel Kerfoot, A. B., M. D., Professor of Anatomy, Columbia University, *1719 De Sales Street, Washington, D. C.*

Silvester, Charles Frederick, Curator of the Morphological Museum and Assistant in Anatomy, Princeton University, *10 Nassau Hall, Princeton, N. J.*

Sisson, Septimus, B. S., V. S., Professor of Comparative Anatomy, Ohio State University, *Columbus, Ohio.*

SLUDER, GREENFIELD, M. D., Medical Department, Washington University, *2467 Washington Avenue, St. Louis, Mo.*

SMALL, RICHARD DRESSER, A. B., M. D., Instructor in Anatomy, Portland Medical School, *154 High Street, Portland Me.*

SMITH, CHARLES DENNISON, A. M., M. D., Professor of Physiology, Medical School of Maine, Maine General Hospital, *Portland, Me.*

SMITH, EUGENE ALFRED, M. D., *1018 Maine Street, Buffalo, N. Y.*

SMITH, FRANK, A. M., Associate Professor of Zoölogy, University of Illinois, *913 W. California Avenue, Urbana, Ill.*

SMITH, J. HOLMES, M. D., Professor of Anatomy, University of Maryland, *2205 St. Paul Street, Baltimore, Md.*

SPITZKA, EDWARD ANTHONY, M. D., Professor of General Anatomy, Jefferson Medical College, *10th and Walnut Streets, Philadelphia, Pa.*

STEENSLAND, HOLBERT SEVERIN, B. S., M. D., Associate Professor of Pathology and Bacteriology, and Director of the Pathological Laboratory, Syracuse University, *505 University Place, Syracuse, N. Y.*

STEWART, GEORGE DAVID, M. D., Professor of Anatomy and Clinical Surgery, University and Bellevue Hospital Medical School, *143 E. 37th Street, New York City, N. Y.*

STILES, HENRY WILSON, M. D., Instructor in Anatomy, University of Michigan, *Ann Arbor, Mich.*

STOCKARD, CHARLES RUPERT, B. S., M. S., Ph. D., Assistant in Embryology and Histology, Cornell Medical School, *28th Street and First Avenue, New York City, N. Y.*

STREETER, GEORGE L., A. M., M. D., Professor of Anatomy, University of Michigan, *Ann Arbor, Mich.*

STROMSTEN, FRANK ALBERT, D. Sc., Instructor in Animal Biology, State University of Iowa, *27 East Burlington Street, Iowa City, Ia.*

STRONG, OLIVER S., Ph. D., Instructor in Histology and Embryology, College of Physicians and Surgeons, Columbia University, *437 W. 59th Street, New York City, N. Y.*

STRONG, REUBEN MYRON, Ph. D., Instructor in Zoölogy, University of Chicago, *Chicago, Ill.*

SUDLER, MERVIN T., M. D., Ph. D., Professor of Anatomy, University of Kansas, *1037 Tennessee Street, Lawrence, Kan.*

SUNDWALL, JOHN, Ph. D., Assistant in Anatomy, Department of Anatomy, University of Chicago, *Chicago, Ill.*

TAUSSIG, FREDERICK JOSEPH, A. B., M. D., Clinical Assistant in Gynecology, Medical Department, Washington University, *2318 Lafayette Avenue, St. Louis, Mo.*

TAYLOR, EDWARD W., A. M., M. D., Instructor in Neurology, Harvard Medical School, *457 Marlborough Street, Boston, Mass.*

TAYLOR, EWING, A. B., M. D., Instructor in Histology, Cornell Medical College, *19 Arden Place, Yonkers, N. Y.*

TERRY, ROBERT JAMES, A. B., M. D., Professor of Anatomy, Medical Department, Washington University, *1806 Locust Street, St. Louis, Mo.*

THRO, WILLIAM C., A. M., *219 E. 27th Street, New York City, N. Y.*

THYNG, FREDERICK WILBUR, Ph. D., *324 Boston Avenue, Tufts College, Mass.*

TOBIE, WALTER E., M. D., Professor of Anatomy, Medical School of Maine, *2 Deering Street, Portland, Me.*

TUPPER, PAUL YOER, M. D., Professor of Applied Anatomy and Operative Surgery, Medical Department, Washington University, *Linmar Building, St. Louis, Mo.*

TUCKERMAN, FREDERICK, M. D., Ph. D., *Amherst, Mass.*

WAITE, FREDERICK CLAYTON, A. M., Ph. D., Professor of Histology and Embryology, Western Reserve University, *E. 9th Street and St. Clair Avenue, Cleveland, Ohio.*

WALKER, GEORGE, M. D., Instructor in Surgery, Johns Hopkins University, *Cor. Charles and Centre Streets, Baltimore, Md.*

WARD, CHARLES HOWARD, Director of Anatomical Laboratory for the Preparation of Osteological Specimens and Anatomical Models, *387 West Avenue, Rochester, N. Y.*

WARREN, JOHN, M. D., Demonstrator of Anatomy, Harvard Medical School, *Boston, Mass.*

WARTHIN, ALFRED SCOTT, Ph. D., M. D., Professor of Pathology and Director of the Pathological Laboratory, University of Michigan, *Ann Arbor, Mich.*

WEBSTER, JOHN CLARENCE, B. A., M. D., F. R. C. P. Ed., Professor of Obstetrics and Gynecology, Rush Medical College, University of Chicago, *706 Reliance Building, 100 State Street, Chicago, Ill.*

WEISSE, FANEUIL D., M. D., Professor of Anatomy and Oral Surgery, New York College of Dentistry, *46 W. 20th Street, New York City, N. Y.*

WEST, CHARLES IGNATIUS, M. D., Lecturer on Topographical Anatomy, Howard University, and First Assistant Surgeon, Freedman's Hospital, *924 M Street, N. W., Washington, D. C.*

WEYSSE, ARTHUR WISSLAND, A. M., M. D., Ph. D., Professor of Biology, Boston University, *688 Boylston Street, Boston, Mass.*

WHITEHEAD, RICHARD HENRY, A. B., M. D., Professor of Anatomy, Department of Medicine, University of Virginia, *Charlottesville, Va.*

WILDER, BURT G., M. D., B. S., Professor of Neurology, Vertebrate Zoölogy, and Physiology, Cornell University, *Ithaca, N. Y.*

WILDER, HARRIS HAWTHORNE, Ph. D., Professor of Zoölogy, Smith College, *72 Dryads Green, Northampton, Mass.*

WILLIAMS, LEONARD WORCESTER, Ph. D., Instructor in Comparative Anatomy, Harvard Medical School, *Boston, Mass.*

WILLIAMS, STEPHEN RIGGS, Ph. D., Professor of Biology and Geology, Miami University, *Box 150, Oxford, Ohio.*

WILSON, J. GORDON, M. D., Associate in Anatomy, University of Chicago, Hull Laboratory of Anatomy, *Chicago, Ill.*

WILSON, JAMES MEREDITH, Ph. B., M. D., Assistant Professor of Histology and Embryology, St. Louis University, *St. Louis, Mo.*

WINSLOW, GUY MONROE, Ph. D., Instructor in Histology, Tufts Medical College, *145 Woodland Road, Auburndale, Mass.*

WITHERSPOON, THOMAS CASEY, M. D., *307 Granite Street, Butte, Montana.*

WOLCOTT, ROBERT HENRY, A. M., M. D., Professor of Anatomy, University of *Nebraska, Station A., Lincoln, Neb.*

WOODS, FREDERICK ADAMS, M. D., Lecturer in Biology, Massachusetts Institute of Technology, *1006 Beacon Street, Brookline, Mass.*

WOOLSEY, GEORGE, A. B., M. D., Professor of Anatomy, and Clinical Surgery, Cornell University Medical College, *117 E. 36th St., New York City, N. Y.*

YUTZY, SIMON M., M. D., Demonstrator of Anatomy, University of Michigan, *Ann Arbor, Mich.*

// THE ANATOMICAL RECORD

Vol. II. NOVEMBER, 1908. No. 8

On the Teaching of Anatomy.

BY

FRANKLIN P. MALL.

The following report on the teaching of anatomy is based upon the course which was given at the Johns Hopkins University during the past academic year. The course, as now given, is of gradual development and was naturally evolved to meet the needs of this institution. However, it is built upon two underlying principles which I believe to be of prime importance in the teaching of any subject: First, the concentration of elementary teaching; this, as applied to anatomy, means that the elementary work be given within the first year and that the student's schedule be so arranged that he may be able to devote the greater part of his time to the study of anatomy until he has finished this elementary work. Second, that only the elementary work be required of all students. Correlated with the elementary courses required of all students, elective or more advanced optional courses become necessary to meet the demands of students who may desire a more profound knowledge of anatomy than is obtained from the elementary courses.

During the first year of the Johns Hopkins Medical School (1893-4) all students pursued parallel courses in osteology, histology, gross anatomy, physiology and physiological chemistry, and since the courses were largely practical, the results were not entirely satisfactory, for the time of the students was broken up too much and their energies somewhat dissipated. The following year the work of the incoming students was largely concentrated, the first portion of the year (until March 15th) being devoted exclusively to the study of anatomy and the remainder to that of physiology and physiological chemistry. During the second year of the medical course the study of gross anatomy was continued during three forenoons each week before Christmas, and five forenoons from Christmas until Easter.

Years ago the value of a concentrated course in anatomy was emphasized with great force by von Baer and later it was strongly advocated, in an address upon the teaching of anatomy, by Waldeyer.

According to our great master, von Baer,[1] universities are in existence for the scientific education of young men, and since this is best obtained by continued self-instruction under guidance and not through numerous comprehensive and elegant lectures, it follows that the work of each semester should be concentrated upon a given main subject, for only in this way can a student obtain critical insight and thorough knowledge. Whenever we wish to do anything well we devote all of our time to it until it is accomplished, and if anatomy is worth studying it is worth studying well, and it is far better to concentrate all of one's attention to this study during a winter than to dissipate it through a number of years. To be sure, children cannot do this, for they tire rapidly and need a varied intellectual diet each day But later in life, a student gains more and is better satisfied when he devotes all of this time to a subject until he masters it through self-instruction. If it be true that a single student can master anatomy in a single half year instead of scattering its study over four or five half years, why is it not possible, von Baer asks, to teach a larger number by the concentration method? Furthermore, he says, that if all of the necessary anatomy could be taught medical students in a winter semester the much overworked professor would have all of his time left during the spring and summer for scientific research, which is absolutely necessary to him if he wishes to exert a vitalizing influence upon his students.

In case the work in anatomy is concentrated into a semester it falls upon the Professor, von Baer continues, to separate the essential from the useful and this in turn from the ornamental. Only the essential and part of the useful become required work, but an opportunity should always be given to study the rest, since the "essential" may lie in this for various individual students. The student who is to become an obstetrician may desire, and in fact needs, different phases of the work from one who is to became an anatomist or an ophthalmologist. Von Baer did not doubt for a moment that in the course of time medical study would change, for during his time practical laboratory work was being introduced into the course, and this of necessity would make the teaching inductive in character, for it could not be otherwise as soon as the power of self-

[1]Von Baer, Nachrichten über Leben und Schriften. St. Petersburg, 1866, p. 176.

instruction began to make itself felt. As the progress of the student becomes of greater importance than the convenience of the professor the concentration system, which in a measure is a forerunner to the elective system, must be introduced.

In his excellent address on the teaching of anatomy Waldeyer[2] discusses the cardinal question—its relation to medical education—and asserts that the method of instruction must be changed to agree with the ideas of von Baer. Times have changed since anatomy has grown out of her swaddling clothes into a mature individual which has given birth to a number of vigorous daughters who must also be courted by the medical student. Half a century ago all the science which a medical student studied was represented largely by the professor of anatomy, and he taught anatomy in the winter and physiology in the spring. There were then no practical courses on histology, pathology, or physiology, not to speak of physiological chemistry, pharmacology, bacteriology, hygiene, nor on the various specialties which were in general tacked on by the professors of medicine and surgery. Furthermore, the number of examinations was much fewer than at present and the student had little or no knowledge of science when he began the study of medicine. It was perfectly natural that under these conditions the study of anatomy should be pursued during a number of years, for only in it was the medical student able to obtain a biological as well as a practical laboratory education.

Now the student must study a number of branches (and in America he works in at least half a dozen laboratories), through which he also becomes thoroughly disciplined. But, Waldeyer continues, the days still contain but twenty-four hours, and life must still be reckoned with three score and ten, and there is no evidence that the mind can stand a greater strain now than formerly. It follows then that the course in anatomy must be readjusted to meet the new conditions. First and foremost we must ask ourselves what is absolutely necessary for the future physician to study in anatomy and what is of secondary value but still useful? The necessary (nöthige) anatomy he would make obligatory and would examine in it, but he would not discontinue courses on the useful (nützliche), for it is through the study of the second that the science progresses. These secondary courses should not be made obligatory in any way, by being prescribed nor through examinations. They should be free, or, in American terminology, they should be elective.

[2]Waldeyer, Wie soll man Anatomie lehren und lernen. Berlin, 1884.

In order to bring about the desired reform, Waldeyer says that the study of the natural sciences (our physics, chemistry and biology) should be concentrated into one year after the student graduates from the gymnasium, and until he has passed a satisfactory examination in these subjects he should not be allowed to matriculate as a medical student. This one year should be devoted exclusively to the above named subjects and should not be mixed with the study of anatomy or of physiology, in order that the student may have leisure time to gain a critical insight in them.

During the second year the study of anatomy and physiology should be taken up and completed—that is, it should be concentrated. According to the conditions which are peculiar to Germany it would throw these subjects into two winter semesters, the intervening summer semester being devoted to military service. Waldeyer continues as follows (the translation is free): It is clear to me that during these two semesters the student who has become proficient in chemistry, physics and biology (which he attains better by the proposed method of concentration) can devote himself more intensely and during all of his time to the study of anatomy and physiology. Then it will no longer happen, as is the sad experience of all anatomists, that the work in the dissecting room and in the histological laboratory degenerates as the time for examinations in physics, chemistry and biology (Tentamen physicum) approaches. Under these conditions the student may learn to dissect well both macroscopically and microscopically, as he can pursue his work peacefully and diligently, for he will not be taken away from it as soon as he has become greatly interested, as is now the case, by a lecture upon some entirely different subject. This latter I consider the chief reason why only a relatively small number of students learn to dissect well, inasmuch as they do not have time to work long enough at their specimens. No sooner are they started at their work than, on account of some foreign lecture, they must lay their knives aside and they may not take them up again until the next day. Thus the work progresses very slowly and the specimens begin to spoil, so that many students lose the desire to finish well. Many of the single hours which lie between the lectures are also completely lost. Furthermore, a fairly industrious student would soon realize that positive progress is made from day to day if he could follow the proposed plan for the study of anatomy. It would also become apparent to him that through concentration the knowledge obtained would be of more permanent value and that the love for his work would increase. I believe that this arrangement of the medical courses would be of the greatest advantage in teaching as well as in studying anatomy.

The above opinion of two of the greatest masters of anatomy is given at some length because it indicates the trend of the relation of anatomy, that is, the proportion of time its study should occupy, to the rest of the studies in a medical course. Both are in favor of a concentrated course and against one in which the students' energies are dissipated by taking numerous studies at the same time. They are of the opinion that the student should confine himself to the intense study of anatomy alone until he has finished the necessary work in the subject.

When the Johns Hopkins Medical School was opened the first condition as laid down by Waldeyer was met by the requirements for matriculation. The course of instruction was planned for the professional training for those who have received a liberal education, as indicated by a collegiate degree in arts or science, including a reading knowledge of French or German and adequate training in those branches of science, such as physics, chemistry and biology, which underlie the medical sciences. In completing the endowment of the medical department Miss Garrett stipulated that the medical school shall be exclusively a graduate school, and since in general a collegiate degree represents about two years more work than that given in a German gymnasium it was believed to be best to require also about a year's work in physics, chemistry and biology, since these subjects could be taken as electives during the last two years of college. The medical course was then divided into two equal parts of two years each and the work of the first part was confined exclusively to the study of the sciences, including pathology and bacteriology. It naturally followed that the medical student must begin his study with anatomy, and much anatomy, for this subject is fundamental in a medical course and the required study of physics, chemistry and biology had been taken before matriculation. At first, during 1893-4, the various subdivisions of anatomy, physiology and physiological chemistry were studied simultaneously, but during the next year, 1894-5, and ever since practically all of the time of the first year medical student, from October until March 15th, is devoted to the study of anatomy. Supplementary courses are given in the spring, during the second year, and later. Most of the time in the spring is devoted to physiological chemistry and physiology, the next autumn to practical physiology and bacteriology, the winter to pathology and advanced anatomy, etc. Thus the concentration system was introduced, which I had seen in operation to great advantage during the two previous years at the University of Chicago, and which has been introduced with variations, during the last decade, in most of our leading medical schools. The concentration method as outlined by von Baer nearly half a century ago is now well under way in America. Let us hope that it will yield some of the fruits that he has predicted it would!

Probably the most important course in medical schools the world over is that in practical gross human anatomy. One might almost say that the removal of any other course from the curriculum would not destroy the course, but if there were no dissecting room the school would have to close its doors; there would be no students. Personally I do not believe that the study of human anatomy is of such value, but it has held its own so long, it is so well intrenched in the medical course and in medical literature, and it has been represented by so many great masters during ages that as a discipline and as a foundation it justly occupies the first position. Therefore, it seems to me that gross human anatomy, as a practical course, should be required of all students and that the best energies of the anatomical staff should be devoted to its teaching. The professors should teach in the dissecting room. They should live there with their students and not delegate this important work to untried assistants.

The next course in order, which no one will question should be required of all students, is that on practical histology. Every medical student should also be proficient in histology, that is, should be able to use the microscope intelligently in working out animal tissues, especially mammalian and human.

In my opinion only these two courses should be required of all students. All the other courses in anatomy should be elective. These I shall discuss somewhat fully presently.

When I first outlined the work in anatomy, microscopic work was given a place in the schedule during afternoons and gross anatomy during forenoons. The plan was to continue both until the student got satisfaction. But as the work developed it soon became necessary to break it up to meet the requirements of an increased number of students and a larger staff. It was no longer possible for all of us to be everywhere all of the time, as is the case when there are but a few students and but one or two teachers.

During the second year of the medical school, with the introduction of the concentration system, it was my good fortune to secure the co-operation of Dr. Barker, who took entire charge of the microscopic work while I devoted all my energies to the teaching of practical anatomy. To this I devoted six full forenoons and Dr. Barker had control of all the students' time in the afternoons. I soon decided to make work in the dissecting during Saturday forenoon optional, and he did the same with his work Tuesday and Thursday afternoons, but this made little difference to the students, for all of them worked with the microscope during those optional periods, although the instructors were not present. Von Baer's plan showed that serious students who had had a liberal education and thorough training in physics, chemistry and biology were able to receive an education in anatomy by self-instruction under guidance. The concentration system permitted us to make the teaching inductive, and it was practical from the beginning.

Of course it was our aim from the very beginning to make our teaching bona fide and serious and in no sense perfunctory. We could not afford to make it inferior in quality to that given in the colleges from which our students had been graduated. Naturally all aids at our disposal were used in teaching, one of which consisted of grading the courses, but in no instances have concessions been made to inferior, indolent or frivolous students.

In arranging the work of a course it is desirable to build a foundation and follow this with a superstructure. If what comes first is really fundamental, that which follows is easily comprehended, and with it come many repetitions of the first. In presenting the essential it is necessary to instruct the student in the ordinary methods of work, of classification, of differentiation, and as much as possible of the steps through which anatomy has made progress, as well as of its use as a science and as an art. While becoming familiar with the structure of the human body he should gain a critical insight into anatomy and should become able to think anatomically.

Since students vary very much in endowment, energy and enthusiasm, and since our students vary much in biological and in anatomical training when they come to us, it became necessary to adjust the teaching to the needs of the individual student, and this naturally brought about the development of an elective system. Soon the elementary, fundamental courses containing the essentials in quality and in quantity became the required courses and all of the rest became elective courses.

For the past ten years, at least, our courses in anatomy have been divided into these two main groups, and we believe it an advantage to medicine to favor the more advanced, diligent and talented student by allowing him to proceed with advanced work,—and there is enough to be done,—rather than to compel him to lag behind with the slowest. In order to make this possible the various courses must begin and end at the same time, so that the student really can arrange his own schedule. If the various courses overlap, as is frequently the case in our various schools, an elective system is out of the question. I do not know what brought it about, but from the beginning of the school we used half-day units in a number of laboratory courses, possibly because pathology had been given as a three half-days course before. After some discussion of the question it was decided that two such half days, or five hours a week, should be made the measure for all courses, each of which should continue for three months, Christmas and Easter being natural dividing lines in medical schools. Thus a five-hour course which continues for three months, or a trimester, is called the unit. The work in the dissecting room, which occupies fifteen hours a week, becomes a three-unit course, and histology becomes a two-unit course. It was also found that the human body can be dissected fairly well by about one-half of the students in two trimesters, so we fixed upon eight units of anatomy as the required work of all students, believing that most of them would elect more anatomy and that some of them would do the required work only and devote their elective time to some other subject. By this arrangement it has been found during the past academic year that in addition to the eight required units each student averaged fully eight elective units in anatomy. Since our medical student is required to show credit for thirty units work, including all of the obligatory courses, before entering upon the work of the third year it is clear that on an average during the past year a little more than half of the students' time of the first two years of the medical course, or one full year, was devoted to the study of anatomy.

I am fully convinced that the inductive method, strongly advocated by Huxley, is the best one to use in teaching any biological subject and that human anatomy is especially adapted to this purpose, for the subject to be studied is of convenient size and its literature is the best.[3] The beginner should start to dissect at once, as recommended by both Hyrtl and Waldeyer. Why pester the students first with a course of lectures which after all rarely serve as an introduction to anatomy? The inductive system is especially of value with mature students who have already studied biology for at least a year, and it has always seemed to me that

[3]See also my article in the Johns Hopkins Bulletin, 1896.

it is our duty to start them in the dissecting room on the very first day of their medical course. Furthermore, this work is the most important for all students of anatomy whether they are to become physicians, physiologists, zoölogists or anatomists. Its position in the literature of science makes it fundamental and essential and therefore it becomes the elementary one for all students of anatomy. I am well aware that we have several strong schools of anatomy in America, not connected with medical education, in which dissection of the human body is neglected entirely, and the papers from these schools often show a deficiency in the knowledge of the object which has received the attention of many great masters, which has the best literature, and from the study of which all biological science has arisen.

The methods in the dissecting room are extremely simple, cadavers are in abundance and are easily preserved indefinitely, and its guide books are in possession of all students; so with order and attention on the part of the instructors students can learn their anatomy first hand and can be thoroughly disciplined in anatomical methods and in anatomical thinking. Of course we should begin to dissect the body from the outside and the skin naturally should be studied first. It must be taken off, and in order to do so the instructor has an excellent opportunity to show the use and value of the various instruments used in dissection. Good knives, scissors that will cut, forceps that will take a firm hold of either a hair or a rope, and a strong steel probe with which to dig about are all the instruments that are needed. The sham sets of a large number of instruments made of cast iron are to be most carefully avoided. The student soon learns that good instruments, if they are kept in perfect condition, extend his fingers and are absolutely necessary in his work. Therefore the care of instruments becomes one of the lessons of the first day's work. Then the student removes the skin, the whole skin and the skin only, from over the region which he is to dissect. This most students learn to do during the first day. Then he begins to seek structures in the superficial fascia, finds veins, arteries and nerves, and if finding these structures arouses the student's interest he naturally reads about them then and there and soon gains confidence in himself.

When I first introduced this method of instruction it usually required six weeks before the majority of students were working well, for at the beginning insufficient stress was laid upon the necessity of having good and sharp instruments as well as upon very careful work. Now, since we make these two points the chief task until mastered, we find that nearly all students are well in hand in less than a week. As soon as they command the methods the study of anatomy begins. After the skin we take up the study of the superficial fascia, then we clean the muscles that are first exposed and gain more knowledge of the deep fascia. The students who are dissecting arms are gradually led by the larger vessels and nerves through the axilla under the clavicle into the neck, and those dissecting legs by the lumbar nerves through the abdominal walls, cleaning the muscles as they proceed.

It is out of place to mention the various steps of each dissection, for they are well known. However, several points must not be omitted.

Each student receives a skeleton at the beginning of the course which he may keep throughout the year. At the end of the first day he is requested to study the clavicle and scapula if he is dissecting the arm, and the innominate bone if he is dissecting the leg. He receives further advice on following days, after which he usually takes good care of himself. Mounted skeletons are hung in each of the dissecting rooms to which constant reference is made and in the adjoining study room a great number and variety of bones are always at hand. At the end of each dissection the muscles are gradually removed in order to study their attachment to the bones, and the ligaments are worked out carefully. At this time the green bone is of necessity studied again, so the course on osteology is given in the dissecting room throughout the year. Since we have been doing this I no longer hear the complaint about dry bones, and I am certain that the students have lost nothing by the change.

It is evident by this time that the student *must* help himself if he wishes to learn anatomy by self-instruction under guidance; our experience is that, if anything, he is far too industrious, and it has been necessary for us to legislate against overwork. Formerly the dissecting rooms were open from seven to five (Saturdays from seven to one), but on account of overwork we have omitted the work on Saturdays and do not open the laboratory until eight o'clock on the remaining week days. While the students are at work they look up the new structures as they are exposed, they make numerous sketches and they study very much in their text-books. Practically all students purchase atlases, and these are of the greatest value to them in their study, for they also aid the imagination in looking ahead. Each student also develops a system of notes which he carries to his home to suggest lines of reading, and in return brings notes to the laboratory which guide his work on the next day. Soon his preparation becomes his problem and then the greatest value of the instructor comes from the aid given him in its development. A given step in a dissection is not complete until the most is made of it, then the next step is discovered with the student, and it has been my habit to follow the student's plan of work if it seems reasonable and not to compel him to follow me blindly. If this is done the student's critical power is developed, for we are reasoning with him and he is choosing. Furthermore, it gives variety to the work and prevents a deadening monotony.

The system which includes two dissections of the human body, first the muscles and then the blood-vessels as is customary in Europe, has never received a firm foothold in America. Here we have usually attempted to work out all structures at once, and if the time is short and the standard is not high the work usually ends in a dissection of the muscles only, and a poor one at that. But when you have to deal with mature students who are proficient in biology and devote their main energy to the work for six months the results are most satisfactory. In general this system calls for as complete a dissection as possible of each part without removing many muscles, after which square cuts are made through them to show deeper structures, and then the muscles are removed systematically to show their deeper attachments and the ligaments.

I prefer to start the beginner on either an arm or a leg, taking for this purpose a cadaver without viscera, leaving the head and viscera until the student has become somewhat proficient in anatomy. By this arrangement we make the most of our material and are not crowded too much for working space. After the student is well started in his work he finds that he can easily occupy himself one week on the thoracic and two weeks on the abdominal viscera, which is certainly out of the question with those who do not master anatomical methods.

In two trimesters there are 110 half days (8 to 1) and if the student shows some interest and industry, and has some talent, he may make in this time a very satisfactory dissection of the lateral half of the human body; he has mastered anatomical methods and he can use anatomical literature. If as a test you ask him to make a dissection of the orbit or of the hand, he can do it intelligently, showing all of the ordinary structures, but he cannot repeat like a parrot from a given quiz compend. In my opinion a satisfactory dissection of the human body made during two trimesters is all that should be required in gross anatomy of any medical student. Of course if he fails to complete the work in the required time, the time should be extended. Nor should we expect that all students who have done the required work will be proficient in anatomy. One of the chief objects of a final examination is to test proficiency.

In the past year some twenty of our students completed their required work in anatomy during their first summer vacation at various universities of America and Europe, but the table shows that thirty-two "elected" elementary anatomy in the second year of their course. A few of them were students who had been prevented from completing the required work in the regular time on account of illness or for other reasons. Most of them preferred to extend the dissection of the entire cadaver over three trimesters, and by no means did this group include all of the poorer students. Why should not a student extend his work even if it is inconvenient to us for him to do so? The object of the university is not our convenience, but the training of students, and an elective system considers the welfare of the student and the progress of science as more important than economy in instruction. Were the latter of the greater importance it would be better to return to the proprietary medical schools which paid large dividends.

For a number of years past the required work in gross anatomy has been in charge of four instructors, and we find it more satisfactory to all concerned to give each instructor entire charge of a section rather than to have daily or weekly rotation of the staff. A student remains in a section for a trimester or less (until he has completed a part) and then is assigned to a new instructor. By this method the student obtains instruction from several teachers, and each instructor is ambitious to hold the quality of the work of his section up to the highest possible standard. I have frequently felt the beneficial effect of a rival young instructor whose dissection room was better than mine. There has been a marked tendency for each of us to follow the best. At present a student may elect his instructors for the required work by going to other universities for it, as is customary in Germany.

The three elective courses on gross anatomy that are much appreciated by many of our students are the one hour conferences for beginners, the systematic study of anatomy with specimens and sections of the body but without dissection, and the one on topographical anatomy. The conferences have been given by a number of instructors, and they have been attended by a greater or less number of students, according to the aid they got from them. In general it is our opinion that the number of such courses should be increased, and we plan to do this during the coming year.

REQUIRED COURSES.

	Number of Students	Hours per week	Trimester	Equivalent Hours per week for one student
Elementary anatomy	85	15	Autumn	1275
" "	84	15	Winter	1260
Elementary histology	73	9	Autumn	657
TOTAL				3192

ELECTIVE COURSES.

Elementary anatomy	24	8	Autumn	192
" "	6	15	Winter	90
" "	2	12	Spring	24
Study-room courses in anatomy	34	6	Autumn	204
" " " "	51	6	Spring	306
Genito-urinary anatomy	12	3	Winter	36
Recitations in anatomy	66	1	Autumn	66
Topographical anatomy	61	15	Winter	915
Histological technique	9	3	Winter	27
Neurology	81	6	Winter	486
" (lectures)	84	2	Winter	168
Embryology	19	9	Spring	171
Artistic anatomy	18	3	A., W., S.	162
Advanced anatomy	5		Spring	
" histology	6	3	Autumn	18
Journal club	10	1	A., W., S.	30
Research	7	3 to 30	A., W., S.	315

Elective for one trimester	3108
Required " " "	3192
Total for one trimester	6300
Average per trimester for one year	2100

Equals an average of 25 hours a week during a year for 84 students, or an average total of 900 hours for each student.

CLASSIFICATION OF STUDENTS.

First year	85
Second year	71
Third year	4
Fourth year	1
Members of staff	4
Artists	4
Physicians	12
Total	181

The study room, which contains many specimens for study, has proved to be a most valuable adjunct in the teaching of anatomy. It has gradually become organized and the work of each student is carefully planned. In general they study serial sections of the body, comparing them with a variety of dissections. Many models, delicate dissections, fine bone specimens, topographical dissections and the like are constantly at the students' disposal. The coarser dissections and the numerous frozen sections are used very much and are replaced as rapidly as they are worn out. Using serial sections in the study of gross anatomy is fully as valuable as dissecting the embryo and making reconstructions are in the study of embryology. During the past year fifty-one first year and thirty-four second year students registered for work in the study room, and it was used by many who did not register for it.

The course on topographical anatomy which has been so well developed by Professor Lewis was attended by sixty-one students, many of whom had gone elsewhere during the previous summer in order to complete the required work which must precede this course. The work consists of making regional dissections and of systematic study, the dissections being reserved for the study room. The course has become too extensive for one instructor who is also occupied at the same time with other students, and it is planned to limit the number taking it during the coming year and to add regional dissection to each dissecting room as second dissections of the same part. Special work in gross anatomy will be discussed presently with that in histology and embryology.

The second required course is that on general anatomy or histology.[4] In general the microscopic work of the student continues from October 1st to March 15th, and of this time during different years from three to five afternoons have been devoted to the study of histology and microscopic anatomy for about four months. When the courses were rearranged to fit into trimesters, that on histology and microscopic anatomy was given three half days a week during the autumn trimester. This time may be somewhat short, but, considering the previous biological training of the students, which usually includes embryology, their opportunity to continue with elective courses and the great amount of time which is devoted to microscopic work in pathology and in other courses, I think an efficient teacher can give the student a strong foundation in histology during one trimester. The students work faithfully from two to five p. m., three times a week, and most of them work also during the

[4]See also Barker and Bardeen, Johns Hopkins Hospital Bulletin, 1896.

two optional afternoons and sometimes during forenoons, as each student's place is reserved for him during the whole day.

About the first half of the trimester is occupied with the study of the tissues, in the fresh state, in frozen sections, and in small blocks which have been treated by a great variety of methods. The student learns to tease and stain under the microscope, and there is no inducement for him to collect a set of sections without studying them, although he often makes permanent mounts. At the beginning of the course he receives as a loan a box of slides containing specimens which are more difficult to make, and these are frequently referred to and studied throughout the trimester.

After the tissues have been thoroughly studied by the various methods mentioned above the microscopic anatomy of the organs is taken up in a systematic way. In this study sections made with the microtome are stained and mounted by the student in order to teach him well established methods. However, it is necessary to connect what is seen in hardened and stained sections with a teased specimen on the one hand and with the gross specimen on the other. In order to meet this difficulty a system, *e. g.*, the digestive, is treated as a whole by having each student dissect it rapidly in a fœtal pig. That which is studied in regions in the dissecting room is here studied as a whole. Then the parts of the alimentary canal are taken up in order and each part is first studied rapidly as a whole. When we take up the liver entire organs are at the disposal of the students, who scrape out and examine the cells and study macerated frozen sections. In this study hardened and injected sections are constantly compared with the fresh, without enlargement, under the dissecting microscope and with high powers. As far as possible the function of the part is constantly emphasized and some of the changes which may take place in disease are not overlooked. We believe that when the teaching of anatomy is from the standpoint of physiology it is much easier to arouse independent effort on the part of the student. By this method an afternoon devoted to the study of the liver, and not to the mounting of sections, is most instructive to the student. And for a number of years past we have not had those who are wholly occupied in collecting a large box full of mounted slides.

When whole animals are used in teaching microscopic anatomy the students would be bewildered by the great amount of material were not an efficient teacher present to guide them. As the underlying liberal education, which our students possess, is intended to give them a critical attitude toward whatever they study, so that they may differentiate and separate the essential from the unessential, so the living teacher, who is also a student and has mastered his subject, easily guides the course in spite of the great quantity of material. The students continue to differentiate and pick out the essential. Were it not so the work would become the dullest kind of useless routine.

As an adjunct to aid in the informal study of histology opportunity is afforded by a large classified collection of slides which students use at odd times. The collection is arranged in boxes according to tissues and organs, and has not only proved to be of great value to the students, but also to the members of the staff. A person working upon the lung appreciates very much the privilege of studying a great variety of well labeled specimens of this organ.

Students who have had a satisfactory course in histology before matriculation usually occupy the time assigned to this subject in our schedule to the study of bacteriology, and during the second year of the course this time in turn is devoted to an elective in this or in some other department.

The course in neurology was formulated during the second year of the medical school (1894) and has been given successively by myself, Professors Barker, Bardeen, Harrison and Sabin. As it was from the first decidedly advanced in character, we naturally made in an optional course, but up to the present it has been elected by practically all of our medical as well as by other students. At first it did not seem reasonable to impose so extensive a course upon all medical students, but now, since the elective system has been introduced, its right to exist is recognized. I may be permitted to say in defense of the course that a thorough knowledge of the nervous system is of fully as much value in medicine as is a knowledge of the skeleton, or of the anatomy of the leg, although the latter is more easy to comprehend. But the great value of the study of neurology seems to be fully appreciated by our students who have done their share in its development as a course during its formative period. This I should like to describe, but will leave it for one who has done most for the course.

At present we devote two afternoons a week for one trimester to the study of the eye, ear, spinal cord, medulla and the brain. Each part of the subject is presented from embryological and comparative standpoints without separating the gross from the microscopic. Especial emphasis is laid upon the study of human tissue. About two weeks are devoted to each of the above mentioned main subdivisions of the subject.

There is a great abundance of material and the work includes, for instance, a study of the convolutions of the brain, a set of serial sections of the medulla, as well as all kinds of gross dissections and microscopic sections of the central nervous system,— the eye and the ear. The nature of modern medicine, the appreciation of the work by our students, and the flattering extension of this course to other medical schools justifies the time, labor and thought expended upon it.

What is written above may be considered by many as a most powerful argument in favor of making the course in neurology obligatory, but that does not necessarily follow. After all, it is better for the course and more credit to the teacher when the students strive to enter it and not to escape it. Under such conditions the spirit is far better, for the students believe in their teachers, and defend them, and do not malign them, as is frequently the case when courses are obligatory.

The other elective courses of necessity cannot be taken by all of the students and generally are limited to a small number. Embryology, for which there is no great demand, since most students have had a satisfactory course in it before matriculation, has gradually become more and more advanced in character, and it is probable that it will develop into one on organogeny. Our students are more interested in the development of the heart than in its anlage. And so on.

The other courses are more or less advanced and are changing from year to year, according to the number of teachers present at the time as well as to their inclination. As the number of students in these courses is limited and as the work is advanced in character the opportunity is an excellent one for the best influence of the teacher to show itself. In fact, I consider it highly desirable for each instructor to give an independent course, for it has a tremendous influence upon his development as a teacher. If he makes himself felt he is rewarded, for his future is assured. The general principles of science must be developed and emphasized again and again in the required courses, which are always of an elementary character; in the elective courses some phases of the subject, or one of its divisions, is taken up and presented in much greater detail. The literature on one topic may be studied, newer technical methods may be repeated, the attention may be devoted to the anatomy and development of a single organ, or an original investigation may be undertaken. By these methods a greater attempt is made to satisfy the craving of an inquisitive mind, and to give further knowledge of anatomy, or to prepare for the subsequent study of one of the specialties, or to train anatomists.

During the past year the course on drawing was given in the anatomical laboratory mainly to first and second year students every Thursday forenoon. It proved to be of so much value to students with artistic talent that they were willing to dissect during odd afternoons in order to attend this course. It was also attended by professional illustrators as well as by some members of the anatomical staff. All of those with some artistic talent have considered it a great privilege to receive instruction in anatomical drawing from one who has mastered it. To make satisfactory anatomical drawings, anatomical objects must be interpreted, and therefore those who have had an education in art do not become anatomical artists until they understand anatomy and the conventions of anatomical illustration; while students of anatomy learn methods of expression as well as these conventions. Not until the student of anatomy has attempted to express what he sees by means of the perspective, shades and high lights, does he really observe well, and no one who studies morphology sees to the greatest advantage unless he sketches constantly or at least makes diagrammatic drawings.

Nowhere in our teaching of anatomy is the value of an efficient teacher demonstrated better than in this course on drawing. The student exerts himself to the utmost in representing an object on a flat surface by means of black and white and then with a few marks from the teacher's pencil and erasures with his rubber the picture is brought out as by magic. Later he is instructed how to correct missteps, and only when he has exhausted all of his resources does the teacher again take the pencil into his own hand. The few strokes which are then used to perfect the interpretation are as a revelation to the student and mean the most to him because he has striven for the same result. Students who do not take the course visit it frequently and are inspired by what takes place in it. Serving as an example, it reflects upon all of the work of the department and permeates the work of the other courses.

Another course which must not be left unmentioned is the journal club. Its membership is limited to ten and the work of the students is energetic and enthusiastic. This spirit depends entirely upon the leader, who selects the articles to be reported with great care. Each student gives a report of twenty minutes' duration every third week. As most of the articles reported are in foreign languages, a good reading knowledge of French and German is required, and during the past year a number of Italian and Spanish articles have been reported also, since several of the students commanded these languages. This proved to be of value to the teacher, for the prolific Ramon y Cajal publishes in Spanish. The students have shown such a decided interest in collateral reading that a number of private reading clubs have been organized, one of which was limited to those who speak German fluently, as all reports were made in this language.

It is not necessary to defend journal clubs and the reading of scientific articles to those who are interested in graduate work, for they believe it to be a necessity in real work, but those who are opposed to more serious efforts on the part of medical students will probably question very much such expenditure of time. However, these efforts are not new in countries where medicine is a learned profession, and where medical schools are also intended to promote medical science. In those countries many of the great leaders in biology are anatomists, and this country gives promise of a development in the same direction With us the demand for this kind of intellectual effort came partly from the students, and we gladly met it. It is gratifying to us to see study of this kind increase, for through it we shall receive our much-needed new growth of medical scientists, which, of course, must also include our future anatomists.

Other and shorter elective courses need not be described in detail, for they are not constant from year to year, but are changing to meet the conditions brought about by an ever-shifting staff. The work in these courses is always informal, often along the line of the teacher's own individual work, and frequently they end by formulating problems for students to investigate. Thus there is always a student or two working in human embryology; in case his interest does not lag it is quite easy to direct it towards a special topic, and in this way most of the work on human embryology which has been published from this laboratory was started.

I have expressed myself repeatedly in favor of anatomical departments as conservators of anatomical science, where all members of the departments are students interested in one or more of its subdivisions and its further growth.[5] The department in a university should be truly a university department and not one that limits itself to instruction which

[5]The anatomical course and laboratory at the Johns Hopkins University. Johns Hopkins Hospital Bulletin, 1896; Liberty in medical education. Philadelphia Medical Journal, 1899; On the value of research in the medical school. Michigan Alumnus, 1904; Wilhelm His, Amer. Jour. Anat., 1905; On the teaching of anatomy, Johns Hopkins Hospital Bulletin 1905; On some recent text-books of anatomy, Ibid., 1906; On some points of importance to anatomists, Anatomical Record, Vol. 1, and Science, 1907.

meets the bare needs of medicine and surgery. Were this the case we should return to the more economical arrangement in which the modicum of anatomy is taught by a busy practitioner, that is, one who knows what is practical, during the few spare hours a week he has to devote to anatomy as an avocation.

But what has research to do with the teaching of anatomy? In a number of prominent American medical schools the professor of anatomy is easily made and with similar ease shifts to some other subject, limiting his teaching to the practical needs of medicine according to some text-book. This method was almost universal with us a generation ago, and in Europe a century ago. In fact, we read of the frequent rotation of chairs in order to keep the professors from becoming narrow. But things have changed and now no one would think of mastering any one of the great subdivisions of medicine, like anatomy, without devoting the best portion of his life to its study. It is out of the question for an anatomist of this kind to turn his entire stock of knowledge over to the students, but he can show them what his science means to the world, how it overcame great difficulties and along what lines it is growing. He teaches anatomical methods, and in fact these are of the greatest value to physicians who would be scientific rather than technical; who view their calling as a profession and not as a trade. When anatomical reasoning is put uppermost the technical details are by no means neglected, for they are given by the inductive method in practical laboratory courses.

Indeed, the very nature of our students, especially of those who have given much thought to biological subjects or had already contributed to the science, made it necessary that the subject of anatomy be presented from a scientific standpoint. Some of these students also naturally demanded more advanced work which often formulated itself into problems. They were always among the best students and they are among those who have distinguished themselves since graduation in scientific as well as in clinical subjects.

Nothing is of more importance to a capable student than to be started aright in scientific work early in his career, and if he is to contribute to science he must begin before he is too old. This can all be done to advantage in a medical course, provided that it is liberal and not stereotyped, and that the principle of equivalents is recognizd by making many of the courses elective. Under these conditions much time, which otherwise would be dissipated, can be devoted to a single line of thought.

According to present arrangements about a year's time in the four years' medical course can be devoted to elective studies, and if this be increased by receiving credit for the required work, which may have been done elsewhere, ample time is obtained to undertake serious scientific work in anatomy. Then for those who "have seen the light" it is perfectly clear that a student who has formulated a problem and has solved it, has established for himself a standard of excellence which will permeate all of his subsequent work. The contribution thus made, though often small, is added to the stock of knowledge, as well as to his own credit, which, as the first dime in an account in a savings bank, is the most important deposit.

If, as is frequently asserted, the chief difference between the work of graduate medical students and of other graduate students, as those of zoölogy and of chemistry who are also professional, is that the latter undertake research work while the former do not, then the plan given above removes the difference in principle at least. However, in the case of the professional student of zoölogy or of chemistry the successful research, which is given in the form of a dissertation, becomes the chief test for his doctorate, while with the medical student no account is taken of it. He does the work for the love of it and usually against opposition. By our present arrangement the time devoted to scientific work counts as time towards the medical degree, but no premium is placed upon a successful effort. At the University of Chicago and elsewhere those who carry their work to a successful termination become candidates for the degree of Ph.D., without disturbing in any serious way their medical course, and this method of procedure is considered the best by many educators. The time is at hand, it seems to me, to make the medical degree fully equal to the philosophical, and this will be done when we also require for it a dissertation containing a contribution to knowledge. Since our medical course is partly elective, and since a number of our better students elect research work and publish their results, I hope to see the day when they are at least permitted to present these results as one of the requirements for the degree of doctor of medicine. In case this is done it will call for a revision of our present system of examination, which, in my opinion, is now in a deplorable condition. In order to aid in bringing about this revision I have always held but a single, and largely practical, examination in anatomy to test the students' proficiency in the subject, but no examinations at the end of individual courses. When examinations for the degree are set to test the students' working knowledge in the larger subjects and the numerous course examinations are omitted, it will not be difficult to value justly a given dissertation.

Since students elect courses because they desire special information and believe in the teachers that give them, it follows that the spirit in such courses is always the best. Under such circumstances a critical insight is most easily attained, and this is what we are striving for in all of our educational efforts. Just in this respect the occidental is superior to the oriental method. But to develop it to the fullest, research work must be undertaken, and this is the chief plea from the students' standpoint for such work. Furthermore, research work will enable us to develop scientists in the medical branches, and the call for them has never been greater than it is to-day. In fact, it is so great that many of our positions in anatomy are filled by philosophical doctors who are not always in sympathy with the problems of medical education.

This brings me to the question of the relation of research work to the teachers of anatomy in a university. As soon as the culture of a nation has reached a plane in which it is desired to utilize to the utmost scientific discoveries as a means towards progres, it becomes necessary for the teachers in universities to be fruitful investigators. Not only must they be masters in their respective professions, but they must also be leaders in them and be able to improve them. A nation that cannot make guns cannot use them, and victories cannot be won unless weapons are constantly improved. The university teacher must have more than literary command of his subject; he must also be an investigator and go back to nature for information. There he will find his inexhaustible teacher. A university teacher of this kind finds an abundance of problems for investigation in his daily routine while he is leading beginners, and if he does not his chances of becoming a pedant, or even less, are excellent. Instinctively the better students listen to the teachers who are recognized authorities in their respective branches and heed their advice. The recognition that this instinct is becoming more pronounced from year to year is one of the most hopeful signs in our higher development to-day. The teachers should be the more experienced older students, working harmoniously with the younger ones, showing constantly that they are serious and that the work is worth while. All this is most likely to happen when the teachers are investigators and their work is elective.

Every member of our staff is placed under these conditions. For conservative reasons all take part in the obligatory courses and each is encouraged to offer an elective course in which, by the way, he may test his pedagogical ideals. As all members of the staff have been engaged in scientific work either here or elsewhere before they were appointed, it is relatively easy for them to continue their own studies during the academic year. Every encouragement is given in this direction. Those who make themselves felt as teachers and investigators are promoted or are called to other universities, and if this principle of adjustment between scientific achievement and worldly career were general that dreadful disease of anatomical departments due to inbreeding would be cured.

It has been the aim of a number of American anatomists to elevate the status of our profession, for it has been resting as a compressed buffer between surgery on the one hand and zoölogy on the other. The former has been squeezing out the worldly part and the latter the spiritual. Through a variety of efforts anatomy has reclaimed her own and is beginning to make herself felt through the Association, the Wistar Institute, journals, and strong university departments, one of which comes to light each year. As a contribution towards the organization of the latter the above is written, with the hope that it will aid the development of the science of anatomy as well as of medical education.

A Note on the Question of Gill-Position in Myxinoids.

BY

CHARLES R. STOCKARD.
Cornell University Medical College, New York City.

In a recent number of this journal Johnston ('08) has made reference to the gill condition in Myxinoids. Dr. Johnston refers in this connection to a former criticism I ('06) made of his position regarding the gills in Bdellostoma. It may have been unintentional on his part, but in attempting to reply to this criticism Johnston has completely evaded the main issue with which I disagreed.

In his paper on the morphology of the vertebrate head Johnston ('05) based conclusions on incorrect results advanced by Price ('96), although these results had been subsequently rectified by Dean ('99) and Price ('04). This unfamiliarity with the literature I mentioned through justice to Price's more recent work and Dean's extended study on the development of Bdellostoma, the latter antedating Johnston's paper by five years. Johnston excuses himself for not having seen Price's more recent paper, which only shortly preceded his, but makes no mention of having overlooked Dean's, for which there was no excuse.

Johnston concluded that the gills in Myxinoids belong originally to the trunk, since during development a long series (twenty-three or twenty-four gills) in front of the permanent ones are lost, *à la* Price's earlier paper. This conclusion is entirely erroneous, since the gills of Myxinoids, during the development of each individual, arise in the head and follow one another at regular intervals from the hyomandibular back to the most posterior member of the series. The adult trunk position Dean had attributed to a process of shifting, not of disappearance. I found that the gills attain their adult trunk position in a manner as follows: A rapid growth area is established between the third gill following the mouth and the fourth, which gives rise to a long region between the head and the most anterior gill of the adult series. This growth, together with the development of the large club muscle and the loose connection of the gill-lappet tissue with the dorsal musculature, accounts for the final trunk position of the gills.

The assumption that the gills belong originally to the trunk is the important issue on which I disagreed with Johnston, and to this he makes no reply. He based considerable speculation on the trunk-gills of Myxinoids and went so far (p. 228) as to suggest that the distribution of the ramus intestinalis of the vagus nerve was coextensive with the primitive gill region. In other words, the stomach of vertebrates has its vagus innervation on account of its once having been a part of the gill region. This reasoning is highly hypothetical, and while one may still hold such a view, the fact is certain, that no support for it is furnished by the gills in Bdellostoma, which do not originally belong to the trunk but arise in the head region.

Johnston's criticism is entirely aside from the results presented in my former paper, none of which he attacks. He criticises justly, however, a carelessly constructed sentence in my review of literature. This sentence must have been due to an oversight, as would be evident to the reader, who finds that it is contradicted by facts clearly brought out in the body of the paper. The extended criticism made of the sentence tends to avoid the real issue and might convey the idea that Johnston was attacking my conclusions, while such is not the case On the other hand, Johnston uses the facts furnished by my work to account for the condition of the glosso-pharyngeal nerve in Myxinoids.

PAPERS CITED.

DEAN, B., '99.—On the Embryology of Bdellostoma Stouti. A General Account of Myxinoid Development from the Egg and Segmentation to Hatching. Festschr. z. 70 Geburtstage C. v. Kuppfer. Jena, pp. 221-276.

JOHNSTON, J. B., '05.—The Morphology of the Vertebrate Head from the Viewpoint of the Functional Divisions of the Nervous System. Jour. Comp. Neur. and Psychol., XV, pp. 175-275.

JOHNSTON, J. B., '08.—A Note on the Presence or Absence of the Glosso-Pharyngeal Nerve in Myxinoids. Anatom. Record, II, pp. 233-239.

PRICE, G. C., '96.—Some Points in the Development of a Myxinoid (Bdellostoma Stouti Loc.). Verhand. der Anatom. Gesellsch. 10 Versammlung, Berlin, pp. 81-86.

PRICE, G. C., '04.—A Further Study of the Development of the Excretory Organs in Bdellostoma Stouti. Amer. Jour. Anatomy, IV, pp. 117-138.

STOCKARD, C. R., '06.—The Development of the Mouth and Gills in Bdellostoma Stouti. Amer. Jour. Anatomy, V, pp. 481-517.

A Contribution to the Embryology of the Liver and Vascular System in Man.

BY

N. W. INGALLS, M.D.

From the Anatomical Laboratory of Western Reserve University.

The present paper is supplementary to a more extensive article that appeared in the Arch. f. m. Anat., Bd. 70[1], and extends those observations and introduces some new material derived from further study of the same embryo. The drawings and plates were made in the Anatomisches Institut in Freiburg last summer and the models worked up here during the past winter.

The structures modeled include the entire liver circulation, together with a part of the sinus venosus, the same with the hepatic tissue in situ, both models also showing that portion of the gut tract included within the limits of the models, and, in addition—appearing in but one plate—the lungs, all 100 times enlarged. These structures, excepting the lungs, extend over some six segments, the last five cervical and the first thoracic. The caudal limits are just above the point where the vitelline duct joins the intestine, the anastomosis between the two omphalomesenteric veins being almost exactly on the same level with the lower free border of the ventral mesentery. Cranially, the plane cuts the two horns of the sinus venosus a little above the point where the right horn opens into the right atrium, the spindle-shaped stomach, which is just beginning its torsion, is cut slightly above the middle. Certain unessential details present in the models have, for the sake of clearness, been omitted in the plates, and for the same reason the connection of the liver substance with the gut in Plate IV is not shown.

Plate I gives a ventral view of the model of the veins and gut tract without the liver, the latter having been severed from its connections just above the gall bladder by a cut passing obliquely downward and forward.

The smaller right umbilical vein is just beginning to form a connection with the liver veins by a few small vessels and continues craniad

[1]Ingalls. Beschreibung eines menschlichen Embryos von 4.9 mm. Arch. f. m. Anat., Bd. 70, 1907.

in the lateral body wall, here much larger than the corresponding vein of the opposite side, and empties, after having increased considerably in size, in common with the right omphalo-mesenteric vein, into the right horn of the sinus venosus. The left umbilical vein, caudally somewhat larger than the right, pours most of its blood into the hepatic sinusoids through two huge branches, its original course in the body wall is represented by a slender vessel, very small in its caudal portion, but increasing in size as it ascends and emptying into the left horn of the sinus venosus, lateral to the left omphalo-mesenteric vein. Of the two omphalo-mesenteric veins the right is much larger and the two are connected ventral to the gut by a very fine cross anastomosis. From here they pass craniad and dorsad in the mesentery and break up into branches on either side of the gut (Plate II). The branches from the right vein are much the larger and reunite again to form the original trunk of the vein. The left vein breaks up into three branches which run almost directly craniad, the two ventral ones connecting with the cranial venosus ring while the dorsal branch in addition anastomoses by two channels with the branches of the vein of the opposite side besides connecting with one of the mesenteric veins; the other mesenteric vein uniting with a branch of the right omphalo-mesenteric vein. There thus results a plexus of veins, half encircling the gut just below the dorsal pancreas anlage, and into which plexus is poured the blood from four veins, two omphalo-mesenteric and two mesenteric veins. From this plexus there pass craniad two wide channels, one, smaller, on the left of the gut, the other, much larger, on the right, which divides into two vessels, the one the continuation of the right omphalo-mesenteric, the other uniting ventral to the gut, just above the connection of the gut with the liver, with the already mentioned channel of the left side. Or, in other words, the branches of the left omphalo-mesenteric vein unite in part to form the left caudal portion of the cranial venous ring while the remaining establish a communication with the opposite side; the branches of the right omphalo-mesenteric vein, after breaking up into some three branches and after having received the branches from the left side, unite again to form one huge blood channel, which divides again almost immediately into a larger external branch which continues craniad and is the proximal portion of the right omphalo-mesenteric vein, and a somewhat smaller internal branch, which passes around the gut to meet the vessel of the left side and so complete the ring.

Thus is formed the second or cranial venous ring, which is far more highly developed than the caudal ring with which it shares in common the dorsal plexiform anastomosis. This cranial ring is in close relation with the gut tract, fitting in, as it were, into the angle formed ventro-cranially by the gut and the connection of the liver with the same, dorso-caudally between the gut and the dorsal pancreas anlage; it is obliquely placed, its ventral surface looking not only caudal, but also toward the right. Ventrally this ring is in free communication with the liver sinusoids and the anastomoses between it and the left umbilical vein are especially free. The cranial half of this ring has a triangular shape, the apex extending upward in front of the future duodenum and is continued into a blood-vessel that ascends on the post surface of the liver, ventral to and very near the stomach. From this ascending channel, the ductus venosus, there are given off—or received—several small branches opposite the caudal half of the stomach (Plate II); these are the veins first described by Broman[2] and to which he attributes so large a rôle during the early development of the stomach; but whether the blood in these few vessels is going to or coming from the stomach, we will not venture to say. It may very well be that the pressure in the ductus venosus, and consequently in these vessels, is, on account of its free connection with the left umbilical vein, higher than in the capillaries around the stomach. That they have, at this stage at least, much functional significance seems to us doubtful. The ductus venosus, just above the cranial limit of the liver tissue in the median line, bends sharply to the right, and, after receiving branches from the liver substance, pours its blood for the most part into the common termination of the right umbilical and right omphalo-mesenteric veins and in part into the latter. At the point where the ductus venosus bends to the right, it receives a communicating branch from the most proximal portion of the left omphalo-mesenteric vein. It is this vessel that later serves to convey the blood from the left lobe of the liver to the inferior cava. The proximal portion of the left omphalo-mesenteric vein still persists, receiving its blood from numerous large anastomosing channels which occupy the left lobe of the liver and which possess free anastomoses with the left umbilical vein and the cranial venous ring, but none with the left omphalo-mesenteric vein. The sinusoids of the left lobe are of slightly larger calibre than those of the right and at the same time somewhat less numerous.

[2]Broman, Ueber die Existenz eines bisher unbekannten Kreislaufes im menschlichen Magen. Anat. Anz., 1903.

Viewed as a whole, the bulk of the blood passing through the liver enters it by way of the left umbilical vein and leaves by the right omphalo-mesenteric. The path of least resistance would be through the branches of the left umbilical vein to the left side of the cranial venous ring, across the ventral half of this to the left omphalo-mesenteric; such may well be the course of the blood, as the right omphalo-mesenteric, where it joins the right umbilical to empty into the sinus venosus, is several times larger than both omphalo-mesenteric veins combined and the tributaries that it receives directly from the liver would not account for its great size.

Further description of the conditions present does not seem necessary, and Plates I and II will render clear the above account and supply whatever of nonessentials have been omitted from the same.

The liver has at this stage the typical horseshoe shape, and when seen as a model without its vessel is quite compact and solid. Its ventral surface (Plate III) is in relation cranially with the horizontal portion of the sinus venosus and presents a corresponding slight concavity from which several veins open directly into the sinus venosus. The caudal half of the ventral surface is in relation with the dorsal wall of the pericardial cavity in the region occupied by the ventricular loop. This surface is more convex and characterized, particularly on the right side, by numerous small, irregular outgrowths of hepatic tissue. Numbers of small vessels are found on this surface, but it was often impossible to determine their connections. The lateral surfaces are much smoother, but the left lobe especially is deeply grooved by the numerous large vessels that have not yet been outgrown by liver cells. The concavity of the liver, *i. e.,* the internal surfaces of each lobe and the dorsal aspect of the connecting mass, presents a smooth surface where appear but a few small vessels aside from the ventral half of the cranial venous ring which lies here closely applied to the liver tissue and from which ascends, upon the dorsal surface of the liver, the ductus venosus. The most caudal extent of the liver tissue is represented by several small processes which extend along the branches of the left umbilical vein or project free into the surrounding mesoderm; this is most marked to the left side of the median line. Not only is the left liver lobe smaller than the right, but relative to the number of blood-vessels there is less liver tissue here. In the upper half of the left lobe the large channels which represent the original left omphalo-mesenteric are entirely exposed on their external surface, internally, on the surface toward the gut, the liver tissue has extended farther and conceals these vessels almost entirely, reaching as far as the connection between the omphalo-mesenteric and the ductus venosus. In the right lobe the hepatic tissue reaches much further craniad, being in relation with the right umbilical at its termination. Only the dorso-lateral wall of the right omphalo-mesenteric vein is more or less free from liver tissue, and above at one point is has been entirely encircled by it. It is on the internal aspect of the right lobe that the hepatic tissue reaches highest as a thin sheet closely applied to the inner wall of the right omphalo-mesenteric vein.

Taken as a whole and without regard to the veins, examination of the liver reveals the following points of interest. Viewed from above it is seen that the right lobe is much larger than the left and extends farther dorsad. In ventral view the right lobe also extends farther craniad, while the bulk of the liver tissue caudally is to the left of the median line. Viewed from either side, but especially marked when seen from the right side, it is found that the liver appears as a somewhat elongated mass, of which the long axis runs caudo-craniad. It will thus be seen that the trend of the liver tissue is the same as that of the blood poured into the hepatic sinusoids, and a line drawn from the point where the branches of the left umbilical vein enter the liver to the point where the right omphalo-mesenteric leaves it, while giving the point of entrance and exit of the bulk of the blood passing through the liver, will also represent the long axis of the mass of hepatic tissue.

For certain details not found here the reader is referred to the above cited description of the embryo.

I should like to call attention here to certain structures already but merely touched upon in the systematic description of the embryo (1) and to which it seems to me possible to give another interpretation. On page 524 of the article just referred to occurs this sentence and outside of which I have not considered the structure in question: "gerade wo die Vena card. post. zur Bildung des Ductus Cuvieri sich stark ventralwärts biegt, empfängt sie einige grosse absteigende Zuflüsse." Fig. 11, page 522, illustrated the condition.

My attention was directed to the possible significance of these vessels by the work of Huntington and McClure[3] on the early development of

[3]Huntington and McClure. The Anatomy and Development of the Jugular Lymph Sacs in the Domestic cat (Felis domestica). The Anatomical Record, Vol. II.

the lymphatic system in the cat, and I have been led to look upon them as the first anlage, or earliest forerunners, perhaps, of the lymphatic system in man.

Figs. 1 and 2 are reconstructions of the right and left sides respectively, showing the anterior and posterior cardinals, the duct of Cuvier and the vessels already mentioned. These structures extend over five segments, the last occipital and the first four cervical. Just dorsal to the most proximal portion of the superior cardinal and emptying in

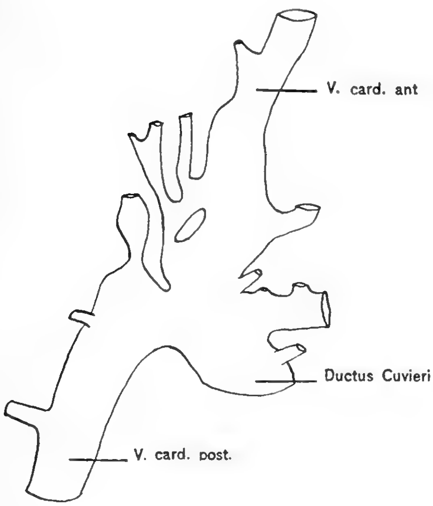


Fig. 1

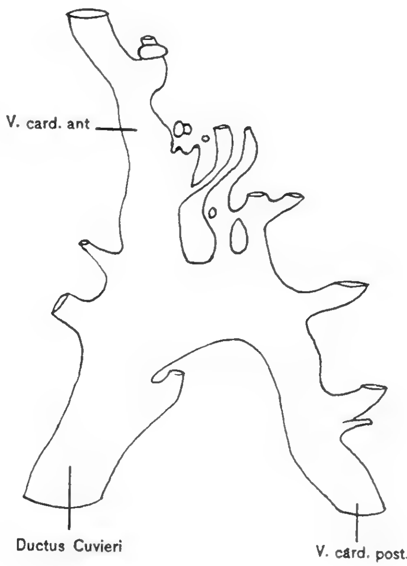


Fig. 2

part into this vesel and in part into the posterior cardinal as it bends forward to unite with the superior cardinal are found a number of small vessels, rather more numerous on the left side. These lie for the most part in a plane placed almost sagitally—the more dorsal vessels being slightly nearer the median line—lateral and somewhat ventral to the dorsal aortæ and ventral or even internal to the ventral border of the myotomes. Most of these vessels have a connection with one of the cardinal veins, but others have apparently no such connections. These structures bear no small resemblance to those pictured by Huntington,[4]

[4]Huntington. The Genetic Interpretation of the Development of the Mammalian Lymphatic System. The Anatomical Record, Vol. II.

Fig. 6, differing from those largely on account of the absence of any fenestration. The stage of the embryo from which his Fig. 6 is taken is, however, much older than that here described. It is true that the beginnings of the lymphatic system have been described in other animals at a stage more advanced than that of this embryo, but the findings here, almost exactly the same topographically, have seemed sufficient to warrant the view that these vessels are veno-lymphatics.

A New Method of Brain Dissection.*

BY

J. B. JOHNSTON.
University of Minnesota.

The object of brain dissection has usually been to study architectural or topographic relations, and the method has been that which seemed to the instructor mechanically the most convenient. After following a well-known guide with his first class of medical students, the writer came to the conclusion that the brain should be dissected with especial reference to the study of functional relations. For this purpose those structures should be studied together which are engaged in the same functions or closely allied functions, rather than those which are related in space merely. Further, the mode of dissection should be such that the specimen will remain as far as possible intact, so that the student may readily review his dissection and by repeated examination of parts which are kept in place may form clear and lasting mental images of the structural relations. This is only equivalent to saying that in the brain as in the animal body, good dissection consists in the separation of parts so as to exhibit their form and relations with the least possible removal or destruction of any of the parts. This is of course much more difficult in the brain than in the dissection of other systems of organs.

An outline for the dissection of the mammalian brain in which the order and mode of dissection was determined by the functional relations was prepared and has been used with four classes of medical students and with some students of zoölogy, with very gratifying results. In order to present the distinctive features of this plan of dissection considerable parts of the outline are published below. In preparing the outline the writer carried forward parallel dissections of the brains of the dog, sheep and man, and it is believed that the outline can be used satisfactorily with any of these brains. In different years the brain of the dog and that of the sheep have been used for the main part of the student's dissection, the human brain being used for dissection or only for demonstration according to the abundance of material.

*Neurological Studies, University of Minnesota, No. 5.

In addition to the material for dissection, there are placed on the demonstration tables: various dissections of the human brain following the usual method, to enable the student to compare the actual specimens with the figures in the text-books and atlases in common use; gross sections in three planes mounted in very thin rectangular jars, for comparison with dissections and with microscopic sections; dissections of mammalian and human brains following the class outlines up to certain points, serving to some extent as models and for the comparison of different orders of mammals; and dissections of the brains and cranial nerves of various vertebrates.

In the following outline the directions for dissection of the mammalian brain are printed from the sheets furnished the students. The other portions of the work are indicated by topical headings only. The study of the brain and cranial nerves of the fish introduces the student to the functional point of view, and the study of sections is carried on in direct connection with the dissection and of course from the same point of view. It should be said that this particular course is preceded by others in which the elements of nervous tissue and the main features in the development of the brain and nerves are studied. It is followed by the course in the physiology of the brain, by a more detailed course in embryology and by a course intended to give special preparation for the study of brain pathology. The practical portion of the examination includes the presentation of a clean and workmanlike dissection and the demonstration in it of the structures studied.

Part I. General Morphology of the Vertebrate Nervous System.

A. Fish type. Dissection of the head of the dogfish, *Squalus* or *Mustelus*.

Sense organs, cranial and spinal nerves, spinal cord and brain.

B. Mammalian type. Study of the brain of the sheep or dog and of man.

I. Membranes and blood supply studied on injected human brains.

II. General features and topography of the spinal cord and brain. (Study of external features and relations from entire and bi-sected brains and demonstration dissections. This acquaints the student with the more important subdivisions and landmarks. He gets his study of the peripheral nerves in the dissecting room.)

Part II. Internal Structure of Mammalian and Human Brain.

I. Somatic sensory division.

1. Spinal cord and nerves. Note again the dorsal root and the dorsolateral sulcus. Examine the dorsal funiculus and see that in the cervical region it is divided by the dorsal intermediate sulcus into the medial *fasciculus gracilis* and the lateral *fasciculus cuneatus.* Which is larger?

Study of sections of lumbar, thoracic and cervical cord (dorsal roots, dorsal tracts, reflex collaterals, dorsal horn, etc.).

2. Myelencephalon. A. Dissection. If not already done, clean away carefully all membranes and blood-vessels covering the myelencephalon and metencephalon, taking the greatest care to preserve the roots of the nerves. With a sharp scalpel make a median vertical incision through the cerebellum and then by vertical transverse cuts slice away the posterior part of the left half of the cerebellum until the striæ acustici in the floor of the fourth ventricle are exposed. Study the following:

a. Form and outline of fourth ventricle as far as exposed. Locate the line of attachment of the tela chorioidea. Shape of the caudal border of ventricles and relation to dorsal sulcus of spinal cord. Across the extreme caudal part of the ventricle a fragment of the tela adheres and is called the *obex.*

b. Fasciculus gracilis. Relation to ventricle.

c. *Clava,* the widened and elevated anterior end of *b.* It contains the *end-nucleus of the fasciculus gracilis* (nucleus of Goll).

d. Fasciculus cuneatus, bounded laterally by the dorso-lateral sulcus.

e. *Nucleus of the fasciculus cuneatus* (Burdach), the enlarged end of *d.*

f. *Corpus restiforme,* the large ridge continuing forward from *c* and *e.* It runs beneath the striæ acustici and will be traced later.

g. *External arcuate fibers.* Note upon the lateral surface of the medulla a broad band of fibers disposed diagonally. They come up from the ventral side of the medulla, cross over the surface of the olive, the trapezoid body and the front part of *e.* They come from the nuclei fasciculi gracilis and cuneati of the opposite side and enter the corpus restiforme to go to the cerebellum.

h. Lateral to *d* and *e* the external arcuate fibers cross a broad rounded ridge which merges with the corpus restiforme as it passes forward. Trace it toward the cord; relation to dorsal root of first cervical nerve. The ridge is formed by the *tractus spinalis trigemini* and the *substantia gelatinosa* (*Rolandi*), which serves as its end nucleus.

i. *Corpus trapezoideum,* the depressed area behind the pons and between the olive and the roots of IX and X. In mammals it is usually elevated.

j. *Nervus acusticus.* Distinguish two main parts, the *N. cochlearis* dorso-caudally and the *N. vestibularis* cephalo-ventrally, and separate them.

k. *Tuberculum acusticum,* a slight elevation on the dorso-lateral surface of the corpus restiforme into which the N. cochlearis enters. From the cochlear centers here the secondary fibers run chiefly in the striæ acustici and in the trapezoid body, to the lateral lemniscus of the same and the opposite side.

l. *Area acustica.* An area in the lateral part of the floor of the fourth ventricle and on the medial surface of the forward part of the corpus restiforme which contains the centers for the N. vestibularis. To see *k* and *l* to good advantage the flocculus, uvula and nodulus of the cerebellum must be removed as directed in the next section.

Now, working carefully with a sharp scalpel, trace the spinal V tract by cutting through the pons, between the VII and VIII nerves and through the external arcuate fibers and gently raising up the overlying structures until the longitudinal tract of fibers can be seen from the root of V caudad.

B. Examine sections through various levels of the myelencephalon in order to trace the internal relations of the above-mentioned structures. (Sections at specified levels are studied and drawn. These and other drawings from sections are made in this way: the section is outlined and a few prominent landmarks are identified and sketched in; then the structures studied in the present section are carefully drawn; later, when other functional systems which are cut in these sections are studied, they are drawn into the same figures; in this way the outline drawings are filled up as the work progresses, guesswork and hasty conclusions due to drawing things which have not been carefully studied are avoided, and the relations between the functional systems are fixed in the mind as the several drawings come up for review and additions.)

3. Cerebellum. The corpus restiforme carries up to the cerebellum the following somatic sensory fibers: root fibers of dorsal spinal nerves (?), direct secondary fibers from the dorsal horn, nuc. gracilis and nuc. cuneati, crossed fibers (external arcuate fibers) from the same nuclei, root fibers of the N. vestibularis and of the N. trigeminus, and secondary fibers from the vestibular nuclei. Continue the dissection of the cerebellum.

a. *Floccular lobe.* A small much convoluted lobe projecting over the root of the VIII nerve. Note its slender stalk of white matter and then with forceps pick away the substance of the lobe, stripping the fibers of the stalk centrally. This will expose more fully *f, j* and *k* above.

b. *Brachium pontis.* Beginning at the cut made to expose the spinal V tract strip the fibers of the pons upward into the cerebellum.

c. *Brachium conjunctivum.* Slice away the remainder of the left half of the cerebellum by horizontal cuts until the corpora quadrigemina and the brachium conjunctivum are exposed. Proceeding carefully remove the remainder of this half of the vermis without injurying the velum medullare anterius or the IV nerve. Note the relative positions of the brachium conjunctivum, corpus restiforme and brachium pontis as they enter the cerebellum. Review *k* and *l* of the last section.

d. Divisions of the vermis. On the median cut surface note the arbor vitæ branching into the gyri, and the very deep sulci cerebelli separating the gyri. Identify the following from before backward: *lingula, lobulus centralis, monticulus* (*culmen* and *declive*), *folium vermis, tuber vermis, pyramis vermis, uvula* and *nodulus.* Which of these are visible upon the surface of an entire cerebellum, and which are not separated from the hemispheres by grooves? Note the *incisura cerebelli anterior,* a broad groove over the c. quadrig., the *incisura cerebelli posterior* between the hemispheres above and behind, and the *vallecula cerebelli* below. The most important fissures seen on the cut surface of the vermis are those between the culmen and declive (*fissura prima*) and between the pyramis and uvula (*fissura secunda*). These divide the cerebellum into *anterior, middle* and *posterior lobes.* The middle lobe expands laterally to form the hemispheres, to which are added the floccular lobes mentioned above.

e. Hemisphere of the cerebellum. On the entire half note the form of the hemisphere, the direction of its gyri, and with the aid of an atlas identify its chief anatomical divisions.

f. *Deep gray masses* or *nuclei* of the cerebellum. These are situated in the roof of the fourth ventricle near the *fastigium,* a name applied to the angle in which the velum medullare anterius and the v. m. posterius meet. The most lateral and largest of these, the *nucleus dentatus,* gives origin to the fibers of the brachium conjunctivum. Examine it in demonstration sections and dissections.

g. Upon the dorso-lateral surface of the brachium conjunctivum note the *fila lateralia pontis* and the *trigonum lemnisci.* The importance of the latter will appear in the next section.

The cerebellum is in reality the greatly enlarged somatic sensory zone—dorsal part of the lateral wall—of the brain which has grown up and arched over the ventricle. Note that its relation to the corpus restiforme is in agreement with this.

4. Lemniscus system, mesencephalon and diencephalon.

a. *Lemniscus medialis* (or fillet). (Traced in sections.)

b. *Lemniscus lateralis.* (Traced in sections.)

Do not attempt to examine *c, d* and *e* until the dissection under sec. 5 has been done.

c. Corpora quadrigemina. These not only serve as a secondary center for the lemniscus system as just stated, but receive a small bundle of general cutaneous fibers from the sensory root of the trigeminus.

d. Corpus geniculatum mediale. See above.

e. *Tuberculum anterius thalami,* contains end-nucleus for medial lemniscus, and other centers.

5. Somæsthetic and motor areas of cerebral cortex. Note in the sheep the *rhinal fissure* bounding the rhinencephalon laterally and distinguish the two main parts of the hemisphere, the *archipallium* and the *neopallium.* Identify the corresponding parts in man. Study the neopallium here. Examine the gyri and sulci, carefully removing the pia and pressing apart the gyri in order to see the depth of the sulci. Beginning around the lateral fissure pick away the cortex with forceps and study the arrangement of the white and gray matter. Make a sketch to show this. Find strands or laminæ of fibers—*association fibers*—connecting adjacent gyri, running in loops beneath the sulci. Deeper there will be found a broad band of fibers which appears to connect the frontal with the occipital and temporal lobes, the *fasciculus longitudinalis superior.* Trace this forward and backward and note its position and extent. Insert it in the drawing of the lateral aspect of the hemisphere. A similar band will be found joining the frontal and temporal lobes and looping around the base of the Sylvian fissure, the *fasciculus uncinatus.* Still deeper in the brain substance will be found fibers running obliquely from beneath the insula toward the parietal lobe. Owing to the radial arrangement of its bundles it is known as the *corona radiata.* Follow it toward the optic chiasma. The deep gray mass in the base of the hemisphere through which it passes is the *corpus striatum.* It will be studied later. In the corpus striatum the fibers collect and receive the name of *capsula interna.* Cut through the optic chiasma and carefully raise the optic tract until the whole of this bundle is exposed. It contin-

ues caudad as the pedunculus cerebri, grows smaller and plunges beneath the pons. Examine sections through the pons and follow it by dissection. Behind the pons the bundles continue as the pyramids. Trace them and find their decussation. The whole system of fibers just described contains most of the *fibers of projection* of the neopallium. Draw in ventro-lateral view of the whole brain.

The following dissection must be made with the greatest care and the examination of fiber bundles made as thorough as possible. Preserve the floor of the lateral ventricle and the temporal lobe. Continue to pick away the cortex of the dorsal and medial part of the hemisphere. As far as possible remove the cortical gray layer and leave the frayed-out bundles of fibers in position. In this way will be found the fibers of the corpus callosum interlaced with those of the corona radiata. The corpus callosum consists of commissural fibers serving to connect the neopallial centers of the two hemispheres. Notice again its position in dissected brains. Continue to pick away the cortex and strip off fiber bundles with the forceps until the whole extent and distribution of callosal and coronal fibers is determined. Does any part of the neopallium seem to be exempt from either kind of fibers? Examine especially the frontal and occipital lobes. The ascending fibers of the corona radiata bring sensory impulses to the cortex; the descending fibers carry "motor" impulses to lower centers. The areas with which these fibers of projection are connected are called the *senso-motor areas.* Impulses from cutaneous sensory centers enter the central and part of the frontal gyri, which constitute the *somæsthetic area* (consult atlas). In the anterior central gyrus and parts of the frontal gyri is the *motor area* from which arise most or all of the fibers descending to motor centers. About the calcarine fissure in the occipital lobe is the *visual area,* and in the temporal part of the operculum is the *auditory area.* The fibers connected with these areas will be re-examined in the next section. Return now to section 4 and examine points *c, d* and *e.*

Examine transverse, sagittal and horizontal sections of the human brain to see the relations of the internal capsules, corona radiata and corpus callosum.

6. Optic tract and visual centers. Higher auditory centers.

A. Lift up the temporal lobe of the hemisphere and the lateral aspect of the diencephalon and mesencephalon will be brought to view. The optic tract marks roughly the cephalic border of the diencephalon. It differs greatly in width and volume in the dog, sheep and man. Trace it into the corpus genic. laterale and the pulvinar and note that the more caudal fibers pass by or over the c. genic. mediale and enter the superior colliculus. Cut the optic tract near the chiasma and strip it off from the underlying structures to its endings. In so doing it will be seen that the tract is interwoven with the most caudal fibers of the capsula interna and that these latter fibers on the one hand are connected with the occipital cortex and on the other plunge directly into the optic centers of the thalamus. They include the ascending optic bundles or fibers of sight.

Tractus penduncculus transversus. Traverses the lateral surface of the mesencephalon nearly vertically. Trace it to its ends.

Superior colliculus. Size, form and relations. Secondary cutaneous and primary optic center. Sends large tract to nucleus of III nerve.

Inferior colliculus and corpus genic. mediale. Note the pear-shape of the inferior colliculus, the strong commissure connecting it with its fellow and the large stalk running from it beneath the c. genic. mediale. Carefully lift up the c. genic. med. and see the fibers of the stalk of the inferior colliculus entering it and demonstrate that fibers from both form an important part of the capsula interna. These bodies are the secondary centers for the cochlear nerve and the fibers are the tertiary auditory tract or fibers of hearing. Where do they end in cortex?

Draw the dorsal aspect of the brain as dissected, leaving the right hemisphere to be drawn later. Add to the last drawing the facts dealt with on this page.

B. Microscopic sections through the colliculi and thalamus.

II. Somatic motor division.

1. The somatic motor fibers run in the ventral spinal and in the XII, VI, IV and III cranial nerves. Review the position of these roots.

2. Location of the nuclei of origin. Remove the right half of the cerebellum by cutting the three brachia close up to the cerebellum. Examine the velum medullare anterius and the decussation of the IV nerve in it. Remove the velum. In the floor of the fourth ventricle and aqueduct note the pair of large ridges next to the median furrow. These contain the nuclei of the somatic motor nerves opposite the respective roots. They contain also the large *fasciculus longitudinalis medialis* and a part of the visceral motor nuclei to be described later. Now note that while the somatic motor nuclei lie in the mid-ventral region the somatic sensory centers occupy the dorso-lateral border of the medulla oblongata. Between the two are the visceral sensory structures to be studied immediately. Examine cross sections through the nuclei of the

XII, VI and III nerves and insert these in sections already drawn or in new drawings.

III. Visceral sensory division.

1. Trunk region. Visceral sensory fibers run by way of the rami communicantes, have their ganglion cells in the spinal ganglia and end in the region of Clarke's column in the cord.

2. Head region. A. Dissection.

a. The visceral cranial nerves are the X, IX and VII (N. intermedius Wrisbergi). Examine again the mixed sensory and motor roots of X and IX and the root of the N. intermedius. Review the course and distribution of the sensory fibers of these nerves.

b. Visceral sensory centers. In the lateral part of the floor of the fourth ventricle note a broad ridge which grows narrower and more prominent caudally. The ridge is known as the *ala cinerea.* The two ridges converge caudally, and as they pass beneath the fasciculus gracilis they are overarched and joined by a commissure. The ridges contain the longitudinal *fasciculus solitarius* which contributes to the commissure. The fasc. sol. is made up of the root fibers of the sensory X, IX and VII nerves. The fasciculus is accompanied by gray matter which forms the bulk of the ala and is continuous with a large median gray mass surrounding the commissure above mentioned. It is known as the *nucleus commissuralis.* The ala cinerea is bounded by two grooves which in the human brain meet at the front of the ala in a depression, the *fovea inferior* or *fovea vagi.* In the negro brain as in that of mammals, the fovea is continued forward as a groove bounding the somatic sensory centers ventro-medially.

Make a drawing of the floor of the fourth ventricle, representing all elevations and depressions, and label carefully all the structures studied.

B. Microscopic sections of spinal cord and medulla oblongata.

IV. Visceral motor division.

a. Trunk region. Visceral excitatory fibers arise in the lateral horn and run in the ventral roots to the sympathetic system.

b. Head region. The lateral horn gives rise to the roots of XI and in the medulla oblongata differentiates into the *nucleus ambiguus* or ventral motor nucleus of X and IX lying deep beneath the ala cinerea, and the *dorsal motor nucleus* of *X* and *IX* which helps to form the floor of the ventricle in the lateral part of the motor ridge above described. *Nucleus of motor VII.* Is similar in position to the nucleus ambiguus, farther forward. The root fibers rise toward the floor of the ventricle and curve around the nucleus of VI, then run ventro-laterally to their exit. The curve is called the *internal genu* of the VII nerve. *Nucleus of motor V.* Forward from nucleus of VII and nearer floor of ventricle. Identify each of these nuclei and roots in sections and insert them in drawings.

V. The Olfactory apparatus (part of visceral sensory division).

a. Gently separate the olfactory bulb from the frontal lobe along the line of the rhinal fissure, and note that it forms a quite independent lobe. How connected with the hemisphere? On the left side cut through the corpus callosum about 4 mm. from the middle line (sheep), opening the lateral ventricle but taking care not to injure structures in its floor. Remove a strip of corpus callosum and follow the ventricle into the frontal lobe. Carefully remove the frontal lobe and trace the ventricle into the olfactory bulb (sheep, not in man). Describe form of ventricle and note that the olfactory bulb is the most anterior portion of the hemisphere. In man the ventricle of the bulb is obliterated during development.

b. *Tractus olfactorius.* Note again its division into lateral, intermediate and medial striations, already seen.

c. *Lateral olfactory area.* Follow the rhinal fissure in the dog or sheep, separating its lips and noting its depth, and note that it forms the boundary between the rhinencephalon and neopallium. The lateral olfactory area lies ventral to it and behind the olfactory bulb. Distinguish three parts: (i) the ventral portion of the temporal lobe of the hemisphere, the *uncus gyri hippocampi* of man; (ii) the *substantia perforata anterior,* into which the fibers of the stria intermedia dip; and (iii) a gray area lateral to the stria lateralis, not seen in man and microsmatic animals. Draw bulb, tract and area in ventral view.

d. *Medial olfactory area.* Trace the stria medialis onto the medial surface of the right hemisphere. It ends in greater part in the *area parolfactoria* (*Brocæ*) and the *gyrus subcallosus,* which together make up the medial olfactory area. Trace a part of the stria medialis across this area up to the genu corporis callosi. Carefully remove the gyrus cinguli from the upper surface of the corpus callosum and trace the strand of fibers over the c. c. to its splenial border, around which it bends to enter the hippocampus. The strand is the *stria longitudinalis medialis* and consists of fibers of the olfactory and of other categories. It is accompanied by a narrow band of gray matter, the *indusium verum,* which is a vestige of a well-developed hippocampal structure which occupies this position in the brain of lower mammals. It is smaller in man than in the dog or sheep. Add this to the drawing of the corpus callosum already made.

e. *Tertiary olfactory tracts* and *hippocampal formation.* Follow the stria lateralis into the uncus by scraping away the superficial gray matter. Find a central gray mass, the *nucleus amygdalæ,* from which a broad tertiary tract passes back. Trace it around the ventral margin of the temporal lobe to the hippocampus, which appears as a rounded ridge projecting ventrally beneath the splenium of the corpus callosum. Indicate the whole course of the stria lateralis and of this tertiary tract in the ventral view made above.

f. *Fimbria hippocampi.* Upon the ventricular surface of the hippocampus, oblique striations which collect into a large fiber bundle running along its cephalic border and partly covered by the chorioid plexus.

g. Hippocampal fissure and fascia dentata. Cut the hippocampus across in several places, beginning at the temporal end, and examine the cut surfaces. Note a narrow fissure from the bottom of which a white line leads in a spiral nearly parallel with the ventricular surface of the hippocampus. It is the hippocampal fissure; is it on the inner or outer surface of the brain? medial or lateral surface? The white line is the cortical substance, and at the end of the spiral it makes an opposite turn and ends in a thickening above the fissure. This is the *fascia dentata.* Above it is the fimbria to which the dorsal edge of the chorioid plexus is attached. Is the fascia dentata to be seen on the inner or outer surface of the brain? The spiral line indicates that the hippocampal formation has been rolled on itself to that extent, the fissure marking the line of in-folding. Draw the cut surface.

Carefully raise up the remaining cephalic portion of the hippocampus beneath the splenium c. c. and examine its form and position. Does the fissura hippocampi extend to its end? Can you verify the statement that the hippocampus bends sharply back here to curve around the splenium as the stria longitudinalis medialis? The upper end of the hippocampus just beneath the splenium c. c. is known as the *fasciola cinerea.*

h. Floor of lateral ventricle. The large convex mass seen in the lateral ventricle and forming the ventro-lateral wall of the brain in the region of the insula is the *corpus striatum.* The portion now in view from within is the *nucleus caudatus;* form?

i. *Fornix.* Follow forward the large band of fibers derived from the fimbria hippocampi. It forms a ridge in the medial wall of the ventricle, the *corpus fornicis,* and bends down over and in front of the foramen of Monro to become the *columna fornicis* (see below).

j. *Corpus striatum* and *anterior commissure.* Cut or pick away the corpus striatum beginning at the front and follow the stria intermedia of the olfactory tract into it, preserving the stria intact. Find it bending mesad into a transverse bundle of fibers, the *anterior commissure.* Note the internal capsule and its relation to the nucleus caudatus.

k. Fornix, continued. Note the broad smooth gray area above the foramen of Monro in which the fornix lies. It is continuous with the medial olfactory area and corresponds to the septum pellucidum, which in man has lost most of its gray matter. Split and strip the substantia perforata from its ventral surface upward and trace fibers from it up in front of the anterior commissure into the fornix. They go to the hippocampus. Continue the dissection deeper until a compact bundle of fibers placed nearly vertically behind the anterior commissure, the *columna fornicis,* is exposed. Follow it to the corpus mammillare.

l. *Commissura hippocampi* (*psalterium*). Lift up the remnant of the hippocampus and fimbria, cutting the chorioid plexus of the lateral ventricle and laying open the third ventricle and foramen of Monro. Between the rounded ends of the two hippocampi and the bodies of the fornix will be seen a triangular membrane which overlies the third ventricle. This membrane is striated by many fibers crossing between the bodies of the fornix. The fibers constitute a *commissura hippocampi* and reach the hippocampus through the fimbria. Notice now more closely than before the connection of the stria longitudinalis medialis with the fascia dentata at the front end of the hippocampal formation.

m. *Anterior commissure.* Dissect away the substantia perforata in front of the optic chiasma until the commissure is fully exposed. In the dog the greater part of it goes into the intermediate olfactory striation, the remainder into the corpus striatum. The latter, posterior, part is believed to serve as a commissure for part of the occipital and temporal lobes of the neopallium. In man the commissure has the same disposition except that the intermediate olfactory striation is small and perhaps in some cases does not reach the commissure at all.

Draw a diagram of the whole olfactory apparatus as if seen from the medial surface of the hemisphere, labelling the fiber tracts of the first, second and third order, I, II, III.

VI. Centers of correlation.

(This is chiefly study of sections with the microscope, but the use of the dissections and gross sections is insisted upon, since nothing can take the place of *handling* an object and seeing it in its three dimensions as a means of gaining a clear conception of its relationships. This section includes the study of the substantia reticularis through the spinal cord and brain stem (tegmentum), the olivary bodies, the pontile nuclei, nucleus ruber, substantia nigra, centers in thalamus and hypothalamus, corpus striatum, olfactory centers, and finally the histological characters of the several areas of the cerebral cortex and the disposition of fiber tracts connected with the hemispheres.)

It is believed that the above plan of dissection gives the student everything in the way of architecture that was to be obtained from the old method and invests the architectural features with such meaning that they will be more vivid and lasting in the memory. The content of the course may be briefly stated thus: the student is first given the main topographical features, then the detailed study of the functional systems by dissections and microscopical sections. In general the work follows the direction taken by impulses and proceeds from the more simple and general to the more specialized portions of the brain. As time goes on the work will be enriched by additions to the demonstration material and by an increase in the microscopic study. At the present time the work outlined occupies 108 hours (nine weeks, three afternoons each week), which includes 24 to 26 lectures and frequent quizzes in sections.

It is part of the purpose of the lectures to determine the spirit in which the student approaches the study. We have come in recent years to correlate the study of the behavior of animals with the study of the anatomy and physiology of their nervous systems. This means that we are coming to realize that in each division of our science (biology) the subject of study is the whole life of the animal. So the human nervous system should be treated as one means of approach to the study of human life, or as an expression of the whole human life. To the medical student above all others the biological aspects of the nervous system are most important. The physician must know the nervous system in all its relations, and it bears important relations in every phase of human life. It has been the writer's effort to stimulate and make use of the biological interest in the courses in neurology, while not neglecting the preparation for the clinical courses. Indeed, the medical student is engaged during his first two years in the study of human biology as a preparation for clinical medicine and surgery. It has seemed important to bring to bear on the interpretation of the nervous system the causes which have been and are at work to determine its structure,—causes found in the evolution of habits and of form and structure in vertebrates, in the changes produced in the nervous system through changes in habits and environment, in the increasing complexity of human actions and relations due to the use of tools and the rise of social relations, in the conditions of development of the individual to adult life, etc. Further, a knowledge of structure is almost worthless without a knowledge of function and an intelligent study of structure is impossible apart from the study of function. Therefore, so far as is consistent with the present organization of our schools, the facts of physiology and physiological psychology are introduced to give meaning to the structures studied.

This outline is published in the hope that it may be helpful to other teachers and students and especially that some teachers may give the method a trial with their classes and report their results in the form of criticisms and suggestions. It is only in some such way as this that an adequate and efficient method of teaching neurology can be developed.

BOOK REVIEWS.*

"THE LABYRINTH OF ANIMALS," Including Mammals, Birds, Reptiles, and Amphibians." By Albert A. Gray, M.D., F.R.S.E. Two volumes containing 450 pages and 76 stereographic photographs. London: J. & H. Churchill, 1907 and 1908.

In these two volumes, Dr. Gray has contributed the most complete and valuable series of observations and illustrations dealing with the Comparative Anatomy of the inner ear of vertebrates. The membranous labyrinths of seventy-six species are beautifully pictured and others are mentioned as having been examined and found so similar to certain of those pictured that it was deemed allowable to omit them. General remarks are made introductory to the description of the labyrinths of the different orders of vertebrates dealt with, each plate is accompanied by one or two pages of individually descriptive text, and summaries are given embracing the chief peculiarities and features of comparative interest of the labyrinths of the respective orders and species. In addition, at the end of the order of mammalia, in Volume II, several pages are devoted to a discussion of the venous system of the labyrinth of mammals. The animals are discussed in series under their orders and suborders, and each of the different specimens is designated by both its common and its classical name. The fishes are omitted wholly and the amphibians are but slightly touched for the reasons that both have been more exhaustively worked up by other investigators and because their labyrinths do not lend themselves so favorably as do the higher forms to the method of preparation devised by Dr. Gray.

The work amply justifies the author's expressed hope that it will be found of value, (1) to students of Comparative Anatomy not only as a matter of general interest, but also as an aid in the problem of the correct classification of the animals; (2) to the student of evolution and phylogenetic problems generally since the labyrinth should be as valuable in indicating relative degrees of antiquity as the teeth and other parts of the skeleton; and (3) to students of physiology since anatomical differences in the labyrinth must indicate differences in the variety of its functioning.

*All correspondence regarding Book Reviews should be addressed to Dr. George L. Streeter, Ann Arbor, Mich.

Dr. Gray makes acknowledgment to the Carnegie Trust for their generosity toward making possible the publication of the second, and larger, volume. All will admit that this aid was well placed.

The entire work represents a period of about seven years of effort. Much of this time was spent in devising a satisfactory method of preparation which would give the entire labyrinth intact and in studiable form. The method arrived at is, in itself, an important contribution to the study of anatomy. It may be given briefly as follows:

The temporal bone is taken, as fresh as possible, and all bone carefully trimmed away except that immediately about the labyrinth and internal meatus. The specimen is then fixed for 1 to 3 days in a 5 per cent or 10 per cent solution of formalin, washed 24 hours in water, dehydrated 24 hours in 70 per cent alcohol, and 14 days in absolute alcohol, during which latter period the alcohol is changed two or three times. It is then transferred to ether-alcohol for 3 or 4 days, thin and mediumly thick celloidin for 14 days, and then placed directly into xylol in a closed vessel, the xylol frequently changed, for 2 or 3 weeks. It is next placed for at least a fortnight into paraffin with a melting point of about 50° C., during which period the paraffin is kept melted and is changed 2 or 3 times. The specimen is then cooled and the paraffin scraped off so that the bone and decalcifying fluid may come in contact. For decalcifying, hydrochloric acid was found to serve better than nitric in that it leaves less of a yellow tinge in the specimen. A fluid consisting of 50 per cent hydrochloric and 5 per cent nitric acid in water is suggested. The specimen is allowed to remain in this fluid till the bone is removed, leaving a pulpy mass in which the celloidin-paraffin cast of the membranous labyrinth lies practically free. The whole mass is then washed in running water for 24 hours, which removes the acid and washes away most of the surrounding pulp. The cast of the labyrinth is further cleansed of pulp and debris by the gentle use of a soft brush and then dehydrated and placed in xylol which removes the paraffin of the cast and leaves the specimen quite transparent. It may be stained faintly with any ordinary transparent stain except carmine. For the photography, it should be cleared in a bottle or jar with plane sides.

For the stereographic photographs, it was found that reflected light gave the best results. Dr. Gray worked with a horizontally arranged photographic apparatus and, therefore, with the labyrinth suspended vertically. To obtain the effects of reflected light, he placed a small, black, circular disc in the center of the condensing lens so that the light passing through the outer portions of the condenser illuminated the object while the disc gave the black background. For the stereographic illustrations, each labyrinth was photographed from two points of view, by first taking one picture and then slightly rotating the object holder to the extent of an arc corresponding to the pupillary distance at the plane of the photographic lens. Each picture then represents the image of one eye. The two pictures are mounted side by side, on heavy cardboard just as ordinary stereographic pictures and, for the use of the reader, the volumes are accompanied by a pair of stereoscopic prisms held in a frame.

In general, it is shown that the size of the entire membranous labyrinth varies more nearly with the size of the head than with the size of the body. The two portions of the labyrinth, the pars superior (the semicircular canals and vestibular structures) and the pars inferior (the cochlea), show great relative variation in different species. Frequently the development of the two portions is unequal according to the requirements of the life habits of the animal. Birds and fishes, migratory animals, have relatively larger superior portions; the sloth has a poorly developed superior portion but a cochlea as well developed as other animals. The semicircular canals may undergo retrogressive changes, but, since no animal can escape from sound, there appear to be no retrogressive changes in the cochlea; certainly none such as are found in other organs, the eye of the mole, for example. The degree of development of the cochlea is considered, in general, a fair indication of the extent to which a given species has departed from the original type, while one cannot attach so much significance to variations in the pars superior.

The spiral form is characteristic of mammalian cochleæ. The monotremata alone do not possess this form beyond a rudimentary manifestation of it, a hook-like termination to a slightly curved tube, similar in certain respects to that of the birds. None other of the mammals examined has less than 1¾ turns in its cochlea. The marsupials, probably most nearly allied to the monotremes, have cochleæ as well developed as other orders. However, only the diprodont branch of this order, considered the most recent, has been examined.

The author finds possible an interesting division among mammalian cochleæ into two general types, (1) the flat type and (2) the sharp-pointed type. The sharp-pointed type is possessed by the Carnivora and

Rodents, while the Primates (with the interesting exception of the slow loris), the Ungulata, Cheiroptera, Insectivora and Sirenia possess the flat type. The Edentata have an intermediate form, inclining toward the flat type, while the Marsupials, remarkable to state, possess both types in the single branch of them examined, the Wallaby and the Kangaroo having the flat type and the Phalanger having a sharp-pointed cochlea. Usually, cochleæ with the greater number of turns are the more sharp-pointed, but not always. The seal's cochlea, for example, has 2¼ turns and is flat; the dog's, 3½ turns and is sharp; but the baboon's has 3½ turns and is of the flat type.

In the descriptions of the individual specimens, accompanying the plates, about twenty measurements are given of the whole and certain parts of each labyrinth, and at the end of each volume these measurements are tabulated with accompanying parallel columns containing the percentage values each part bears to the whole labyrinth. These measurements involve the following: extreme length of labyrinth; diameters of lowest whorl and second whorl of cochlea; diameter of tube of cochlea in front of round window; longest diameter of vestibule; internal and external diameter and height of superior canal, and diameter of tube of superior canal at vertex; the same four measurements of the posterior and horizontal canals; the major axis of oval window; slant-height of cochlea; and the number of turns in the cochlea. With the cochleæ of birds and reptiles, which are not of the coiled form, the length is given from the tip (apex) of the cochlea to the front of the oval window.

In order to give the reader of this review an idea of the varieties of mammals alone involved in Dr. Gray's investigation, the following list is given with certain of the measurements of the labyrinth of each, taken from his tables.

One of the most distinctively curious labyrinths found among the mammals is that of the capybara, one of the Rodents. The peculiarity of this consists chiefly in the shape of the cochlea, which is the most extremely sharp-pointed and consists of the greatest number of turns found in the entire series of mammals examined. It is so closely coiled that it comprises some over 4¼ turns with a slant-height of 6 mm. The distribution of the pigment in the vestibule and semicircular canals of this labyrinth is also described as distinctively peculiar.

The labyrinths of the Insectivora examined lend support to the conjecture of comparative anatomists that this order is of an ancient race. When analyzed, their labyrinths show more "ancient characteristics"

		Number of turns in Cochlea	Slant height of Cochlea	Diameter of second whorl	Diameter of lowest whorl	Major axis of oval window	Longest diameter of vestibule	Extreme length of labyrinth
			mm.	mm.	mm.	mm.	mm.	mm.
I. PRIMATES	Man	2¾	7.0	4.62	8.25	2.25	3.5	17.25
	Yellow-faced Baboon	3¼	4.0	3.0	6.0	2.0	4.0	12.5
	Black Ape	2¾	5.5	3.75	6.0	1.5	3.25	12.0
	Green Monkey	2¾	4.25	2.5	5.25	1.75	3.0	11.5
	Hocheur Monkey	2¾	4.5	3.0	5.75	1.5	3.25	11.5
	Mona Monkey	2¾	4.0	3.0	5.25	1.0+	3.0	11.0
	Common Marmoset	2¾	3.0	2.0	4.5	1.0	2.75	8.0
	Mongoose Lemur	2¼	3.0	3.0	5.0	1.0	3.0	10.0
	Slow Loris	2¼	2.25+	2.5	3.75	1.5	2.5	8.0
II. CHEIROPTERA	Indian Fruit Bat	2	3.0	2.75	3.5	1.25−	2.5	6.5
	Papistrelle	1¾	2.25	1.5	1.75+	0.5	1.5+	3.5
III. CARNIVORA	Tiger	3¼+	6.5	4.25	8.0	3.0	5.5	15.0
	Lion	3¼	7.5	6.0	9.0	3.0	5.0	17.0
	Domestic Cat	3+	4.25	3.5	6.0	1.5	2.75	10.0
	Puma	3	5.0	3.75	6.0	2.0	3.0	14.0
	Dog	3¼	4.75	3.5	6.25	2.0	3.0	12.0
	Aard-Wolf	3¼	5.5	4.0	7.0	2.0	4.0	12.0
	Mongoose	3	3.0	2.75	3.5	1.25	2.5+	8.5
	Otter	3¼	3.25	2.5	4.0	1.5+	3.5	9.5
	Common Weasel	3½	2.0+	2.0−	2.5	0.75	2.0	6.0
	Crab-eating Racoon	2½	4.0	3.5	6.0	1.75+	4.0	11.0
	Common Seal	2¼	7.0	6.0	10.0	3.0	5.5	21.0
	Grey Seal	2+	6.5	4.75+	10.0	3.0−	7.0	19.0
	Cape Sea-Lion	2¼	4.0	3.0	6.0	2.0−	4.25	11.0
IV. UNGULATA	Beisa Antelope	2½	7.0	3.5	7.5+	3.0−	4.0	17.0
	Indian Gazelle	2½	5.75	3.5	7.0	2.75	3.75	14.0
	Common Sheep	2¼	5.0	3.5	7.0	2.0−	3 0	13.0
	Dromedary	2¾	7.5	5.0	10.5	3.5+	8.5	18.5
	Common Pig	3½	5.0	3.0	5.5	1.5	3.5+	13.5
	Horse	2½	6.0	5.0	9.0	3.5	5.75	19.5
V. EDENTATA	Three-toed Sloth	2½	3.75	3.75	5.5	1.5−	3.0+	10.0
	Tamanduan Ant-Eater	2	4.0	3.5	5.25	1.5	3.25	11.5
VI. RODENTIA	Common Hare	2½	3.5	3.0	4.0	1.25	3.25	8.5
	Common Rabbit	2½	3.25	2.0	3.0	1.2	2.75	7.5
	Common Rat	2¼	2.75	1.75	2.5	1.0−	2.0	5.25
	Common Mouse	2	1.5	0.75	1.5	0.5+	1.0	3.5
	Hairy-footed Jerboa	2½	2.5	2.0	2.5	1.0−	2.25	5.5
	Common Squirrel	2¾	2.75	2.25	3.25	1.5	3.0	7.5
	Capybara	4¼	6.0	4.5	7.0	2.0−	5.0	14.5
VII. INSECTIVORA	Common Hedgehog	1½	2.5	1.75	3.0	1.0	2.5−	6.5
	Common Mole	1¾	1.5+	1.0	2.0	0.5	1.75	5.0
VIII. CETACEA	Whale	2	13.0	12.5	20.5	6.0	6.0	25.0
	Porpoise	1¾	6.5	4.5	8.5	1.25	1.25+	9.5
IX. SIRENIA	Sea Cow (Dugong)	1½	7.0	6.75	10.5	5.25	9.0	18.0
X. MARSUPIALIA	Brush-tailed Wallaby	3	3.75	2.5	4.5−	1.5	4.5	8.0
	Black-faced Kangaroo	2¾	4.75	3.5	6.0	2.0	4.0	12.0
	Vulpine Phalanger	3¼	4.0	2.75	4.0	1.5−	2.75+	9.0
	Marsupial Mole	1½	1.25	1.25	2.0	0.5	1.5+	4.5
	Pouched Jerboa Mouse	1¾	1.75	1.5	2.0	0.5	2.0	4.5
	Pouched Mouse	1¾	1.5	1.25	2.0	0.5−	1.75	4.0
	Brush-tailed Phascologale	2½	2.5	2.0	3.0	1.0−	2.5	5.75
	Short-nosed Bandicoot	2¼	2.75	2.0	3.0	1.0	2.25	6.5
XI. MONOTREMATA	Duck-billed Platypus	½	3 lgth*	......	......	1.5	2.75−	10.25

*Length of 3 mm. from front of round window to apex.

than those of any other order of mammals except those of the Monotremata, Cetacea, Sirenia and certain of the marsupials.

Of the Sirenia, the labyrinth of the dugong (sea cow) alone is examined and it is described as being "almost as interesting as the animal itself." Its cochlea has only 1½ turns, is of the flat type, and is of somewhat irregular shape, having two rounded corners in its lower whorl. The fenestra ovalis has a major axis of 5.25 mm., no other animal having it relatively so large and but one animal, the whale, having it actually so large. Another unique character of this mammalian labyrinth is an anterior, conical projection of the vestibule just below the opening of the ampullæ of the superior and horizontal canals. It was found, further, that the nerve fibers to the superior and horizontal canals actually pass through this unusual prominence and thus pass through a portion of the cavity of the vestibule, while in all the other mammals examined these nerve fibers always remain outside this cavity. The semi-circular canals of the sea cow and their ampullæ are poorly developed, and the nerve supply to the ampullæ is apparently scanty as compared with conditions found in most other animals. This may be associated with the restricted movements of the head upon the trunk of this animal.

Of the monotremata, the duck-billed platypus is the only specimen examined whose labyrinth is represented. As is to be expected from its position in the mammalian group, its labyrinth is very different from that of the higher forms. In outward form, this labyrinth bears resemblances to those of the birds and certain reptiles. Its superior semicircular canal, instead of being rounded as is characteristic of the mammalia, is distinctly angular in shape, while its cochlea is scarcely coiled at all, for only about one-half of the first turn is evident. The posterior and horizontal canals are more regularly rounded than the superior, the horizontal being similar to that of other mammals, except that it lies in a relatively lower plane and that its posterior limb opens into the ampulla of the posterior canal.

Several pages are devoted to a discussion of the venous system of the labyrinths of mammals. The interesting observation is made that while the labyrinth is supplied with blood by way of a single artery, it is drained of blood by way of several channels, thus decreasing the possibilities of blockage and hemorrhages which would manifestly be serious occurrences in this organ.

The blood is drained from the labyrinth (1) by a vessel which accompanies the aqueduct of the cochlea; (2) by a vessel which accompanies the acoustic nerve; (3) by a vessel which accompanies the aqueduct of the vestibule. It is left to be inferred that the capillaries and venules of the labyrinth anastomose before giving rise to the three drainage canals. The first mentioned vessel seems to drain the larger area of the three, being formed by conjunction of venules from the cochlea, the ampullæ of the three canals and from the vestibule. All the blood from the cochlea passes through this vessel, discharged into it from a spiral vein descending the modiolus. This spiral vein is formed by three sets of venules which converge into it radially. The first set passes inwards from the outer surface of the whorls of the cochlea and along their under surface; the second set passes inwards with the nerve fibers through the spiral lamina, and the third set passes inwards along the upper surface of the whorls.

The general opinion that there is no communication between the vessels of the labyrinth and those of the middle ear is confirmed.

Of the avian labyrinths studied, the Rattiæ are represented by the maisai ostrich, the rhea and the apteryx, while the order Carinatæ is represented by from one to three specimens of each of the following genera: *colymbiformes, ciconiiformes, anseriformes, falconiformes, tinamiformes, galliformes, gruiformes, charadriiformes, cuculiformes, coraciiformes,* and *passeriformes.* The reptilian labyrinths examined include the *Chelonia,* represented by the giant tortoise; the *Lacertilia,* represented by the Moorish gecko, the black-pointed teguixin and the stump-tailed lizard; and the *Ophidia,* represented by the West-African python.

It is remarked in general that the labyrinths of birds and reptiles resemble each other more than either resembles those of the mammals. Of the two groups, the avian labyrinths resemble the mammalian more than do those of the reptiles. The most striking difference from the mammalian is the absence of a complete spiral coil in the cochleæ of both groups. However, as mentioned above, the labyrinth of the duck-billed platypus, the only monotreme examined, shows likewise but little evidence of spiral form. On the other hand, the typical labyrinths of birds and reptiles are very unlike each other in many of their details. Of all the reptilian labyrinths, that of the alligator alone shows real similarity to the form typical for birds. The most marked differences between those of birds and reptiles are, (1) in the birds, the vestibules are very small throughout the order, while the vestibules of the great majority of the reptiles is by far the largest part of the labyrinth; (2) in the reptiles, the semicircular canals surround the vestibule, as it were, while in the birds (and mammals) they lie entirely away from it; (3) in the reptiles, the otolithic structures are large and fill the vestibule in great part, while this condition is not found in birds (nor mammals); (4) in the majority of reptiles, the semicircular canals are angular in shape, while in the birds (and mammals) they are always rounded; (5) like the mammalian labyrinth, the three semicircular canals of birds are set approximately at right angles to each other, while those of reptiles are not set at right angles, and frequently their planes cut one another at angles of 45 degrees. To this latter fact is called the attention of those physiologists who assume right angled relations of the canals in all forms in their explanations of the functions of the canals.

In the reptile, the aqueduct of the cochlea is by far the widest communication through the bone between the cavity of the labyrinth and the cranial cavity, and the same relation, with some exceptions, is found in birds and mammals. The usually very large size of this aqueduct in reptiles and birds is interesting from the philogenetic view-point as an explanation of the fact that in all forms, the main channel for the drainage of the labyrinth is the vein which accompanies this aqueduct. In man, the bony channel occupied by the aqueduct of the cochlea has become long and attenuated, a fact of importance to pathologists and aurists because of the consequent possibilities of obstruction in the accompanying vein leading to increase in the amount of endolymph and disturbances of the normal tension of the intra-labyrinthine fluids.

Considerable space is given to a discussion of the peculiarities of the semicircular canals of birds and reptiles, to the communications between the canals, to the occurrence of pigment, the varying relative dimensions of the labyrinths and of their different component parts, and to the vascular supply. Special attention is given to the perilymph recess, or the recess of the scala tympani, which is found to be general for birds and to bulk largely in most of them.

Of all the birds examined, the cochlea, never of the spiral type, is proportionately shortest in the ostrich, and the interesting note is made that the cochleæ of the song-thrush, the owl and the cockatoo are proportionately the largest found. These latter show considerable curve. Their relatively large size seems to be due entirely to a greater length of their basal portions, and these portions show a particularly abundant blood supply. Further, in the song-thrush the recessus utriculi is more prominent than in any other bird examined.

At the end of the division of the work dealing with birds, some remarks are submitted on the more noticeable similarities and differences found in the labyrinths of the various orders as suggesting aid in the difficult subject of the classification of birds.

In general, the labyrinth of the reptile may be described as pyramidal in shape with the cochlea forming the apex of the pyramid. Of all the reptiles dealt with, the labyrinth of the alligator alone presents any real outer similarity to that of birds, but that of the alligator is very different from the typical reptilian labyrinth. The typical reptilian, such as that of the tortoise or lizard, has angular semicircular canals, very large vestibule, extremely large otolith apparatus and particularly small cochlea. The horizontal canal alone approximates the curved outline possessed by other divisions of animals. The vestibule, usually the bulkiest portion of the labyrinth, varies in shape from an irregular sphere to an irregular oval, and the otolith apparatus within it consists of innumerable small crystals supported in a semiglutinous substance, instead of having a single crystal or a few crystals as in many of the fishes. The reptilian cochlea, never coiled, is usually in the form of a cone; in very rare instances it is drawn out into a tube as in the alligator and teguixin.

Only two specimens from the Amphibia were studied, the giant toad and the tigrine frog, both belonging to the Anura. The amphibian apparatus is not adapted to Dr. Gray's method of preparation, and this is one of the reasons so few are given. More specimens need to be examined before satisfactory comparisons and generalizations can be made.

The microscopic structure and comparison of the different labyrinths is not included within the scope of Dr. Gray's work. Such might reveal greater similarities among the labyrinths of the different orders and species than is shown in the external morphology. The works of the various investigators of the microscopic detail indicate considerable similarity of cell arrangements in the labyrinths of all forms, including those of birds and reptiles. Dr. Gray gives references to the more important papers dealing with his phase of the subject. He is to be sincerely congratulated upon the valuable contribution he has made to the knowledge of the membranous labyrinth.

Irving Hardesty.

Normentafeln zur Entwicklungsgeschichte der Wirbelthiere. Herausgegeben von Prof. Dr. F. Keibel, LL.D. (Harvard). Achtes Heft. Normentafel zur Entwickelungsgeschichte des Menschen. Von Franz Keibel und Curt Elze. Mit 6 Tafeln und 44 Figuren im Text. Jena. Verlag von Gustav Fischer, 1908.

Since the appearance of the first part of the Normentafeln in 1897, the great work edited by Professor Keibel has become familiar to all anatomists, and it is natural that they have looked forward with especial interest to this, the eighth part, which is devoted to a consideration of the human embryo. The monumental work of His on the anatomy of the human embryo in a way brought into existence Keibel's Normentafeln, for in it a standard plate is given, and it was to extend this plate to include various vertebrates that Keibel assumed his task.

Nearly a quarter of a century has elapsed since the completion of His's "Anatomie Menschlicher Embryonen," and we see in Keibel and Elze's "Normentafel zur Entwicklungsgeschichte des Menschen" what progress has taken place in human embryology in this period. The work gives a detailed account of the degree of development of organs and tissues of eighty-four human embryos from .5 to 26 mm. long, all of which came under the authors' observation. The earlier ova are given in great detail and are compared with the other young ova which have been described by various authors. There is also an excellent chapter on the comparison of young human embryos with those of the monkey, and finally there is a summary of the time of the appearance and transformation of some of the organ anlages of the human embryo, which are compared with the same in other classes of vertebrates given in the first seven parts of the "Normentafeln."

The whole work, which fills 314 large quarto pages, is concluded with the bibliography relating to human embryology since 1880. This is practically complete and includes about 5,000 titles.

The work of Keibel and Elze is intended primarily to standardize various stages of the human embryo. Naturally, the external form of the embryos must be considered first and then the degree of development of the various organs to correspond with the various stages. Not only is this expressed in carefully planned tables, but also in a series of excellent illustrations on plates which are further elaborated by many figures of sections. The descriptions thus given are graphic and equal almost, on account of their excellence and necessary analysis, to the specimens themselves. The specimens described are nearly all new ones, many of which were obtained from operations, and, therefore, are probably normal. This mine of information is analyzed most carefully, and all statements regarding the sequence of development are given in a most conservative and trustworthy way. No rash statements are found in this excellent work, and I believe that it will withstand the test of time and prove to be a most valuable aid to all investigations of human embryology. As a whole it marks the first great "next step" as a standard since the appearance of His's monograph in 1880. The summary found in it will prove to be of the greatest use to all interested in human embryology and of great value to investigators in this science.

Keibel ventures to construct several diagrams, based partly upon observations and partly upon hypothesis, regarding the earliest stages of development. He starts with the assumption that fertilization takes place immediately after ovulation and that segmentation is more or less complete by the time the ovum reaches the uterus. About four or five days are required for this process to take place, and the ovum as a whole does not increase in size until segmentation is completed. It is also probable that the ovum eats itself into the mucous membrane of the uterus much as is the case in the guinea pig, and, judging by the size of the opening left, it cannot have been over .5 mm. in diameter when it became implanted. At this time the mesoblast is formed. Shortly after this the cœlom, the cavity amnion and that of the yolk sac must develop. He believes that the exocœlom is formed within a solid mesoderm on account of the isolated strands of cells which cross it in early stages, and recently the observations of Bryce and Teacher have confirmed this view. Both the amniotic cavity and the hollow yolk sac are formed from solid cell masses, the former not being the result of an infolding, as has generally been believed. These views are based upon comparative evidence as well as by observations upon the human ovum, and are illustrated beautifully by a series of diagrams which will no doubt displace those given in various text-books. The peculiarity of the human ovum is due to the very early formation of the amnion and of the exocœlom. There is no inversion of the membranes, and what appears to be an inversion is due to a confusion of the very early amniotic cavity with this process. He does not venture to give an opinion regarding the sequence of the formation of these three cavities, but the very young ovum recently described by Bryce and Teacher shows that the exocœlom is the last to be formed, for in this ovum the cavities of the amnion and yolk sac are present, while the rest of the ovum is filled with an even mesoderm, there being no exocœlom. After it is once formed the exocœlom extends very rapidly, and the medullary plate, primitive streak, allantois canal and neurenteric canal follow in rapid succession. From now on in the monograph the formation of the body of the embryo is followed in successive stages. For instance, in a discussion of the anterior neuropore, he says that in man it is just closed in an embryo with 23 somites, in Macacus with 19, in Tarsius with 18 to 20, in the pig with 20, in Lacerta with 20, in the chick with 12 to 13, and in the rabbit with from 9 to 11 somites. Here we have a comparison of various vertebrates, not dependent upon stages, size nor age, but upon the degree of development, and as far as I can determine we shall be compelled in the future to designate young embryos by their number of somites and other anatomical conditions and not by their length in millimeters nor their age in days. The latter, on account of the very probable errors, and on account of the unequal degrees of development within a given time is probably the worst of standards in human embryology and has caused endless confusion. His makes his stages dependent upon their length and their general external form, while Keibel improves His's standards by including the anatomy of the embryo. In order to do this it has been necessary for him to study all of the details of the embryos under consideration with great care, and by the comparison of stages of the same size, which resulted in the observation that the sequence is not always the same, he has laid a firm foundation for the scientific study of variations in the adult.

Among the youngest embryos described by His, that is, those under 4 mm. long, a dorsal kinking is observed, and His is of the opinion that this bend is to be considered normal. However, it is not present in all embryos of this stage; the form of the curve appears to be artificial; it is rarely present in embryos that have been hardened within the ovum and it can easily be produced artificially in the fresh chick and pig embryos. Therefore, it is highly probable that this dorsal kink is an antifact. Keibel is also strongly of this opinion, and he described normal embryos of this stage as being somewhat spiral and curved ventralwards, that is, the dorsal border of the embryo is always convex. The stages around 3 mm. long (from 13 to 30 segments) given by Keibel bear upon this point, but are too few in number to give an entirely satisfactory conclusion. To fill out the series it has been necessary to include two embryos (Nos. 6 and 7) with heads that appear atrophic, much as is the case in an embryo described on several occasions by the reviewer (Mall, No. 12). Before this gap is filled out in an entirely satisfactory manner more embryos of this stage will have to be studied. However, the point made by Keibel against the dorsal kinking is sound and the distorted figures of embryos which have gradually crept into the literature will no doubt be replaced by those of normal ones with a delicate and slightly spiral dorsal convexity.

The material brought together by Keibel and Elze shows that a "Normentafel" of the human embryo can be constructed about as well as for any of the other vertebrates. Gaps do exist, but it will be quite easy to fill them in since the way to follow has been pointed out. This can be done by individual workers if they will take the trouble to tabulate their specimens as Keibel and Elze have done and not forget to give careful drawings of the specimens. No doubt a number of such unpublished drawings now exist, as they do in my own collection, which if published would be of value in the study of human embryology. It might be well for the investigators in this science to analyze still further the various stages given by His and by Keibel and Elze, making, for example, the embryo Bulle with 14 myotomes "stage D" instead of a "14 day embryo." For the present we must designate young human embryos after the myotomes appear by their number, and if we add to this the appearance and disappearance of organs and cavities many workers can contribute to the standardization of human embryos. They will thus help to elaborate Keibel's "Normentafeln," which are intended in the first place to establish the norm for various stages of development in different vertebrates.

The "Heft" by Keibel and Elze upon human embryology marks a distinct step in advance, for it arranges and compares various stages, with the control of comparative embryology The embryos included have been carefully selected and the statements regarding them are sound and conservative. This is especialy necessary in the study of human embryology, for many of the specimens obtained are pathological, and on account of the wide interest in this subject are often extravagantly and poorly described. The great work of Keibel and Elze is to be recommended equally as much for what has been omitted from it as for what has been included, and for these two reasons it will prove to be of the greatest value to all scientists and physicians who are interested in human embryology.

Franklin P. Mall.

The Problem of Age, Growth and Death. A Study of Cytomorphosis, based on lectures at the Lowell Institute, March, 1907. By Charles S. Minot, LL.D. (Yale, Toronto), D.Cc. (Oxford), James Stillman, Professor of Comparative Anatomy in the Harvard Medical School, President of the Boston Society of Natural History. Illustrated. No. 21 in the Science Series, edited by Edward L. Thorndike, Ph.D., and F. E. Beddard, M.A., F.R.S. G. P. Putnam's Sons, New York and London. The Knickerbocker Press, 1908.

This interesting discussion of age, growth and death is in the form of lectures, and is based on a course given by the author at the Lowell Institute in the spring of 1907.

The book is dedicated to Professor Mosso, of Turin, and in the introductory letter addressed to him, Minot gives a brief history of the progress and connections of his studies on growth—the titles of his papers appearing as foot notes.

The important contributions which have been made by Minot to the interpretation of growth are well known, and his colleagues will, therefore, not be surprised to find that in the present instance, both the raw material and the points of view are largely the outcome of the author's own labors, the results of which are here for the first time brought together and collated.

The lectures were planned to answer the questions "why animals grow old, and consequently die?" The answer which Minot gives is in the terms of structure, and in considering his conclusions, this fact must always be kept in mind.

The author lays special emphasis on the changes in the cell during its life cycle, and this phenomenon he has designated cytomorphosis. The consideration of cytomorphosis, involving as it does changes in both size and structure, is the central point in the argument. As one outcome of these studies, Minot formulates the following laws of cytomorphosis:

First. "Cytomorphosis begins with an undifferentiated cell," *i. e.*, a cell in which the cytoplasm does not show special structural modifications.

Second. "Cytomorphosis is always in one direction through progressive differentiation and degeneration towards the death of the cell."

Third. "Cytomorphosis varies in degree characteristically for each tissue, hence in the adult higher animals, nearly all stages of cytomorphosis may coexist."

To the foregoing we venture to add his conclusion that cytomorphosis is not reversible.

In general, cytomorphosis implies an increase in the size of the cell with age. At the same time, the growth of the cytoplasm is more rapid than that of the nucleus, while the ultimate size of the cell appears to be regulated mainly by the interaction of these two portions. Structural differentiation is especially evident in the cytoplasm. This differentiation has a certain optimum phase, when it is most valuable to the organism as a whole, but it tends to continue in such a way that the cell becomes over-differentiated and ultimately breaks down. Hence the increase in the cytoplasm with accompanying differentiation is presented as the proximate cause of senescence.

Minot holds that this process is never reversed, so that when cells in part already differentiated regenerate after injury, he considers that the portions of the cell previously specialized, disappear and that the new growth is due to the activity of portions of the cytoplasm which remained unspecialized. Roughly speaking, then, in any cell the proportion of this unspecialized cytoplasm would measure its capacity for regeneration. That at any given time cytomorphosis has not progressed to the same stage in all the cells of the body is easily demonstrated.

In presenting his problem in terms of the cell, Minot associates the phenomena of senescence with changes in the structural units of the animal body, and thus puts the discussion on a broad biological basis.

Of course, if senescence could be discussed in terms of chemical reactions, it would be possible to carry the analysis still further. Although that time is approaching, the fact is that at present the chemical data are insufficient for such a discussion. The observations here presented are, therefore, not only necessary as a preliminary to any future investigation along chemical lines, but also represent the most general treatment of the problem now possible.

The changes in the cell, representing as they do a series of alterations occurring at a diminishing rate, but ultimately leading to the death of the cell, must be the outcome of potential energies stored in the cell when it enters on its life cycle, and the question is naturally asked how such storage is accomplished. How, in man, for instance, the cell is wound up to run through its cycle of three score years and ten? This process takes place in the fertilized ovum, the product of the germ cells which in turn are early segregated, while the ovum at least is protected against differentiation, although it is not a strictly young cell.

The formation of young cells is discussed under the caption "rejuvenation." Here Minot especially directs attention to the phase of growth in the ovum immediately subsequent to fertilization, when there is a rapid formation of new cells, with a proportional increase of the nuclear substance. The cells which so arise are, he thinks, the really young cells and are thus prepared for subsequent multiplication, differentiation and enlargement, processes which are in turn the cause of the evident growth changes in the entire body.

In this connection Minot formulates his first law of age, namely: "Rejuvenation depends on the increase of the nuclei." The author calls attention to the novel character of his interpretation, and awaits the comments of his colleagues.

After the cells thus rejuvenated start upon their cycle of growth, the results of their activity can be weighed and measured and the rate of growth determined. As a measure of the rate of growth, Minot has used the relative increment in weight during equal periods of time. Applying this measure to the growing animal, it is found that in every case the rate of growth diminishes very rapidly from the time at which the young cells are first formed. The earliest divisions of the ovum, when the process of rejuvenation is occurring, represent growth changes of another sort, and this phase precedes and is distinct from that to which the above general statement applies.

The most rapid diminution in rate is during the earliest periods of growth, and by the time birth is reached, in the case of the mammal, the rate has fallen off enormously, so that after birth it is not only much less rapid, but literally slow.

Minot is able to illustrate this from the existing data on man and from the growth of the guinea pig, which he himself previously studied, as well as by two new series of his own, one based on the rabbit and the other on the chick, the detailed tables for which are given in appendices.

The foregoing observations, taken together with those on cytomorphosis, lead the author to the paradoxical conclusion that the progress of senescence is most rapid during the early stages of life, and that the period of old age, as commonly understood, is but a terminal event in the cycle of cell changes which at that time have almost ceased. A word of comment on this conclusion is given at the end of this review.

Natural death appears to follow as a corollary to cellular differentiation, and in this connection Minot discusses the notions of death as an acquired character, and the views of Wiesmann, touching immortality in the Protozoa. It is hardly necessary to add that the incidental topics, such as the size of animals, the size of cells, the size of nuclei (new data), regeneration and longevity, which arise in the course of the lectures, are treated in the most suggestive way, and that the book, which carries a number of references to the special literature, is of the greatest value to all students of growth, and must prove a stimulus to new activity in this field.

In order to comment on the views just presented, it seems desirable to examine laws of age in which the author has condensed his conclusions. There are four of these laws. The first has already been noted on a previous page. To appreciate the second law, it is necessary to consider cytomorphosis in relation to senescence. The cytomorphic changes involve at least four sets of modifications:

1. Disappearance of the power of division.
2. Change in size (usually enlargement).
3. Relative increase in the quantity of cytoplasm.
4. Differentiation in both nucleus and cytoplasm—but most evident in the cytoplasm.

These changes are most rapid in the earlier stages of life and in general progress as the cells become older. Cytomorphosis is presented as the proximate cause of senescence, meaning by senescence (p. 132) changes in the structure of the body as the years advance. Thus the structural changes in the body as a whole are expressed in the terms of changes in the size and structure of the cells. Minot's second law of age, therefore, takes this form: "Senescence depends on the increase of the protoplasm and on the differentiation of the cells."

His fourth law of age is as follows: "Senescence is at its maximum in the very young stages, and the rate of senescence diminishes with age." According to the second law just cited, the explanation of senescence is given in terms of structure. Under these circumstances, the fourth law. as phrased above, might be misleading in its first portion, as it should not mean, of course, that the amount of structural change is at its maximum in the very young stages, because this is not the case. To preserve the meaning of the law, and at the same time guard against a possible misinterpretation, it might be rephrased as follows: "The rate of senescence is at its maximum in the very young stages, and this rate diminishes with age."

In his third law of age Minot deals with growth—a functional character. The law reads: "The rate of growth depends on the degree of senescence." This statement seems to neglect one important factor which modifies the rate of growth. If we analyze the conditions which lead to the diminution in rate, we find the general processes about as follows:

The constituent cells of the body enlarge, divide and in turn enlarge, at the same time that some of them cease to divide further. The number of these latter cells increases rapidly, while the relative number of the dividing cells diminishes. As to the absolute number of the dividing cells with advancing age, our information is very meager. The body increases in weight so long as the dividing cells continue to multiply and the others to enlarge. Growth is increase in weight. The rate of growth, as has been shown, falls off rapidly, especially during the earlier stages. In addition to the other circumstances which contribute to this result, it appears to be due in large part to the accumulation of cells, which at any given time have attained more or less their full size, and in which further growth has practically ceased.

Coincident with these events, the cytomorphic changes causing senescence are in progress, but it is not clear that senescence as defined in the foregoing second law of age involves this idea of the accumulation of the products of growth. Hence, while it is true that the rate of growth diminishes as the condition of senescence advances, the rate of growth is also very largely modified by the factor to which we have just called attention.

At the same time the comparison between the rate of growth and senescence is rendered difficult by the further circumstance that, while it is possible to plot a curve showing the diminution in the rate of growth, it is not in the same way possible to make a graphic representation of the progress of senescence. The correspondence between the two series of events is then more general and less complete than the phrasing of the law would indicate.

In the course of the presentation Minot discusses the connection between his view of senescence and the development of the physical and mental powers of man, and at least implies that these latter follow the same course as is indicated by the curve of bodily growth.

On the physical side, learning to play golf and to ride a bicycle at different ages, are used at illustrations, and on the mental side, the acquisition during the first year of childhood of the general notions fundamental to normal psychical life, and it is pointed out that in the early years we learn both faster and better than we do later.

It should be remembered in this connection that the foregoing are functions which can be observed only after birth, and when senescence, according to the measure proposed by Minot, is already far advanced. Further, that both of them depend mainly on changes in the central nervous system.

The similarity between the course of physical and mental learning, on the one hand, and the rate of growth on the other, depends on the relative rapidity of change in the early stages of development—which is common to all. Further than this the comparison should not be pressed, for not only does the rate, but also the absolute increment of growth, fall off with advancing age, whereas in the case of the physical and mental functions, the efficiency of the individual increases for a long time—certainly up to the stage where bodily growth has practically ceased.

There is here, then, an essential difference, depending, as it seems, in large part, on the establishment of pathways and connections between the different portions of the central nervous system, a phenomenon the like of which does not occur in any other system of the body.

One point more touching the interpretation of the fourth law of age. As we have noted, Minot measures the rate of senescence by the rapidity of the cytomorphic changes, and the degree of it by their amount. On the other hand, it is common usage to measure the degree of senescence by the loss in the physical and mental efficiency of the body with advancing years. These two methods of describing the same phenomenon are, however, not essentially contradictory, but merely different, and the solution of the paradox previously mentioned is thus given. At the same time, one may venture the assertion that the common method or measuring old age can be retained without diminishing in the least the appreciation due to the important contributions made by Minot in these, his studies on cytomorphosis and the phenomena of growth.

Henry H. Donaldson.

"RAUBER'S LEHRBUCH DER ANATOMIE DES MENSCHEN." Neu bearbeitet von Dr. Fr. Kopsch. In 6 Abteilungen. Siebente Auflage. Leipzig: Verlag von G. Thieme.

The seventh edition of A. Rauber's Lehrbuch der Anatomie, five of the six volumes of which are now in print, has been revised by Dr. F. Kopsch, of the University of Berlin. The changes in text from earlier editions are such as to bring the work in harmony with the results of recent investigations. Influenced by the Atlases of Toldt and Spalteholz, nearly

500 new illustrations have been added to the work. Many of these are in colors and on an especially good paper which makes possible the presentation of the figures in a manner unexcelled in any text-book of Anatomy. It will be easier to take up a consideration of this work by a discussion of the merits of the individual volumes.

Part I, devoted chiefly to General Anatomy, is introduced by a chapter on the history of anatomy. Fifty figures, reproductions of busts, paintings and photographs of men who have been prominent in the development of anatomy, illustrate this chapter. These half-tones of Fallopia, Malpighi, Vieussens, Hunter, Gall, Burdach, Purkinje, Schleiden, Schwann, Remak, Broca and others who have lent their names to our anatomical literature, are a valuable addition to a chapter of this character.

The chapter on cytology and histology is very completely and excellently illustrated. For nervous tissues alone, thirty new figures are added. The common classification of tissues is used. Connective tissues are classified according to Waldeyer.

Part 2 is devoted to Osteology and Arthrology. In this as in the other volumes, chapters presenting new subjects are introduced by a consideration of microscopic anatomy and development. The large size of the page makes it possible to present the greater number of bones and ligaments in natural size, and other figures are larger than in any of the newer atlases. The figures are numerous, very excellent, and as a rule, well grouped, which adds to the facility of study and comparison. At times, however, the illustrations are placed at some distance from the descriptive matter, and related figures are scattered and out of place. The carpal bones are preceded and followed by figures of the innominate. The skull of the new-born fills out a page devoted to tarsal and metatarsal bones, 25 pages removed from the other illustrations of the skull of the new-born. To a lesser extent this same criticism holds for the part of this volume devoted to arthrology.

Part 3 is devoted to a consideration of muscles and blood-vessels. The figures of the muscles are very large, colored, and have the names printed directly upon them. The illustrations are numerous. For the upper extremity there are 14 full-page, 9½-inch figures with names directly on the parts, and 24 smaller figures. The black print on the red muscles is difficult to read by artificial light. Variations are figured. Fifteen forms of the superficial and deep palmar arch are presented. Though good, there is nothing remarkable about the chapter on angiology.

No notice is taken of the recent work on the development of the lymphatics.

Part 4 takes up a consideration of splanchnology. Many of the illustrations are very excellent, as for instance, those of the pancreas, stomach, submaxillary gland, and thymus. In these and other figures large sections are shown at medium and small portions of these sections at high magnification. If the same plan were adopted in the illustrations of the bladder, adrenal, and indeed throughout the whole volume it would greatly improve an already excellent presentation of splanchnology.

Part 5, devoted to the Nervous System, is one of the best volumes of the set. The peripheral nerves are neither figured with the excellence of Spalteholz nor is this part of the volume up to the standard of a number of our texts. But the gross anatomy of the central nervous system compares with the best, while the illustrations of the microscopic anatomy of the central nervous system are the best in print. These illustrations are microphotographs in which the nuclear masses have been drawn in, in red. A systematic but not too detailed description of these figures is followed by a consideration of the different tracts of the central nervous system and the central and cortical connections of the cranial nerves as we understand them to-day. This part of the work is illustrated by 19 diagrams constituting a very valuable feature of the chapter. In these diagrams, the mistake of showing too much has been avoided. Each diagram presents clearly some nerve tract with its central connections.

The subject matter in these volumes is well arranged and systematically and clearly presented. The text is large and legible. The BNA nomenclature is used throughout. Where new terms are introduced they are noted as not in the BNA. Bibliographies are introduced frequently throughout the work. There is an excellent index in each volume.

B. D. Myers.

NOTES AND APPOINTMENTS.

The resignation of Professor Whitman as Director of the Marine Biological Laboratory at Woods Hole, Mass., which was announced last summer, is of interest to anatomists, for he has been a very important factor in the cultivation of anatomical science in America.

During the twenty-one years in which he has been director of the Marine Biological Laboratory every opportunity and encouragement was given for the study of anatomy in its broadest sense, and we have seen there those beginning scientific work encouraged and inspired by many distinguished investigators, all appreciating fully the congenial scientific atmosphere which was established and kept alive by Professor Whitman.

The most noteworthy investigations from this laboratory which have enriched anatomical science are those on descriptive and experimental embryology, cytology and teratology, which, taken together, form a scientific monument of the first rank and have done much to establish our good reputation abroad. It certainly must be gratifying to Professor Whitman to see this result.

When the University of Chicago was founded, in 1893, Professor Whitman was made head of the biological department, which in its organization was unusually strong on the anatomical side. It was planned at the beginning to divide the department as soon as circumstances should warrant, and with the very rapid growth of the university this took place within a year. Then the anatomical department was established co-ordinate with those of zoölogy, physiology and botany. This proved to be the most important step in the organization of anatomical departments in America, and for it we are largely indebted to Professor Whitman.

But there is another event which should not be overlooked by anatomists, and that is the founding of the American Morphological Society, in 1890. The Association of Anatomists had been founded two years before, and it seemed to Professor Whitman and his twenty-five followers that the latter society was not likely to be vigorous, and their action in forming a new one gave an opportunity to test this opinion. During the following five years, while Whitman was president, the morphological society flourished with great energy, while the anatomical society showed all signs of early decay. In 1899 the American Society of Zoölogists was founded at Chicago and the Association of Anatomists began to awaken at about the same time; in 1902 the former absorbed the morphological, while the latter expanded with as great force as the morphological did ten years before. Scientific anatomists are under the greatest obligations to Professor Whitman for the stimulus he thus exerted upon their association between 1890 and 1900.

At the time Professor Whitman was elected director of the Marine Biological Laboratory he also began the publication of his excellent Journal of Morphology, which, according to the announcement, was to be devoted principally to *embryological, anatomical* and *histological* subjects. The file of seventeen volumes published during a period of fifteen years shows, as Whitman predicted, the imperative need of a journal of this kind. "The previous mixed character and scattered sources of our publications have been twin evils that have become intolerable at home and abroad. The establishment of the Journal of Morphology may not be a deathblow to these evils, but there is hope that it will, at least, relieve the most embarrassing difficulties of the present situation." By 1901 it became apparent that the new journal could not pay its own way, and as soon as the publishers withdrew their support its end was in sight. However, the anatomists of the country, realizing fully the necessity of a journal of anatomy of this quality, at once secured a sufficient endowment to continue the good work in the form of a new journal, the American Journal of Anatomy, which has not only been a financial success, but also acted as a means of establishing other new journals and strengthening old ones, as well as re-establishing the Journal of Morphology. In place of one journal we now have five, all vigorous and all on the sound foundation of the Wistar Institute. As the morphological society served to stimulate the anatomical so in turn the anatomical journal has revived the morphological.

The Journal of Morphology has further served as a model for many of our scientific serials, both biological and medical, which have come into existence during the past twenty-one years. The importance of sound scientific journals to anatomical and zoölogical science is now clear to all, and both anatomists and zoölogists owe to Professor Whitman a debt of gratitude for having been the pioneer in this field.

The establishment of a modern scientific laboratory at Woods Hole, the making of the anatomical department at Chicago a university department, the indirect invigorating influence upon the Association of Anatomists, and the establishment of the Journal of Morphology, are the four great services Professor Whitman has rendered the science of anatomy in America. But there is another, more general and more important service he has rendered our universities, which, as years go by, will gradually grow and become recognized. This is the establishment of an institution for science and for scientists. The Woods Hole laboratory has in its organization the true soul, for it is managed from top to bottom by scientists. In that institution the worthy young student is received with open arms, is inspired and encouraged, but is never called upon to prostitute himself as a research assistant; the overworked college professor finds a scientific haven; and many distinguished biologists breathe there the congenial scientific spirit. The democratic organization appeals to all, as the laboratory is ruled by leaders of its own choice and not by a group of men who employ professors. Repeatedly has Woods Hole declined riches when by its acceptance there was only the remotest possibility of interference with this indispensable independence. All of the proffers fell upon deaf ears. The nightingale may be captured, but it can never be made to breed by the huntsman nor be made to sing in confinement. It must live in its own peculiar habitat, and this is found for scientists at Woods Hole. In this country we are searching for heroes in productive science, but "the birds that may sing seem to avoid the golden cage."

The spirit of independence and co-operation established and maintained at Woods Hole by Professor Whitman, although constantly streaked with abject poverty, has made there the ideal home for biology, as well as the most productive and famous scientific laboratory that America has yet seen. Whitman is the chief benefactor of this laboratory, for he has endowed it with the right ideals.

The corporation and trustees in accepting Professor Whitman's resignation requested him to serve as honorary director and trustee, but in declining this his fine spirit did not falter.

"Your action in which you express a desire to have me serve the laboratory as honorary director and trustee is in itself alone an all-sufficient reward for whatever service I have rendered as director. Your good will is the all-important recompense, and no title that you could confer could add to the weight of your approbation. In fact, titles belittle the spirit. Let me have the latter without the former—without title or office of any kind. Please respect this wish and believe me, as ever, a sincere and devoted friend of the laboratory."

We are authorized to announce that S. Hirzel, of Leipzig, will soon publish the first volume of a larger work entitled "Handbuch der Entwicklungsgeschichte des Menschen," which will be edited by Professor Franz Keibel, of Freiburg, Germany, and Professor Franklin P. Mall, of Baltimore. The second volume will follow early in 1910.

The treatise is to cover in as brief a form as possible consistent with thoroughness the whole of human embryology, emphasizing the gaps which are still to be investigated. By doing this it is hoped that the critical analysis of the available material will serve to stimulate further investigation, which, after all, is one of the chief aims of co-operation in research.

It is also planned to include a complete bibliography of embryology as far as it relates to man, and that on comparative embryology only in so far as it is necessary to fill out gaps and to discuss general problems, especially those relating to histogenesis, growth, variations and anomalies, as well as those relating to the anatomy of the adult.

There will be chapters upon sex cells; fertilization; segmentation; youngest human ova and embryos up to the time of the formation of the myotomes; their age; formation of the germ layers and the problems of gastrulation; external morphology of the embryo; development of the membranes and the placenta; menstruation; development of the integument; development of the central and peripheral nervous systems; chromaffine organs, and adrenal, carotid and coccygeal glands; the sense organs; the respiratory and alimentary canals; the heart, blood-vessels and blood; the lymph vessels, lymph glands; hæmolymph glands and spleen; differentiation of the cœlom and the formation of the diaphragm; development of the skeleton, including the histogenesis of the connective-tissue group; the muscles, including their histogenesis; development of the urogenital system; co-ordination of various developmental processes; the importance of experimental embryology in human embryology and pathology, with especial reference in the study of tumors; and the pathology of early human embryos, considered also in relation with teratology.

The following is a list of the collaborators: Charles R. Bardeen, Madison; Walter Felix, Zürich; Alfred Fischel, Prague; Otto Grosser, Vienna; Franz Keibel, Freiburg; Frederic T. Lewis, Boston; Warren H. Lewis, Baltimore; Franklin P. Mall, Baltimore; Charles S. Minot, Boston; J. Playfair McMurrich, Toronto; Felix Pinkus, Berlin; Florence R. Sabin, Baltimore; George L. Streeter, Ann Arbor; Julius Tandler, Vienna, and Emil Zuckerkandl, Vienna.

We are also pleased to learn that arrangements have been practically completed with a leading American publisher to bring out an English edition of the "Handbuch," which is to appear simultaneously with the German edition or shortly after it.

Through the interest and generosity of Mr. Robert S. Brookings, the anatomical department of Washington University, St. Louis, has received substantial aid.

The annual appropriation for salaries and for the ordinary running expense has been increased and a special allowance made for new apparatus. The department has thus been enabled to increase its staff and to add materially to the library and to the equipment of the laboratories.

The staff as now organized is constituted by Robert J. Terry, M.D., professor of anatomy; Paul Y. Tupper, M.D., professor of applied anatomy; William T. Coughlin, M.D., instructor in anatomy, all members of the old staff; and Victor E. Emmel, Ph.D., instructor in histology and embryology; Charles H. Danforth, A.B., instructor in anatomy, new members. Dr. Emmel received his doctorate at Brown ('07) and last year held an Austin teaching fellowship in Professor Minot's department in the Harvard Medical School. Mr. Danforth (Tufts '08) was formerly in Professor Kingsley's laboratory as instructor in biology. An assistant for the technical work of the microscopical laboratory has been found and means provided for clerical help.

The greater part of the special appropriation has been used in equipping the microscopical laboratory with new microscopes and unit system desks; a portion was expended for apparatus for research and the sum of two thousand dollars set aside for additions to the anatomical library.

The anatomical department, with the other fundamental departments of the medical school, is housed at present in a building in the heart of the city, a situation unfavorable for many reasons. It is the intention of Mr. Brookings to transfer by 1910 the work of the first two years to new laboratories on the site of the university in the western part of the city adjoining Forest Park.

THE

ANATOMICAL RECORD

Vol. II. DECEMBER, 1908 No. 9

Embryonic Transplantation and Development of the Nervous System.[1]

BY

ROSS G. HARRISON

Yale University, New Haven, Conn.

With 23 Figures.

It is my intention this evening to give you an account of a certain field of anatomical study, with the purpose of showing how the experimental method may be applied to the solution of embryological problems, and more particularly of those that have to do with the development of the nervous system.

It is generally recognized in science that the experimental method, by which we may deliberately vary the conditions bearing upon a natural event, is a vastly more efficient means of analysis than the method of merely observing phenomena as nature presents them to us. The sciences that have used this means of advancement have attained a much higher degree of perfection than those that have not. While, of course, this has been due in a great measure to the fact that the former, the physical sciences, deal with relatively simple phenomena, still it cannot be doubted that those sciences that have to do with living things might have made greater progress had the possibility of experimentation been more fully realized. In physiology this has been done, and with good effect, but until a comparatively recent date it has not been the case with that branch of biology which deals with the form and structure of organisms, morphology or anatomy. In recent years, however, morphologists have begun to experiment, and now this method of study, introduced about twenty-five years ago by Pflueger, Roux and Born, has found wide application. This is true especially in the field of embryology.

[1]Lecture delivered before the Harvey Society in New York, March 7, 1908.

The complexity of the processes of development, and the extreme delicacy and minuteness of the objects to be studied have, of course, tended to limit the field to which the method could be applied. Especially is this the case with the embryos of the higher vertebrates which are so carefully protected in the maternal body, or by complex fœtal membranes, that they are only to a limited extent amenable to experimentation. We must, therefore, be content with the use of lower forms for this purpose. Yet, fortunately for the possibility of extending our conclusions to many of the phases of human development, we have in the embryos of the frog and the fish forms which are sufficiently closely related to man, and which permit of the most varied kinds of experiments.

In general the methods of experimental embryology have been of two kinds. In the one, the whole organism is subjected to changed conditions, as is the case when the medium in which it develops is altered, for instance, by changing its temperature, illumination or chemical composition. In the second it is the immediate organic environment of the parts of the egg or embryo that is altered, as when the different substances of the egg are separated by means of the centrifuge, or as when certain parts are removed or others added by transplanting living material from one position to another.

One of the most extraordinary discoveries in the latter mode of procedure was made in the year 1894 by the late Professor Born, of Breslau.[2] While experimenting upon the regeneration of lost parts in the frog embryo, this observer was astonished to find that pieces which had been entirely severed from one another might heal together again. Born then showed that it was possible to heal together parts of embryos in any manner imaginable. All that was necessary was to bring two freshly cut surfaces together and to hold the pieces in position for several hours, when they would be found to be firmly and permanently united. In this way individuals of normal form, but with parts taken from two distinct embryos, could be obtained, also any kind of double monster or such with a head in place of a tail or a tail in place of a head (Fig. 1). Some of these specimens were reared past their metamorphosis into the young

[2]For a full account of Born's work see Archiv für Entwickelungsmechanik, Bd. 4, 1896-7. For a general account of the subject of embryonic transplantation see the admirable address of Spemann before the Versammlung Deutscher Naturforscher und Aerzte in Stuttgart, 1906; also Spemann, Zum Problem der Correlation in der tierischen Entwicklung, Verh. d. Deutschen Zool. Gesellschaft, 1907; Braus, Propfung bei Tieren, Verh. d. Naturhist.-medizin. Ver. z. Heidelberg, Bd. VIII.

frog. Born showed that even portions of embryos of two distinct species, in fact, organisms as far removed from one another as the common European green frog (Rana esculenta) and the fire toad (Bombinator igneus) could be united.

These experiments have since been repeated, and amongst my own material I have had many specimens of which the anterior half was of one species and the posterior half of another.[3] Many of these lived for a long time and one passed through its metamorphosis, becoming a frog of perfectly normal form, showing in each half the characteristics of the proper species (Fig. 2). Obviously an experiment of this sort would be the ideal one to test the influence of the body upon the reproductive cells within it, though unfortunately the difficulty of rearing frogs in confinement from the egg to maturity has, up to the present time, stood in the way of carrying out the experiment to a successful conclusion. Another use to which the union of parts taken from different species may be put is dependent upon the circumstance that the embryos of the several species are characteristically pigmented. For a considerable period in their development these color differences may be seen in each individual cell, and on this account it is possible to follow in composite embryos the wandering and shifting of the parts during that time. I have made use of this method to study the wandering of the epidermis and the development of the sense organs of the lateral line,[4] which may be traced with great nicety in this way (Fig. 3).

These transplantation experiments are rendered possible by a fortunate combination of qualities in the amphibian embryo. As a factor of first importance we find the extraordinary wound-healing power. The healing is very rapid and always *per primam intentionem*, and this to a degree of perfection never obtained in ordinary surgical procedure. Another important factor is that at the time when the transplantations are usually made there is no circulating medium such as blood or lymph present, but each cell of the embryo is capable of maintaining itself independently of it neighbors, living upon the large quantity of yolk stored within it. On this account it is even possible to make monsters of a great variety of forms, which later, when the yoke is gone, become physiological impossibilities, such as specimens with a tail in place of a head or vice versa. As long as food yolk is present such specimens are capable of maintaining themselves in some fashion, and creatures of

[3]Archiv für Entwickelungsmechanik. Bd. 7, 1898.
[4]Archiv für Mikroskopische Anatomie. Bd. 63, 1903

this character may even be kept alive for a still longer period by a method that I first used to rear tadpoles from which the central nervous system had been extirpated,[5] and which in consequence could not get about in a natural way to obtain food. The method consists in uniting the patient to a normal individual, which serves as a nurse. The vascular and intestinal anastomoses that ensue upon such an operation are sufficient to care for the nutrition of the helpless component, at least for a considerable time (Fig. 4).

In view of the frequency with which the question has been asked how it is possible to perform such delicate and at the same time radical operations, a few words in explanation of the technique will not be out of place. The experiments are usually made upon comparatively young embryos, *i. e.,* from the gastrula stage to those of about 3 mm. in length, with medullary folds just closed. The original method of Born was simple and it was applied to the transplantation of relatively large pieces. The parts to be united were brought into contact along freshly made wound surfaces, were then gently pressed together, and secured in position by placing small pieces of silver wire around them. This is necessary, for, although the embryo at this stage is unable to perform any muscular movements, the action of the cilia which cover its surface is so vigorous as to cause the pieces to separate unless securely held in place. After an hour or two, or even less in favorable cases, the pieces so held will be found to be firmly united and soon afterward all traces of the wound become obliterated.

The refinements of technique introduced by Lewis and by Spemann[6] were made possible by the use of the binocular dissecting microscopes of Zeiss. Under these instruments the frog embryo may be readily magnified to the size of a mouse, and the long working distance of the lenses allows one to operate with every comfort. With very sharp needles, forceps, and small eye scissors, the points of which are sharpened to the fineness of a needle, or, as Spemann recommends, with instruments made by drawing out glass rods and pieces of cover slips to a great degree of fineness, operations of almost incredible delicacy may be performed. The epidermis of the embryo may be lifted, the Gasserian ganglion may be removed to some other part of the body, the ear vesicle may be taken out and replaced upside down, or the right and left ears may be interchanged, as Streeter[7] and Spemann have done. Small organs or

[5]The Journal of Experimental Zoölogy, Vol. 4, 1907.

[6]Verhandlungen der Deutschen Zoologischen Gesellschaft, 1906.

[7]The Journal of Experimental Zoölogy, Vol. 3, 1906, and Vol. 4, 1907.

pieces of tissue may be transplanted to little pockets made under the skin or between the larger organs, and they will grow readily in their new surroundings. Again, pieces of epidermis may be taken from one part of the body and be made to cover wounds in other regions. It was by means of such experiments that Lewis[8] was able to show that epidermis from any part of the body could give rise to a crystalline lens when brought into contact with the optic vesicle at the proper stage of development.

Such experiments as have just been described are done without anæsthesia because the embryos in these early stages have neither muscles nor nerves differentiated. For operations in later stages, as in the case of Braus's experiments in transplanting limbs, which were made upon tadpoles already able to swim actively, an anæsthetic is necessary. Chloretone is found to be excellent for this purpose, a solution of from two to three parts to ten thousand of water being sufficient to produce a deep narcosis in a few minutes. The recovery after bringing the animals back into pure water takes place with almost the same rapidity. In none of the experiments are there any complications due to sepsis.

Let us now proceed to consider the application of these methods to the study of the development of the nervous system. The problems here involved, which have been the most discussed and which have proved to be the most perplexing, have to do largely with the development of the nerve fiber. We find in the adult nervous system a most intricate maze of fibers, connecting the various parts of the organism, and in each species of animal the arrangement of these fibers is very constant. How can it possibly come about that these interlacing bundles always connect their proper end stations? What are the factors which influence the laying down of the nerve paths during embryonic development? Before these questions can be satisfactorily answered there are other more concrete ones that must be settled. What is the nerve fiber in terms of the cell doctrine? Is it an appendage of a cell or does it consist of a multitude of cells? Again, does the connection between the nerve center and the end organ exist from the beginning, or is it established gradually as development proceeds by extending out from the nerve centers? These questions are old ones, and the various answers now given to them had all been given fifty years ago. Each view has had its vicissitudes, but at the present time it cannot be said that any one of them prevails by weight of authority, for each numbers distinguished investigators among its advocates.

[8]American Journal of Anatomy, Vol. 3, 1904, and the Journal of Experimental Zoölogy, Vol. 2, 1905.

We may first take up the question of the constitution of the nerve fiber. The answer originally given by Schwann,[9] later by Balfour,[10] Dohrn[11] and many others, and again more recently by Apathy,[12] Bethe[13] and O. Schultze,[14] is that the nerve fiber is the product of a chain of cells, which reaches all the way from the center to the peripheral termination, these cells secreting the fibrillæ within their protoplasm much as an embryonic muscle cell secretes the contractile fibrillæ. The opposite answer, first stated with perfect clearness by His,[15] and afterwards ably supported by Ramon y Cajal,[16] von Lenhossék[17] and the neuronists in general, is that the nerve fiber is the process of a single ganglion cell, and is formed by growing out from the cell towards its peripheral connection.

In reality it is difficult to decide between these two alternatives, as may readily be appreciated when we study, for example, the development of a typical spinal nerve in a vertebrate embryo. At an early stage we find the motor root extending out from the medullary cord, and consisting of delicate fibers, with which are intermingled in a most intimate manner numerous spindle-shaped cells. The fibers may be traced into the cord and there they may be seen to proceed from certain cells, which are destined to become the motor nuclei of the ventral horn. The question to be decided is: which of these two kinds of cells, the spindle-shaped cells along the nerve, often called cells of Schwann, or the ganglion cells within the cord, is the essential agent in forming the axis-cylinder of the nerve fibers? The attempt to answer this question, from normal embryos, has been largely a matter of individual interpretation as a glance at the figures will show. Fig. 5, taken from Bethe, expresses one view; Fig. 6, taken from His, and Fig. 7, taken from my own study upon the salmon embryo, express the other view, and the latter is represented in more diagrammatic form in the familiar Golgi picture, taken from Ramon y Cajal (Fig. 8, I). The same is likewise shown in the figure of a section through the chick embryo prepared by the silver reduction method (Fig. 8, II).

[9]Mikroskopische Untersuchungen, 1839.
[10]Development of Elasmobranch Fishes, London, 1878.
[11]Mitteilungen aus der Zoologischen Station zu Neapel, Bd. 10, 1891.
[12]Mitteilungen aus der Zoologischen Station zu Neapel, Bd. 12, 1897.
[13]Allgemeine Anatomie und Physiologie des Nervensystems, Leipzig, 1903.
[14]Archiv für Mikroskopische Anatomie, Bd. 66, 1905.
[15]Archiv für Anatomie und Physiologie, Anatomische Abtheilung, 1886.
[16]Anatomischer Anzeiger, Bd. 5, 1890.
[17]Anatomischer Anzeiger, Bd. 7, 1892.

Although my own work upon the normal development of the salmon and frog[18] had led me to a decided opinion in favor of the cell-outgrowth theory, the attitude of many later investigators showed that we should never be able to obtain evidence from the study of normal development, that would convince everyone alike of the truth of either of the views just stated. A decisive answer to the question, it seemed to me, could

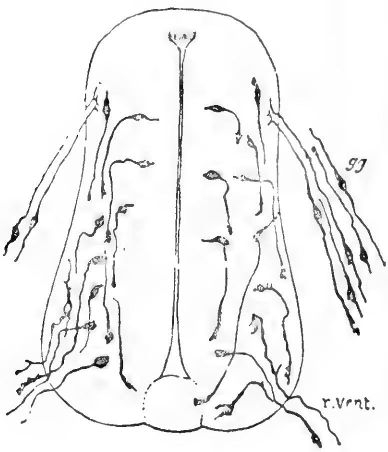


Fig. 8 I

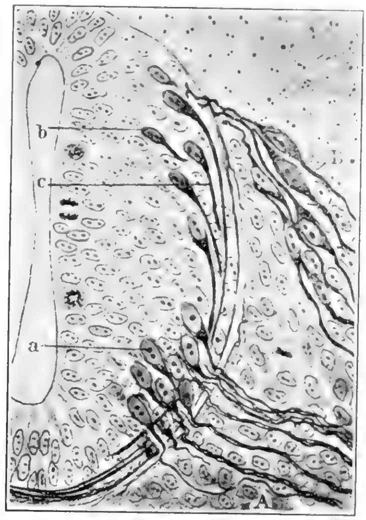


Fig. 8 II

Fig. 8.—I, Semi-diagrammatic cross section through the medullary cord and spinal ganglion of a chick embryo, prepared by the Golgi method. *gg*, spinal ganglion; *r. vent.*, ventral root. II, Section through the spinal cord of a chick embryo of three days. *A*, motor root; *B*, spinal ganglion; *a*, motor neuroblast; *b*, *c*, commissural neuroblasts. (After Ramon y Cajal.)

be obtained only by a more exact method of study, *i. e.*, by the elimination, in turn, of each of the two conflicting elements.

This was accomplished by operations upon the embryo,[19] in which certain parts were removed before the development of the peripheral nerves had begun. The first task, viz., the removal of the source of the spindle-shaped cells of Schwann, which may also be referred to as sheath cells, was complicated by the circumstance that there had been no agree-

[18]Archiv für Mikroskopische Anatomie, Bd. 57, 1901.

[19]Sitzungsberichte der Niederrheinischen Gesellschaft für Natur- und Heilkunde zu Bonn, 1904; American Journal of Anatomy, Vol. 5, 1906.

ment among embryologists as regards their place of origin. As the weight of opinion seemed to lean towards the derivation of these elements from the ganglion crest, and as this structure is easily accessible to the knife, the experiments were begun by removing this structure. Embryos of Rana esculenta were used for this purpose, and, as it was necessary to begin with a stage in which there was as yet no differentiation of the nerve cells or fibers, embryos were taken in which the medullary folds had just closed over to form the tube. Such embryos are about 2.7 mm. long. With the aid of the fine scissors, a thin strip was cut off the dorsal surface of the embryo (Fig. 9), removing the dorsal half of the medullary cord, which includes the neural or ganglion crest. The embryo was thus left with its central nervous system as an open groove along the back, the walls of which contained the elements which were to become the motor cells of the spinal cord. In order to reduce to a

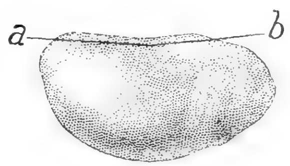


FIG. 9.—Frog embryo 2.7 mm. long. The line a-b indicates the incision for the removal of the ganglion crest.

minimum the possibility of regenerative processes setting in and vitiating the results, two embryos which had been operated upon in this way were in each case brought together by the wound surfaces and were readily healed together. They grew normally, except for the defects due directly to the operation (Fig. 10), and after an interval of six to eight days they were preserved and examined, either in serial sections, or else preparations of the obdominal walls were dissected out and examined *in toto* (Fig. 11). It will be understood that in removing the ganglion crest, the source of the spinal ganglia had been eliminated as well as the presumed source of the Schwann cells. The result was that the embryos were found to lack spinal ganglia entirely, as well as sensory nerves, except those derived from the cranial ganglia, which had been left intact in the operation. What interests us most is the character of the motor spinal nerves. These are found to be present, but to differ entirely from the normal condition (compare Fig. 11, b and c). They are mere naked threads or strands, which extend in normal position from the spinal cord to the periphery. They may be followed to their extreme terminal points in the abdominal muscle near the ventral mid line. In cases in which the operation has been exact, not a single Schwann cell can be found in the whole course of the nerves; and in cases in which a few cells are found, sections show that small groups of spinal ganglion cells are present, indicating that the ganglion crest has not been

Fig. 10.—Two double embryos from each of which the ganglion crest has been removed. Upper figure, two days after operation; lower figure, six days after.

entirely removed. The nerves are thin and delicate, and have a fibrillar structure, although it has not yet been possible to test whether they give the specific neurofibrillar reaction with the silver or gold methods.

The experiment shows, first, that the source of the sheath cells, both of the motor and sensory nerves, is in the ganglion crest, and secondly, that these cells are unessential to the formation of the nerve fiber. The ganglion cells of the ventral part of the medullary cord are capable by themselves of forming the motor nerves. While it has not been possible to corroborate this by experiment upon sensory nerves, owing to the fact that the sheath cells and ganglion cells of these nerves are derived from the same source, still we have evidence, from normal conditions, which bears out in a striking way the correctness of this conclusion. In the case of the nerve fibers derived from the dorsal giant cells of Rohon-Beard, we have simply naked axis-cylinders (Fig. 12). Likewise in the newt larva the sensory nerves of the tail fin are entirely devoid of cells for a short while during their early development. In other words, nature has here performed an experiment for us, in that she holds back the sheath cells from some nerves until after they have extended out to full length, thus showing that in the formation of these nerves the sheath cells are not an essential element. Another of nature's experiments has been recently recorded by Dohrn,[20] and this corroborates in a very striking way the results above described. In dogfish (Pristiurus) embryos it seems that the *n. trochlearis* receives its sheath cells not directly from the neural tube or ganglion crest, but from a particular branch of the trigeminus nerve, the *n. ophthalmicus minor.* In one case which Dohrn describes the latter nerve was inhibited in its development by some unknown cause, and it was found that the trochlearis consisted of naked fibers throughout its entire extent, not a single sheath cell being present from the decussation to the superior oblique muscle.

Having thus established the fact that the ganglion cells could without the aid of sheath cells give rise to the axis-cylinder of the nerve, it now became of great interest to ascertain if the sheath cells were by themselves capable of giving rise to nerve fibers when the ganglion cells were excluded. This experiment involved greater technical difficulties than the first, but nevertheless it was found possible to carry it out as follows: The dorsal half of the cord was separated from the rest of the embryo, as in the operation previously described, except that it was left attached at one, usually the anterior, end; then the ventral half of the cord was cut out and the thin strip containing the dorsal half healed back in place. Thus the ganglion cells of the motor nerves were removed, the source of the sheath cells and sensory nerve cells (spinal ganglia) being left intact. The embryos developed normally and remained almost motionless, though after a few days slight reactions to stimuli in the form of quivering movements were observed, and later these were found to be due to incipient regeneration of the motor cells within the spinal cord. Examination of the abdominal walls showed, however, that here only sensory nerves were present (Fig. 11, d). The

[20]Mittheilungen aus der Zoologischen Station zu Neapel, Bd. 18, 1907.

motor nerves were lacking, although in normal individuals they run for a long distance in common with the sensory nerves, an arrangement which would give the Schwann cells of the latter ample opportunity to form the fibers of the motor rami. The fact that none were formed can only be ascribed to the inability of the Schwann cells to form them.

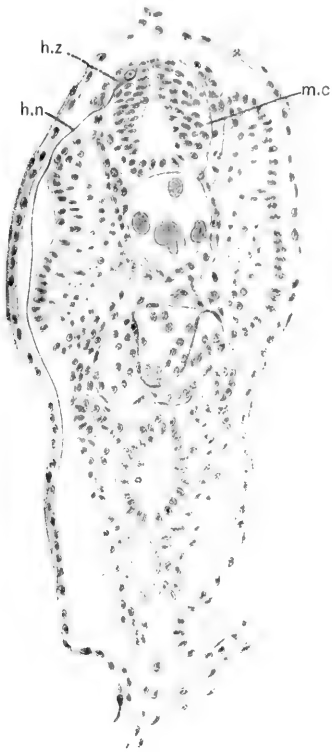


FIG. 12.—Cross section through salmon embryo showing long nerve (*hn*) derived from one of the giant cells (hz) in the spinal cord.

This conclusion has been confirmed by the behavior of nerves that have been deprived of connection with their ganglionic centers after development had begun.[21] In the case of the abdominal nerves of the tadpole, and also of the lateral line nerve, degeneration was found to take place very rapidly after removal of the ganglia, and no signs of

[21]Journal of Experimental Zoölogy, Vol. 4, 1907.

constructive developmental changes were ever observed under such conditions. We may conclude, then, that not only do the sheath cells fail to form nerve fibres, but that they are unable to continue their development or even to maintain the fibres already formed in the absence of connection with the nerve center. The opposite conclusion, which was reached by Brauss[22] and by Banchi[23] upon experimental evidence, may be explained by the fact that these observers did not exclude every possibility of contamination by ingrowth from other nerves, and it is my opinion that this same objection still holds with reference to the evidence for auto-regeneration of peripheral nerve fibers.

Having established the conclusion that the ganglion cells within the nerve centers alone have the power of forming nerve fibers, the spindle-shaped cells merely forming the sheaths of the fibers, we may next inquire into the question as to how the nerve fiber extends from the ganglion cell to its peripheral ending. Is this process a mere differentiation of protoplasmic connections already *in situ,* as Hensen[24] first maintained, or is it an actual outflow of substance from the ganglion cell towards the periphery?

In the past few years the trend of opinion has been unmistakably toward the support of Hensen's theory, according to which protoplasmic bridges are supposed to be left everywhere between dividing cells of the embryo, so that at the time when the nerves begin to differentiate there is already a complex system of protoplasmic connections between various parts of the body; those which function as conduction paths are supposed to differentiate into nerve fibers, while the rest ultimately disappear. There has ever been something insinuating about this theory, putting, as it does, the whole question of the development of nerve paths upon the physiological basis of functional adaptation; but, brilliant and attractive as it seems, very little real evidence has ever been brought forth to support it. In fact, its mainstay has been the imaginary difficulty of conceiving how the alternative view could be true. "How can it be possible," it has often been asked, "that a nerve fiber can grow out for a long distance from its ganglion cell and always reach the right

[22]Anatomischer Anzeiger, Bd. 26, 1905.

[23]Archivio di Anatomia e di Embriologia, Vol. 4, 1905; Anatomischer Anzeiger, Bd. 28, 1906.

[24]Virchow's Archiv, Bd. 31, 1864; Archiv für Mikroskopische Anatomie, Bd. 4, 1868; Zeitschrift für Anatomie und Entwickelungsgeschichte, Bd. 1, 1876; Die Entwickelungsmechanik der Nervenbahnen im Embryo der Säugetiere, Kiel und Leipzig, 1903.

place?" However, within the past three or four years a number of investigators, amongst whom may be mentioned Kerr,[25] O. Schultze,[26] Paton,[27] and, in a modified sense, Held,[28] have sought to place Hensen's theory upon the basis of direct observation. But the point to be decided is really a very difficult one, and one in which the histological method again fails us, refined as the newer neurological procedures may be. It has, on the other hand, been possible to attack the problem experimentally, and with results which seem to me to disprove entirely the theory in question.

It will be readily seen that the two theories differ from one another in attaching to different elements of the embryo chief importance as regards the formation of nerve fibers. According to the outgrowth theory, the ganglion cell situated within the nerve centers is the all-important factor, while on the other view it is the extra-ganglionic protoplasmic structures that play the chief rôle. But, unfortunately for the purpose of devising a clean-cut and crucial experiment, the antithesis between the two views is not complete, for, even according to the first, the organs outside the nervous system are supposed to have some influence in determining the course which a nerve fiber takes as it grows out, while the second view admits that the ganglion cell has a functional or trophic influence upon the processes of differentiation.

The first experiments of my own having a bearing upon this problem were of a comparatively simple nature, but, though helpful, were not crucial.[29] After it had been shown that no peripheral nerves would develop in an embryo from which the nerve centers had been removed at an early stage, thus proving that the ganglion cells were at least one essential element, experiments were made in which the immediate organic environment of the developing nerve was radically altered. This can readily be accomplished by cutting out the spinal cord of an embryo before there is any trace of differentiation in the nervous system. After the wound heals there remains between the notochord, muscle plates and skin a space filled with mesenchyme tissue, which is a portion of the space normally occupied by the spinal cord. Now, if the various fibers which normally arise from the brain and extend as longitudinal funiculi into the cord are formed of protoplasmic processes already situated within

[25]Trans. Roy, Soc Edinburgh, Vol. 41, 1904.
[26]Archiv für Mikroscopische Anatomie, Bd. 66, 1905.
[27]Mittheilungen aus der Zoologischen Station zu Neapel, Bd. 18, 1907.
[28]Verhandlungen der Anatomischen Gesellschaft, 1906.
[29]American Journal of Anatomy, Vol. 5, 1906.

the cord, we should expect to find that no development whatever of these elements would take place. This is, however, not the case, for a few days after the operation very stout bundles of fibers are found extending from the medulla oblongata longitudinally through the mesenchymatic tissue, which has taken the place of the medullary cord. It has been possible to follow such fibers for nine or ten segments, *i. e.,* through the whole length of the trunk region, where they gradually lose themselves in the mesenchyme without showing any definite point of ending. In other words, these fibers have been formed in surroundings entirely different from their natural path and with connections which preclude any possibility of function having played a part in influencing their development. Similarly Lewis[30] has shown that after removal of the embryonic brain the olfactory nerve develops and is found after a few days to extend out from the nasal epithelium and gradually to lose itself in the mesenchyme occupying the position normally taken by the fore-brain. Corresponding results have been obtained in the case of the optic nerve.

The following experiment, which is somewhat more complicated, entirely corroborates the foregoing. The whole trunk region of an early embryo was made sterile as regards peripheral nerves by cutting out the entire spinal cord. Then a bit of the medullary tube, taken from another embryo, was transplanted to a pocket under the skin of the abdominal walls. After the expiration of six or seven days, the abdominal wall was dissected out and mounted *in toto.* The only nerves found in the specimen (aside from the branches of the *r. lateralis vagi,* which come from the head) were those which originated in the transplanted tissue. These were found to radiate in various directions, and not to follow any particular path corresponding to the course of the nerves in normal specimens. It was one of these cases that showed the interesting condition of a nerve crossing the peritoneal cavity. The specimen in question, when dissected out under the binocular microscope, showed an extremely fine thread which extended from the piece of transplanted tissue across the abdominal cavity to the base of the mesentery where it was attached. It was cut off at this end, and, after the specimen was mounted, the thread was found to consist of three axis-cylinders, entirely devoid of sheath cells, which proceeded from a group of three ganglion cells, a miniature spinal ganglion, that had apparently been detached from the main mass of transplanted tissue; root fibers were present connecting

[30]American Journal of Anatomy, Vol. 6, 1907.

this with the main mass. That this nerve had grown where normally no nerve paths ever have been present is clear, although there is some doubt whether it actually did grow through a cavity filled with fluid, for at the time of transplantation it seems that the somatopleure and splanchnopleure were still in contact, the body cavity not yet having been formed between them.

It would seem that these experiments should be interpreted as practically deciding in favor of the outgrowth theory, for the nerve center is shown to be the commanding influence in the development of the fibers. On the other hand the remarkable experiments of Braus[31] have been taken by their author to support Hensen's view. As these experiments are so original in their conception, and lead to otherwise very important results, even though their author's interpretation of them does not seem to me to be justified, a brief account of them will not be out of place here.

Braus transplanted limbs of very young tadpoles to various parts of the body of other individuals and studied the nervous system in the transplanted appendages. It was found that no matter where the limb was implanted, its peripheral nerves would develop normally as regards the distribution of the branches within the appendage itself, though these nerves would have abnormal connections in the host. For instance, a fore limb implanted in place of a hind limb, which had been removed, would develop into a typical fore limb, acquiring a complete system of peripheral nerves, normal in their arrangement, though derived from the lumbo-sacral plexus. A limb transplanted to the head might even acquire normal nerves derived, for instance, from the facial nerve. These nerves are not only normal as regards their arrangement, but they are also functional, for such transplanted limbs not only move in response to stimuli, but they may also exhibit spontaneous movements. These fundamental facts are of extreme importance, though they do not answer in themselves the question at issue, for, either the beginnings of the nerves might themselves have been transplanted with the limb, as Hensen's view would postulate, or else the nerves might have grown in from the nerves of the host, being merely guided in their growth by the structures present in the transplanted part.

In order to decide this point, Braus conceived the very ingenious experiment of transplanting, instead of a normal limb, a limb-bud taken from a larva which had been deprived of its central nervous system at a very early age, and which had, in consequence, developed without any

[31] Anatomischer Anzeiger, Bd. 26, 1905.

peripheral nerves. Braus found in his experiments that even when such a limb is implanted into a normal embryo, no nerves develop within it. In addition to this, he also found that when supernumerary appendages arise from normal transplanted limb-buds, as they do frequently by a process of twinning (Fig. 13), they are likewise devoid of nerves. From these results Braus inferred that within the peripheral parts of a developing organism there is normally some structure which is essential to the formation of the nerve fiber, and which is destroyed when it is cut off for a time from its connection with the central nervous system. In other words, Braus concludes that the peripheral parts of an embryo do not merely serve to guide the nerves in their distribution, but that they actually contribute formed structures to build up the nerve fibers.

Similar experiments which I made in the spring of 1906 upon other species of amphibians[32] show, however, that these results are not of general validity. In the case of the wood frog (Rana sylvatica) and the common toad (Bufo lentiginosus) it was found that the transplanted limbs, whether taken from normal or from nerveless tadpoles, would in the course of their development usually acquire a system of normally arranged nerves, and this was found to hold for the supernumerary as well as for the primary transplanted appendages. The individual cases showed considerable variation as regards completeness of innervation, but this condition could not in any way be connected with differences in the origin of the limbs and could only be referred to slight accidental inequalities in the operations. Were there within the limbs any kind of preformed structures, which give rise to nerve fibres, we should according to Hensen's view, expect them to atrophy through disuse in nerveless individuals long before transplanting, as is actually the case with nerves that are already visibly differentiated. Indications that something was lacking in the nerveless limb would then be shown in the inability of the nerves to develop within it. But this is not the case, for the nerves do develop within such limbs just as in any normal appendage. The results of these experiments, instead of supporting Hensen's theory, add, therefore, further evidence against it.

Distinctly as all of the foregoing facts point to the correctness of the view that the nerve fiber is formed as an outgrowth from the ganglion cell, there is still one defect in the conditions of experimentation which stands in the way of rigorous proof. The nerve fibers have in all of the experiments developed within living tissues and the possibility of the latter con-

[32]The Journal of Experimental Zoölogy, Vol. 4, 1907.

tributing organized material to the nerve elements has not not been entirely excluded. This matter has again recently been taken up by Held[33] and Paton,[34] who have endeavored to show by the aid of exquisite histological methods that the protoplasmic bridges, found between the cells of the embryonic body, do actually take part in the formation of the nerve fibers. Both of these investigators support, in other words, Hensen's view, although Held's conception is a distinct modification of it,

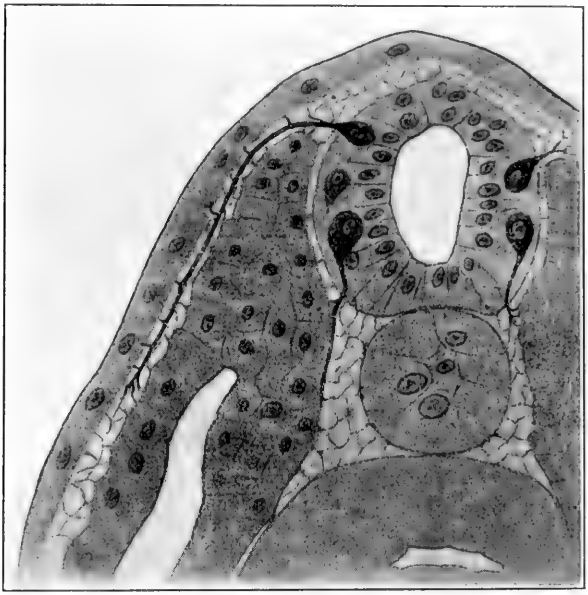


Fig. 14.—Semi-diagrammatic section through the spinal cord and adjacent organs of an axolotl embryo. (After Held.)

in the sense that it approaches measurably the outgrowth theory of His. According to Held the peripheral nerve fiber does not grow out free into spaces between the cells, but it can grow only into the protoplasmic bridges or plasmodesmata which have already been formed by other cells. To translate his own words: "The nerve paths arise through the transformation of plasmodesmata into neurodesmata" (Fig. 14). Striking as Held's preparations are, it does not seem to me that they prove the

[33]Verhandlungen der Anatomischen Gesellschaft, Rostock, 1906; Anatomischer Anzeiger, Bd. 30, 1907.

[34]Mittheilungen aus der Zoologischen Station zu Neapel, Bd. 18, 1907.

essential nature of the protoplasmic bridges. In fact, it is not even proved that these so-called plasmodesmata are not to a considerable extent coagulation products, and even if they are actually present in the living embryo just as seen in preserved specimens, their extremely fine structure would seem almost to preclude the possibility of distinguishing whether the nerve fibers actually grow within them, or whether they entwine themselves amongst them as a vine growing upon a lattice.

That the material upon which Held bases his views is quite capable of another interpretation is evidenced by the fact that Ramon y Cajal,[35] who has studied the same question, upon similar material, making use of the same methods as Held, emphatically supports the outgrowth theory in its original form. The conclusions drawn from such preparations, however definite they may seem, appear, therefore, to be nothing more than a matter of interpretation.

In order to reach a final settlement of this question it thus became necessary to devise a method by which to test the ability of a nerve fiber to grow outside the body of the embryo, where it would be independent of protoplasmic bridges. At first a number of futile attempts were made to cultivate pieces of embryonic nerve tissue in various physiological salt solutions and within the cavities of the normal embryonic body. It then seemed that the outgrowing nerve might be stereotropic, and hence unable to leave a solid mass of cells to grow into a perfectly fluid medium. As the most suitable solid medium in which it would be possible to envelop embryonic tissue and observe its subsequent development, fresh lymph was chosen, first, because the fibrin threads which are formed on clotting might simulate mechanically Held's "plasmodesmata," though they could not be supposed to actually transform themselves into the nerve fiber; and, secondly, because the serum of the lymph would presumably afford a natural culture medium for the embryonic cells. Small portions of various tissues of the embryo were dissected out and removed by a fine pipette to a cover slip upon which was a drop of lymph freshly drawn from one of the lymph sacs of an adult frog. The cover slip was then inverted over a hollow slide and sealed on with paraffine. These manipulations were carried out as far as possible under aseptic precautions. The lymph clots almost immediately and holds the transplanted tissue in place. The specimen can then be readily observed under high powers of the microscope from day to day.[36]

[35] Anatomischer Anzeiger, Bd. 30, 1907; Bd. 32, 1908.

[36] Proceedings of the Society for Experimental Biology and Medicine, 1907

It has been found possible to keep such preparations alive for more than five weeks, and during the first week at least, differentiation takes place in a manner characteristic of each tissue. Cells taken from the muscle plates differentiate into muscle fibers with striated fibrillæ, and when small pieces of spinal cord with portions of the muscle plates attached are taken, twitching movements of the muscle fibers may often be observed on the following days.

In order to understand the behavior of nervous tissue under the conditions just described, it will be well to examine for a moment the appear-

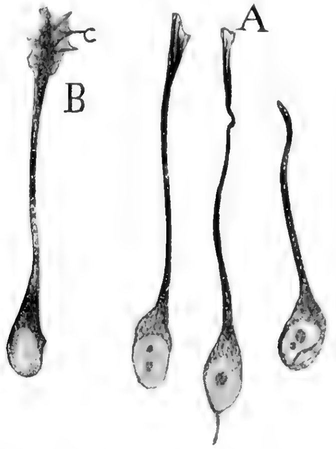


FIG. 15.—A, neuroblasts stained with silver nitrate; B, neuroblast impregnated by the Golgi methed; C, growth cone. (After Ramon y Cajal.)

ance of the end of a growing nerve fiber as pictured by various authors from normal preserved specimens. In the figure by Held (Fig. 14) the nerve fiber is seen to run out into a number of fine filaments, which are supposedly the protoplasmic bridges (plasmodesmata) between the cells. According to Ramon y Cajal[37] we find at the end of the growing fiber a swelling (cône d'accroissement), which has a few short processes extending out from it; such endings have been demonstrated both by the Golgi and the silver reduction methods (Fig. 15). In the regenerating fiber, as shown by Ramon y Cajal and by Perroncito[38] there is found a somewhat similar structure at the end of the axis-cylinder (Fig. 16).

[37]Anatomischer Anzeiger, Bd. 5, 1890; Bd. 30, 1907, and Bd. 32, 1908.

[38]Ziegler's Beiträge zur pathologischen Anatomie und zur allgemeinen Pathologie, Bd. 42, 1907.

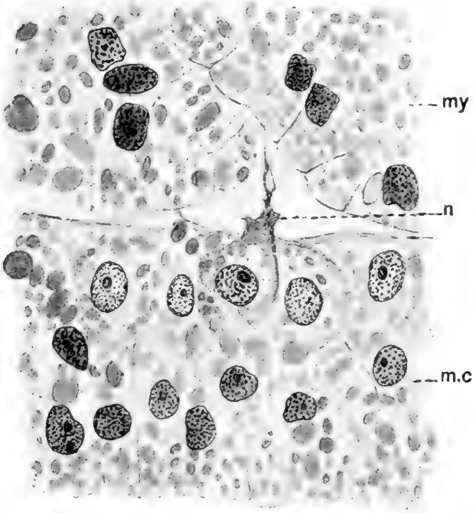


FIG. 17.—Portion of a horizontal longitudinal section through the spinal cord (*m.c.*) and portion of two muscle plates (*my*) of a frog embryo. The cell (*n*) with the branched process is a neuroblast showing the first stage of the formation of the nerve fiber.

FIG. 18.—End of growing nerve fiber (*n.f*). From a sagittal section through a frog embryo slightly older than the one from which Fig. 17 is taken. The nerve fiber is growing between the epidermis (*ep.*) and the muscle plates (*my*).

A nerve fiber, which is just beginning its development, taken from a section of a normal frog embryo about 3 mm. long is shown in Fig. 17. We see a branched protoplasmic process extending out into the space between the two myotomes and the skin from a cell situated within the medullary cord. If we examine one of these same nerves in a slightly older embryo we find that it has become a fiber of some length,

Fig. 19

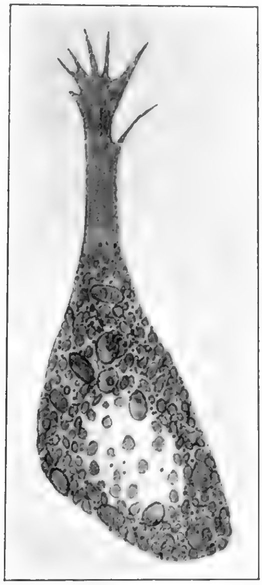


Fig. 20

Fig. 19.—End of growing nerve fiber, as seen in section. Similar to fiber shown in Fig. 18.

Fig. 20.—Isolated cell from a piece of embryonic spinal cord growing in a drop of clotted lymph. The cell body, which is filled with yolk granules, is sending out a hyaline protoplasmic process which undergoes amœboid movements. Drawn from a live specimen.

having at its end a structure (n.f) such as is shown in Figs. 18 and 19. Here there are several fibers bundled together, ending in a mass of hyaline protoplasm resembling a rhizopod with fine branched pseudopodia. These structures may be best seen in the fibers that arise from the dorsal giant cells of Rohon-Beard, and are well brought out by the ordinary embryological methods of fixation and staining.

Let us now observe how the nerve tissue under cultivation in the lymph behaves. It must be borne in mind that when this is taken from the embryo it consists entirely of rounded cells without any signs of differentiation into fibers. Examined after a day or two of cultivation, fibres are found in a considerable number of cases extending out from the mass of tissue into the lymph clot. An early stage of this develop-

Fig. 21.—Two views, taken twenty-five minutes apart, of the same nerve fiber growing from a group of embryonic spinal cord cells into the lymph.

ment is shown in Fig. 20, which represents a cell that has become detached from the main mass of tissue. This cell is still gorged with food yolk, but at one pole it has sent out a hyaline protoplasmic process, which was observed to undergo distinct changes in form. Fig. 21 shows another case. Here the fiber proceeds from a mass of cells and its own particular cell of origin can not be distinguished. The figure represents two stages of the same fiber sketched at an interval of twenty-five minutes, during which time the fibre has lengthened twenty microns. The case shown in Fig. 22 is a much larger fiber, about 3 microns in

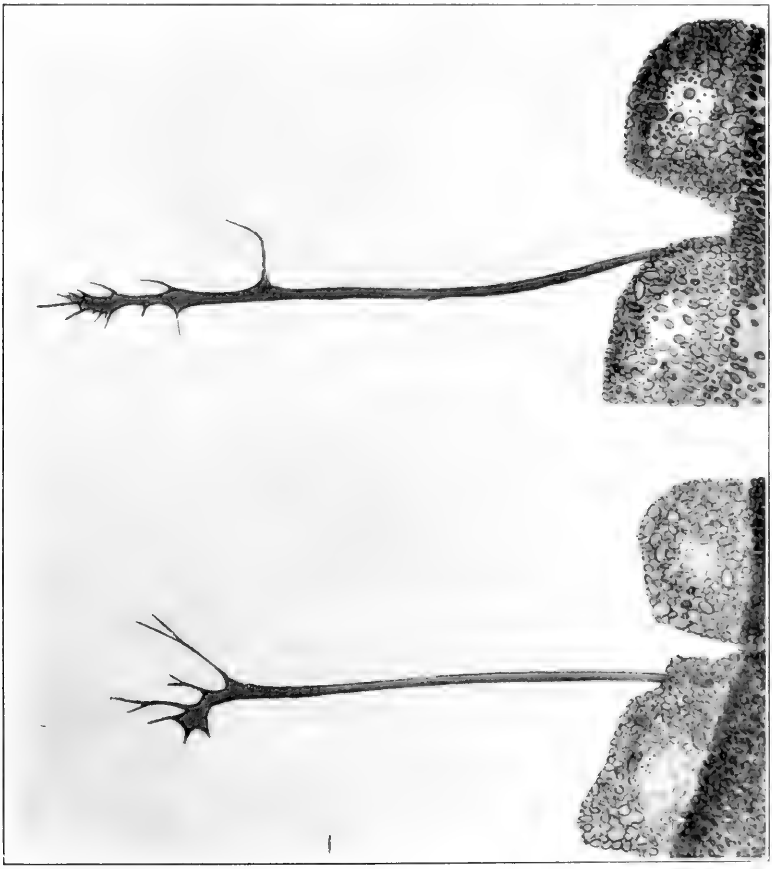


Fig. 22.—Two views of the same nerve fiber, taken fifty minutes apart. Preparation similar to that shown in Figs. 20 and 21.

diameter, with much more protoplasm at the end. The movements of this fiber were extremely active, and the change of form with accompanying lengthening is well shown by comparing the two sketches, which were made fifty minutes apart.

Similar phenomena were observed in the case of pieces of ectoderm taken from the branchial region, which is known to give rise in part to the ganglia of the cranial nerves (Fig. 23). On the other hand, other tissues of the embryo do not give rise to such structures, though kept under exactly similar conditions. This holds for muscle plates, notochord, yolk endoderm, and ordinary ectoderm from the abdominal

Fig. 23.—Isolated ganglion cell with branched nerve process from tissue taken from the branchial sense organs of frog embryo. The preparation also shows a cell with a short process and twin cells joined by a hyaline protoplasmic fiber. From a live specimen in lymph.

walls. All of these cells exhibit amœboid activity in a greater or less degree, though it does not result in the drawing out of the protoplasm into a filament. There can be no doubt, therefore, that the free-ending filamentous structures are specifically nervous, and when we see the exact morphological correspondence between them and the nerve fibers in sections of embryos of the corresponding age, it becomes certain that the two things are the same.

The foregoing observations show beyond question that the nerve fiber begins as an outflow of hyaline protoplasm from cells situated within the central nervous system. This protoplasm is very actively amœboid, and as a result of this activity it extends farther and farther from its cell of origin. Retaining its pseudopodia at its distal end, the protoplasm is drawn out into a thread, which becomes the axis-cylinder of a nerve fiber. The early development of this structure is thus but a manifestation in a marked degree of one of the primitive properties of protoplasm, amœboid activity. We have in the foregoing a positive proof of the hypothesis first put forward by Ramon y Cajal[39] and von Lenhossék,[40] who based it upon the consideration of the cones of growth found by the Golgi method at the end of the growing fiber.

At present we have but little evidence regarding the influences which bear upon the growing nerve, though now that its mode of growth is known with certainty, we may hope that further experiments will soon throw light upon the problem. From the fact that the nerve fiber is capable of growing out into a lymph clot, and from other facts touched upon in the above discussion, it seems to be established that the mere act of extension is independent of external stimuli, or in other words, that it is due to properties that lie within the cell itself. On the other hand, we cannot escape the conclusion that within the body of the developing embryo there are many influences, exerted by the various organs and tissues, that guide the moving protoplasm at the end of the fiber and ultimately bring about the contact with the proper end organ. The experiments in transplanting limbs show, for instance, that we must seek in the limb itself for the factors which influence the distribution of the ingrowing nerve; for any nerve at all, in whose way a limb may be implanted, may enter the latter and become distributed in a manner normal for that limb. The shifting of parts during development is another factor of importance, as Hensen originally pointed out. For example, the lateral line nerve grows out and establishes its connection with the rudiment of its end organs at a time when its ganglion and the latter are very close together; and the enormous length that the nerve attains in the full-grown tadpole is due solely to the shifting of the sensory rudiment during development. Still, such crude mechanical factors are by no means sufficient to explain the intricacies of the nervous system of a higher animal, and

[39]La Rétine des Vertébrés, La Cellule, T. 9, 1893.

[40]Der feinere Bau des Nervensystems im Lichte neuester Forschungen, Berlin, 1895.

we must seek farther for more subtile influences, possibly such as tropisms, as originally suggested by Ramon y Cajal.[41] Very convincing evidence of chemotropic influences has already been found in the case of regenerating nerves by Forssmann,[42] who showed in a most ingenious manner that degenerating nerve tissue would attract the regenerating fibers. How far such influences, and how far mechanical stimuli determine the course of the nerve fiber in embryonic development, can only be determined by experiment. It is to be hoped that the method of isolation as described above, will here yield results of value.

As regards the theories of nerve development that have been the subject of the foregoing argument, I need scarcely point out that the experiments now place the outgrowth theory of His upon the firmest possible basis,—that of direct observation. The attractive idea of Hensen must be abandoned as untenable. The embryological basis of the neurone concept thus becomes more firmly established than ever.

[41]In the course of the experiments here described, small pieces of tissue taken from the muscle plates or from the epidermis were in a number of cases placed in the drop of lymph along with the nervous tissue. It was hoped to find by this means evidence of attraction or repulsion exerted by these tissues upon the growing nerve fibers. No definite results, however, have as yet been obtained from these experiments.

[42]Ziegler's Beiträge zur pathologischen Anatomie und zur allgemeinen Pathologie, Bd. 24, 1898, and Bd. 27, 1900.

On an Instance of two Subclavian Arteries of the Early Arm Bud of Man and its Fundamental Significance.

BY

HERBERT M. EVANS.

From the Anatomical Laboratory of the Johns Hopkins University.

I. Introductory.
 (a) General considerations of the arm as a polymetameric structure.
 (b) Historical review of the literature on the earliest arm vessels.
II. Description of the present case.
III. Relation of the foregoing to the general principles of the development of the vascular system.

I. Introductory.

The question of the morphological nature of the vertebrate limb has for many years interested anatomists, and among them, some of the greatest minds in anatomical science. Curiously enough, however, some of our most fundamental conceptions of the limb are as yet by no means clearly established or beyond dispute, *e. g.* its relation to the metamerism of the body.

This problem has been attacked again and again through the skeletal, the muscular, and the nervous system, but it is only within the last year oı so that any significant work has been done on the primitive limb vessels. The blood vessels, moreover, must claim our deepest interest from quite another point of view, namely for what light they may shed on those general principles which govern the development of the vascular system throughout the body.

Into the early arm bud grow the fibers from all those spinal nerves opposite it and whatever changes in position the limb may subsequently undergo, it always carries its nerves with it. These structures, then, form excellent guide ropes, as it were, marking not only the early position of the arm but also, with great clearness, the particular segments involved in its structure.

What we know of the close association of muscle and nerve in normal development calls for a similar participation in the developing limb of the corresponding myotomes, and as a matter of fact, the ingrowth of the myotomes into the limb fundament had been known ever since the time of Balfour. Though undoubtedly the case in Selachians, for example, this has been seriously disputed for man and it is only very recently that new observations in fortunate stages of development make it probable that the human embryo does not differ in this respect from what has so clearly been observed elsewhere by Balfour, Kleinenberg, Mollier, Braus, Dohrn, and others.[1]

With these conceptions consciously or unconsciously in mind, it is only to be expected that the vascular system of the extremities should be similarly derived, *i. e.* in each case from several segments. But since in the case of the arm, for instance, only a single supplying artery exists, several hypotheses have been advanced for its explanation. These may be briefly enumerated as follows:

1. The subclavian artery is in reality several segmental arteries fused into a common trunk.

2. The subclavian is a single segmental vessel. Either
   (a) This is from the very beginning the only vessel supplying the arm, or
   (b) This is merely the persisting one of a series of original segmental vessels to the limb.

We may dismiss the first theory with short notice. It was advanced by the English anatomists Macalister[2] and Mackey[3] on purely theoretical grounds, and discredited by the very first actual observations made on the embryonic subclavian. Hochstetter[4] showed clearly, at first in his research on the primary avian subclavian, and afterwards in the case of mammals, that this artery belongs to only one of the segmentals. In

[1]It is not my intention to more than refer here to the very extensive literature on the origin of the limb musculature. One does not need the appearance of the ingrowth of myotomes or of large muscle buds streaming from the myotomes to establish the metameric origin of the limb musculature. Ample evidence is furnished by the observation of a few cells budding in this way. Cf. Ingalls, Archiv f. Mik. Anat., LXX, 1907.

[2]Macalister. Morphology of the Arterial System in Man. Jour. Anat. and Phys., XX, 1886.

[3]Mackay. "The arterial system of vertebrates homologically considered." Memoirs and Memoranda in Anatomy, Vol. 1, 1889.

[4]Hochstetter. "Ueber den Ursprung der Arteria subclavia der Vögel." Morph Jahrb., Bd. 16, S. 494, October, 1890. "Ueber die Entwicklung der A. vertebralis beim Kaninchen." Ibid., December, 1890.

all cases it pierced the limb as an axially directed vessel and undoubtedly corresponded to the adult trunk.

Although I am now convinced that a whole series of interesting changes in the history of the arm's vessels had occurred before the stages observed by Hochstetter, nevertheless his observation was of fundamental importance. It pointed clearly to the fact that the subclavian was to be regarded as the enlarged vessel from a single segment. But it afforded no explanation of the dissimilarity apparent in the behavior of the blood vessels when compared with any of the other segmental structures—the nerves or the myotomes. In every other respect the arm was a polymetameric structure; in its vessels, singularly enough, but one segment was represented. Not only was this unexplained, but, on the contrary, an erroneous interpretation of this as the most primitive stage observable here destroyed much of the value of this contribution. Nevertheless the observation of a stage in which the subclavian can be clearly seen to come from one of the dorsal segmental vessels has been abundantly confirmed by many workers in both mammalian and human embryology. In Man, for instance, we know that the subclavian is a lateral branch of the seventh segmental artery.

But, recognizing none of the recent work on this subject, Hochstetter[4a] has maintained this as the earliest condition and this view has been reflected and emphasized in the recent article by Curt Elze[5] from Hochstetter's laboratory. On the other hand, the most convincing evidence in favor of the existence of many segmental subclavians as the more primary condition has just been given us by the work of Erik Müller[6] and of Hans Rabl.[7]

Professor Müller has for several years prosecuted a series of embryological and comparative studies of the limb vessels which have apparently

[4a] Handbuch der vergleich. und experiment. Entwickelungslehre der Wirbelthiere. Hertwig, 1906, IV Kapitel von Hochstetter, p. 108. "Bei den Embryonen der Amphibien und sämtlichen Amnioten verläuft die einfache Arterie der Extremität *ursprünglich* ziemlich genau in der Achse des Extremitätenstummels." The Italics are mine.

[5] Elze. "Beschreibung eines menschlichen Embryo von zirka 7 mm. grösster Länge." Anat. Hefte, I-35, S. 409. December, 1907.

[6] Müller, Erik. "Beiträge zur Morphologie des Gefässsystems." I. "Die Armarterien des Menschen," Anat. Hefte, I-22, 379-574, June, 1903; II. "Die Armarterien der Säugetiere." Anat. Hefte, 1-27, 73-235, December, 1908. III. "Zur Kenntnis der Flügelarterien der Pinguine." Anat. Hefte, 1135, February, 1908.

[7] Rabl, Hans. "Die erste Anlage der Arterien der vorderen Extremitäten bei den Vögeln. Arch. f. Mik. Anat., Bd. 69, 340-389, 1907.

yielded a rich harvest from this special standpoint. He has not only described embryos in which several segmental subclavians existed, but has also been able to point out that different ones of the segmental series are chosen to become the main vessel in different species.

Müller has described multiple segmental subclavians in Selachians, Reptiles, and Birds, but his studies did not disclose such a condition in Mammals or, till recently, in Man. In human embryos, though, models of the early arm vessels had shown him an interesting condition of the axillary artery—his so-called plexus axillaris arteriosus. This vessel, later a single trunk, was in this stage represented by a plexus and Müller thought he could trace in this plexus the remnants of the segmental subclavians which had helped form it. Moreover, this condition of the axillary suggested clearly to him that he had seen a place where the plexus origin of a large trunk was proven.

Rabl, ignorant of the work of Müller, was suprised to find three segmental subclavians in the wing bud of duck embryos. His own recent contribution to this subject has all the value of an independent discovery. Furthermore Rabl has demonstrated the capillary-plexus origin of several of the limb vessels in the Bird.

Curt Elze[8] has recently severely criticized Müller's findings and interpretations. His conclusion is that Müller has mistaken secondary formations for primary plexuses and that the arm vessels do not develop from such primary capillary plexuses. Elze is not only mistaken in some of his other arguments, but he has chiefly attacked Müller's work by discrediting the normal conditions of the embryos he studied.

Elze is evidently unaware that a system of delicate and easily collapsed tubes like the embryonic capillaries require some distending agent, be it the blood corpuscles or an artificial injection before we can trace with certainty all of their connections.[9] Thus he has censured Müller, who would intentionally choose such material, and cites the well-known fact that living embryos quickly fixed do not show the capillary system well filled, whereas those permitted to die more slowly, always do. He argues

[8]Elze. Loc. cit.

[9]Familiar as we all are with the impossibility of demonstrating the finer portions of the adult vascular tree save by some sort of injection, it is quite inconceivable why we should not recognize the necessity of similar help in the more delicate and transitory vessels of the embryo which collapse with great ease. Professor Sabin informs me that a similar neglect of method has prevented some investigators from getting a correct conception of the connections and course of the embryo's lymphatic system.

then, that specimens showing well-filled capillaries are consequently not trustworthy. Certain it is that just such specimens are best suited to follow carefully the finer vessels, nor do I believe that the distention of the capillaries thus produced has altered gravely the appearance of the vessel wall or neighborhood from what it may be in life.

In his general denunciation of the results of all work on embryos showing imperfections in fixation or other departures from the most perfect conditions obtainable, Elze has seen fit to instance the embryo described by Gage as a good example of the unreliability of such material. It is, strangely enough, this very same embryo which is described in the present paper and which has been fated to furnish one of the first links in the chain of evidence against Elze's contentions. Beyond some obvious shrinkage which dehydration has produced, this embryo meets perfectly the conditions Elze has imposed. In it are mitotic figures in all stages, and furthermore it was obtained by an artificial abortion from an entirely healthy uterus. His own best specimens, though I do not doubt their normal structure, were obtained from diseased uteri.

Elze has called in question Müller's recognition of the brachial artery in these young stages, because, he says, the future territory of the brachial has not yet developed. He explains this still further by outlining briefly his own conception of the development of the arm, according to which, the stages Müller studied contained only the anlage of the hand. The arm is successively pushed out of the body wall, he says, and after the hand, we can recognize the under-arm, the elbow, the upper-arm, and finally the shoulder. These remarkable statements show that Elze is ignorant of much work on the development of the arm, for when we can recognize the various parts of the arm at all, we can recognize the differentiation of upper-arm, lower-arm, and hand, in an order just the reverse of that Elze has maintained.[10]

Elze's answers to Rabl's careful study of the developing arteries in the early wing is weak. He asserts that Rabl's conclusion that these vessels come out of a capillary plexus are not necessarily proved by his

[10]Cf. Lewis, W. H. "The Development of the Arm in Man." Amer. Jour. Anat., I-156. If the arm were merely pushed out from the body wall by the proliferation of the cells at the arm base, as Elze maintains, then the youngest tissue is to be found there and at the arm tip the oldest. But, unfortunately, the facts prove the reverse of this, for hand muscles, for instance, are as yet a mass of embryonic mesenchyme when those of the upper arm are differentiated Professor Lewis informs me that there is no justification in the position that the limb is at any time merely the hand.

facts, a charge which will hardly be supported by those who will read carefully this excellent research. And in addition, says Elze, the history of the development of the Duck's subclavia argues nothing for the conditions in Man.

Finally, I may be permitted to add (what he has himself frankly admitted) that Elze's embryos are too old to furnish any evidence on the earliest limb vessels and that they have contributed nothing to our knowledge of this portion of the subject.

In quite another way, however, Elze has contributed something to the general subject, for by opposing the plexus origin of vessels he states definitely the issue between the two leading views now held on vascular development; and that Müller's fundamental conceptions on this point are in the main quite correct, regardless of what minor errors he may have made, I regard as certainly true and *capable of demonstration in every portion of the body.*

Until the appearance of his last paper in February, 1908, Müller had never been able to find a human embryo with more than a single subclavian. His "plexus axillaris arteriosus" was the nearest approach to this. Indeed Müller has gone so far as to label certain of the channels in this plexus as representing the persisting proximal portions of the pre-existing segmental subclavians, and on this evidence, scanty though it was, declared the human arm bud originally supplied with these multiple subclavians. Whether the individual channels in the "plexus axillaris arteriosus" are constant enough in number and exact position to be referable to the segmental subclavians or whether, indeed, they may not be merely the variable bars which form the meshes of any general capillary net, must be left to future researches to decide.[11] Other and far better reasons for the prediction Müller made were to be found in more general considerations and undoubtedly a correct fundamental conception of the growth of vessels guided him to a prediction which his few facts could hardly prove to others. Having traced the arm to a stage in which the axillary artery was represented by a capillary plexus, it was reasonable to suppose that the subclavians also had passed through this stage.

[11]My own work points strongly to this latter interpretation. In many injections of the limb buds of early bird embryos, I have observed a most variable condition of the capillary plexus distal to the line of first anastomosis of the multiple subclavians. Indeed, from this point on, one cannot segregate portions of the plexus as belonging to individual subclavians. Elze's criticism of Müller here is quite justified, for one must doubt seriously the exact value of his "plexus arteriosus axillaris."

If it be true that blood vessels can grow out as single trunks before dividing to form a plexus, then Müller's supposition was in no sense necessitated by the picture he saw. But if vascular trunks are resolved out of and hence preceded by a simple capillary plexus, then Müller's declaration was most plausible—for the segmental subclavians were probably true capillaries, both in delicacy of wall and in size and their anastomoses with one another had given a plexus similar in character to, and continuous with, that now remaining in the place of the axillary artery. The interpretation, then, depended entirely on the pre-existing condition here, and, in lieu of any evidence on this point, quite entirely on one's acceptance of certain principles of blood-vessel development.

In his last paper, Müller[12] announces the observation by Keibel of a double subclavian supply to the arm bud of a 4½ mm. human embryo. Few other details are given and the condition of the embryo was such that little could be determined save that both vessels could be distinctly traced from the aorta into the extremity, in which were numerous capillaries.

An examination of Keibel's Normentafeln[12a] which has just appeared, shows that this embryo is numbered seventeen in his series and that the subclavians present in this case came from the sixth and seventh dorsal segmental arteries.[12b]

This, then, comprises all that is known at present of the earliest stages of the human subclavian. The uncertainty in which the matter appears to stand makes it necessary that these meagre results be verified. Our own specimen had been observed by Professor Mall a considerable time before the appearance of Müller's last report, so that at the time I was permitted to investigate this point more carefully, it was believed that we had the first authentic instance of a human arm bud early enough to display more than a single subclavian.

As it is, the facts here presented supplement in an interesting way those reported for Müller's embryo, for in this case, as I shall presently describe, the segmental subclavians represent the two lower segments opposite the arm, whereas the Embryo 17 of Müller's possessed sub-

[12]Müller. Loc. cit.

[12a] Keibel. Normentafeln zur Entwicklungsgeschichte der Wirbelthiere. Heft VIII. Norm. z. Ent. des Menschen. Keibel und Elze. Jena, 1908. Keibel has also noted here another embryo (No. 16) which on one side possessed two subclavians from the same two segments, *i. e.*, 6th and 7th.

[12b] I number the segmental vessels to correspond to the nerves. Following Hochstetter's usage these would be 5th and 6th instead of 6th and 7th.

clavians form the two upper segments. This report also, I trust, will establish the reliability of this as a normal finding in the human embryo.

Description of the Present Case.

The present case concerns the condition present in the right arm bud of a human embryo—No. 148 of Professor Mall's collection—four and three-tenths millimeters long (neck-breech).

As has been said, the embryo gives all the appearances of well fixed and healthy tissue, though slightly shrunken by alcohol; so that any evidence it presents can not be cast out on the grounds of any pathological taint about it. It was obtained from a healthy uterus, is beautifully fixed, and is itself normal.

A detailed description of it is not necessary, as Gage[13] has done this quite fully. Suffice it to say, however, that this study showed the presence of 28-29 myotomes, of which two are occipital.

The arm buds extended from the seventh to the thirteenth myotomes. They are formed of a homogeneous appearing mesenchyme in which are many capillaries. On the right side, the serial sections showed that two vessels left the aorta and entered the root of the limb. These were separated by a considerable interval and were both perfectly distinct. They occur in sections 82 and 91 respectively. They appeared to contribute to the general capillary plexus of the limb as soon as they reached its root, *i. e.* could not be traced any distance into the limb core as is the case with the axial subclavian we find in slightly older stages. The more anterior of these two subclavians can be followed in its entire course in two succeeding sections. The first section shows it extending laterally a far as the base of the arm bud and mesially to within a short distance of the right aorta. The succeeding section discloses its origin from the aorta. Its course is almost in a straight transverse line. Taking origin from the upper lateral portion of the aortic wall, it passes over and considerably above the posterior cardinal vein and the cephalic portion of the primitive cœlom here present. It has just reached the tissue of the limb bud, when an alteration in its trend, together with the collapsed state of its walls, forbids our following it accurately further. However, several capillary channels in the immediately neighboring mesenchyme apparently join it. The subclavian is everywhere a delicate endothelial tube. Its origin from the aorta is as a small conical protuberance of the

[13]Gage, S. P. "A Three Weeks' Human Embryo." Amer. Jour. Anat., IV, pp. 409-445, 1905.

aortic wall, an appearance presented by most of the early outgrowths of the aorta. The collapse of its walls prevents any accurate estimate of its calibre, but a small distended segment next its origin indicates that it does not exceed that of any ordinary capillary. (Fig. 1.)

A few sections beyond the above, the corresponding segmental vein appears and can be followed from the ventro-lateral aspect of the spinal cord to the post-cardinal trunk.

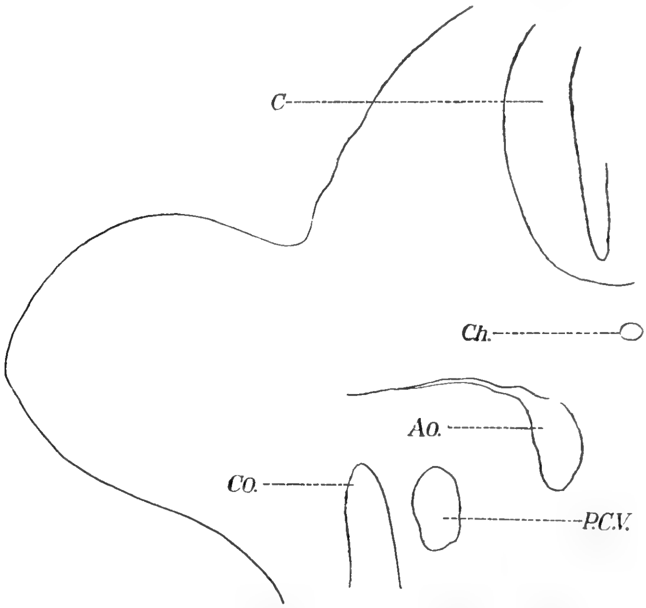


Fig. 1. Camera lucida tracing of the subclavian artery of the seventh cervical segment in human embryo No. 148. C., spinal cord; Ch., Chorda; Ao., right aorta; Co., cœlom; P.C.V., post-cardinal vein.

The second subclavian present here does not differ essentially from the more anterior one. However, it is less collapsed and penetrates the blastema of the arm bud a slight distance, showing there a considerable dilatation. (Fig. 2.)

One of the points of greatest interest in the foregoing, was the determination of the exact position of these vessels and their relation to the primitive segments. The sections were cut obliquely; consequently it was impossible to take the particular spinal ganglion appearing in a section which showed a subclavian as representing the level of origin of the vessel in question. Fortunately, however, two careful models of the embryo had been made, in one of which the relation of the plane of section to the embryo had been most painstakingly determined. Employing an accurate profile of the reconstruction with the lines of section indicated, it was easy to draw in those parallel lines representing the sections which interested us. The section disclosing the first subclavian had also shown the ventral root of the eighth cervical nerve and, employing my figure, I

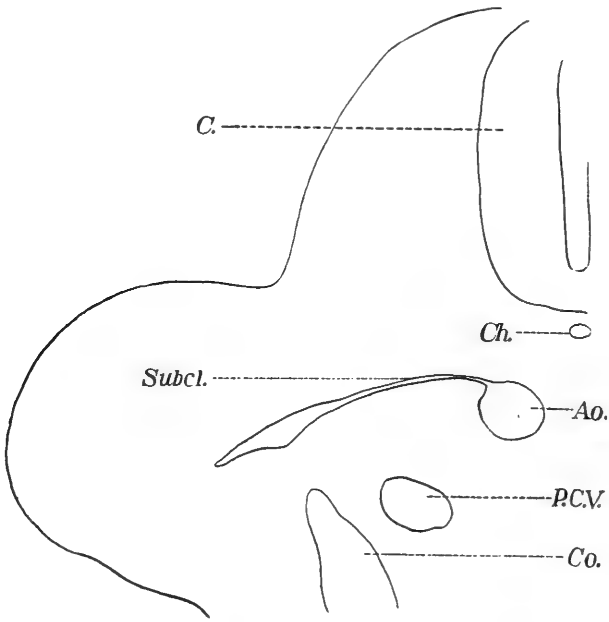


Fig. 2. Camera lucida tracing of the subclavian artery of the first thoracic segment. Lettering as in Fig. 1.

found that such a section must have cut the aorta at the preceding inter-segmental point. There was high probability, then, that the first vessel could have corresponded only to the seventh segmental one; and when the segmental vein, referred to above, was located near it, there appeared adequate evidence for definitely determining it as at this location.

The second subclavian, by the same evidence, fell at the second lower inter-segmental point and hence is doubtless to be regarded as opposite the first thoracic segmental vessel.

Fig. 3 shows a reconstruction of these vessels and their relation to the myotomes. I regret that we can not speak more definitely of their relation to the dorsal, so-called "segmental" vessels, not that their position could thus be determined any more positively than it already has been by reference to the myotomes, but for quite another reason. In the Birds, where we now have the most complete account of the earliest limb vessels, the subclavian arteries are primitively independent lateral offshoots of the aorta and only later come to be included as branches of the dorsal segmentals. It is not unlikely that our case represents this primary condition in Man. In Müller's embryo, which is slightly older,

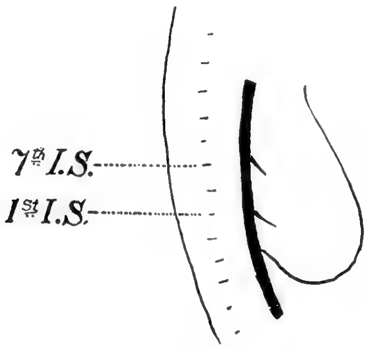


Fig. 3. Reconstruction of position and course of segmental subclavian arteries present in this case. 7th I.S., seventh cervical intersegmental space; 1st I.S., first thoracic intersegmental space.

the subclavians are already definitely branches of the corresponding dorsal vessels.

Relation of the Foregoing to the General Principles of the Development of the Vascular System.

It has already been emphasized that the dispute on the method of development of the subclavian has established clearly the two modern views on the development of the vascular system. According to the one, blood vessels grow out to their territory as definite stems from the very beginning; whereas, according to the other view, they are always preceded by a capillary plexus the conversion of which into the later stem or trunk involves the selection of one path through the mesh and the atrophy of all or most of the others.

Many years ago, as Müller has shown, Aeby[14] and his pupil Baader[15] put forth the hypothesis of a general embryonic net from which all arteries and veins arose. They were led to this view by a careful study of variation in the vascular trunks of the adult. The variations could be explained on no other basis so well as by the theory of a pre-existing uniform net or plexus. No more direct evidence than that afforded by the grown body did they attempt to seek, and an exploration of developing blood vessels to throw light on this point, waited almost twenty years, when Ruge[16] thought he could test the point by examining the limb vessels in a twenty-five millimeter human embryo. There, of course, the subclavian artery was present as a distinct trunk, giving off its customary branches, all of which was so clear that Ruge saw no need of regarding the theory further or of testing it in earlier stages! On this evidence he took issue with the idea of a capillary mesh anlage for the vessels and stated his belief that "bereits an allen Embryonen die grossen Gefässe der Extremität als solche ausgebildet waren."

Most of the voluminous researches since Ruge have told us nothing on this fundamental point. One brilliant exception must be made in the work of Thoma.[17] Choosing a flat and expanding area of blood-vessel development, the area vasculosa of the chick, he concentrated his attention on the very points we have been discussing and established beyond doubt that both arteries and veins in any area are a later elaboration from a pre-existing capillary net. Thoma went further, as is well known, and showed that this elaboration or transformation was merely an inevitable result of definitely acting hydrodynamic laws which need not be referred to here.

Most of the workers since Thoma have either ignored this important work or have possibly fancied that facts gained from the chick's yolk vessels could not be seen to apply in the case of the trunks in the body of the embryo. However, from this laboratory from time to time, earnest attention has been called to Thoma's great contribution and at least the capillary anlage for the vessels has not been doubted to apply in the growth of the vascular system of any area or organ of the embryo.

[14]Aeby. "Der Bau des menschlichen Körpers," 1871.

[15]Baader. "Ueber die Varietäten der Armarterien des Menschen." Inaug. Diss., Bern, 1866.

[16]Ruge, G. "Beiträge zur Gefässlehre des Menschen." Morph. Jahrb., Bd. 9, 329, 1884.

[17]Thoma, R. "Untersuchungen über die Histogenese und Histomechanik des Gefässsystems," 1893.

Perhaps the clearest expression of this is to be found in Professor Mall's "A Study of the Structural Unit of the Liver," Amer. Jour. Anat., Vol. V, No. 3, p. 251: "The first and guiding blood vessel is the capillary, which grows in all directions, forming a plexus. Secondary changes make arteries and veins of them." Convincing proof that this is true will probably only come when a method of investigation is used which will give us without doubt the whole picture of all the vessels present in the various parts of the embryo, including the entire capillary bed and even its endothelial sprouts. Such a method is the method of injection.

However, without this aid, attentive examination of sections have revealed much to Müller and to Rabl. Their contributions mark the first established instances of the application of the capillary plexus theory for the growth of the body's vessels. But their interpretations will doubtless be questioned until the successful employment of the method suggested above brings the telling proof.

It is only necessary to call attention to one other point which may be used by the opposing school. They may admit, as Elze does, that segmental subclavians may occur, but see in this rather support for their own ideas. How is it, they may ask, if this is a simple capillary plexus, that the first mesh is rigidly governed by the somite's width?

Till recently, we could have only answered here that these vessels are capillaries as far as their size, the character of their walls, and their anastomoses are concerned. That they do not arise at more frequent intervals from the aortic wall—intervals more the width of the usual capillary mesh—is doubtless owing to the influence of the metameric organization of this portion of the embryo, an influence governing the outgrowth of all of the dorsal capillaries of the aorta and an influence, they may be reminded, whose fundamental significance has not yet been altogether explained. If vessels grow at all, it appears they must grow at segmental points, *i. e.* between the myotomes. But if the vessels which grow there are capillaries, behaving from these points on as capillaries do, then they offer no contradiction to our theory.

I have discussed this merely to support the evidence which Rabl and Müller have acquired by a body of new facts which have come out of a long series of vascular injections of young bird embryos. I may thus be pardoned for announcing here so briefly what I have described in necessary detail elsewhere.[18]

[18]Evans. "On the Earliest Bloodvessels in the Anterior Limb Bud of Birds and their Relation to the Primary Subclavian." Amer. Jour. Anat., Vol. VIII, 1908.

Injections will give us at a glance more knowledge than we can hope to laboriously acquire by reconstructions. *By employing the method of injection in the case of the arm bud, it is now possible to recognize, preceding the stage of segmental subclavians, a more profuse outgrowth of capillaries from the lateral aortic wall than we had ever suspected.* Indeed, in one case, I was able to count eleven of these delicate vessels streaming into the arm blastema where but three could have been expected had they risen merely at intersegmental points. In other words, then, *when the arm tissue is first supplied by vessels, and it is supplied very early—it is supplied merely by capillaries growing from multiple points and anastomosing to form a typical and simple plexus.*

Thus we have followed down to this most primitive condition one of the largest trunks in the entire body—the subclavian artery—and one can hardly doubt but that the methods of its formation can be seen again in its growth—that all of its branches down to the digital are successively preceded in their development by zones of true capillary nets, out of which, in each instance, the stem in question is ultimately derived.

We must now expect to see the discovery of more vessels in still earlier human arm buds and in the mammals as well. But that such observations will be abundant or easy is negatived by what we know of the delicate and extremely transitory character of such vessels in those cases where they have already been demonstrated.

In conclusion, I wish to express my many thanks to Professor Mall.

Standardization of Anatomical Teaching in American Medical Schools

The Association of American Medical Colleges has for some time been making an attempt to standardize the medical course. A standard course of four thousand hours has been adopted in which various subjects belonging to the medical curriculum are given a number of hours proportionate to their supposed value or difficulty. Recently a committee on syllabus of this Association, composed of Doctors F. C. Waite, Egbert LeFevre, R. D. Coale, C. M. Jackson, P. M. Dawson and Henry Albert, have been considering the teaching of the curriculum in so far as it relates to histology, embryology, materia medica, chemistry, gross anatomy, physiology and bacteriology. A report of this committee is published in the Proceedings of the meeting of the Association, held in Cleveland, Ohio, March, 1908. In this report may be found a number of interesting details. The subject is taken up from the standpoint of medical schools in which the minimum entrance requirement is a four-years' standard high-school course. More recently the Council on Medical Education of the American Medical Association has taken up the matter from a slightly different standpoint. Committees have been appointed to take up the matter of the entire medical curriculum from the point of view of medical colleges in which the minimum requirements for entrance are at least one year of college work in physics, chemistry, biology, and language in addition to the four-year high school curriculum. The Council has appointed ten committees, each committee composed of ten men. To each of the ten committees a specific subject is assigned, as follows:

1. Anatomy, including Histology, Embryology, etc.
2. Physiology and Physiological Chemistry.
3. Pathology and Bacteriology.
4. Pharmacology and Toxicology.
5. Medicine.
6. Surgery.
7. Obstetrics and Gynecology.
8. Eye, ear, nose, and throat.
9. Dermatology and Venereal Diseases.
10. Hygiene, Medical Jurisprudence, and Medical Economics.

Each committee will decide upon a course of study and equipment, etc., suitable for the subject for which it is appointed, and the chairmen of these various sub-committees will compose a committee of ten to map out a complete medical curriculum. It is provisionally assumed that the course in medicine shall consist of four years of thirty weeks each, and thirty hours of instruction each week, making thirty-six hundred hours for the course.

The committee appointed to outline courses in anatomy, histology, embryology, etc., is composed of Professors G. A. Piersol, F. P. Mall, I. Hardesty, G. S. Huntington, J. P. McMurrich, A. C. Eyclesheimer, T. G. Lee, C. M. Jackson, G. Carl Huber, and C. R. Bardeen, chairman.

It is desired that this committee make specific recommendations regarding:

(a) The place of the various subdivisions of anatomy in the medical curriculum, in the first, second, third or fourth years. In connection with this specific recommendations should be made in regard to preparatory work in morphology in the premedical biological courses.

(b) Pre-requisite courses, either preliminary or medical.

(c) The necessary qualifications of instructors.

(d) The best methods of teaching.

(e) The necessary laboratory equipment. What apparatus is essential for each student for each subject.

(f) The proportion of didactic and practical teaching.

(g) The minimum number of hours to be devoted to each subject.

It seems probable that the first convenient time for holding a meeting of the committee will be at the next meeting of the Association of American Anatomists, to be held in Baltimore late in December. It is therefore important that as much preliminary work as possible be accomplished before that time. The chairman of the committee will welcome suggestions concerning the various topics which should be considered and the best way of getting useful data.

Probably most anatomists will agree upon certain general propositions, such, for instance, as:

1. No one should be allowed to practice medicine who has not at least a minimum knowledge of anatomical facts, a minimum understanding of the fundamental principles of organic structure and a minimum familiarity and dexterity with anatomical methods.

2. The minimum amount of time devoted to the anatomical sciences must be sufficient in amount to insure for a student of good ability the training necessary for meeting the requirements mentioned above.

3. No department of anatomy can meet the minimum requirements which is not prepared to offer much more than the minimum opportunities for meeting the minimum requirements.

While broad propositions like the above may meet with fairly general acceptance, it is not to be expected that there will be a similar concurrence as to specific details in carrying the general propositions into effect.

In order to get data for further work it is desired that teachers of anatomy in American medical schools send to the Chairman of the Committee as promptly as possible, answers to the following questions:

1. What preliminary training in plant and animal morphology and physiology should be absolutely required of students before they are permitted to take up the study of human anatomy? How much of this preliminary training should be obtained, (a) in the high school, (b) in college previous to matriculation in the medical school, (c) after matriculation in the medical school?

What additional preliminary training of this character may be strongly advised but not absolutely required?

What equipment is necessary for the teaching of the required work? For teaching the more advanced work?

2. What courses in the anatomical sciences should be offered by the anatomical department or allied departments of the anatomical sciences in a college of medicine? In which years should the courses come? Which of these courses should be absolutely required of all students, which should be strongly advised, and which should be designed primarily for students especially interested in anatomy as a science, rather than for the average medical student?

How much time should be devoted, (1) to lectures, (2) to recitations and (3) to laboratory work in the courses required and in those advised for all medical students?

What equipment is necessary for preparing material and for giving the courses mentioned?

What special qualifications should be required of the instructors?

3. What training in the anatomical sciences should be expected to be given in other departments than anatomy, such as those of physiology, pathology, medicine, surgery, obstetrics and gynecology, eye, ear, nose, and throat, etc.

Please address communications on these subjects to Dr. C. R. Bardeen, Science Hall, Madison, Wisconsin.

Report on the Present Status of the Academic Institutes for Brain Study, together with a Report of the Meetings of the Executive Committee of the Brain Commission, Held at Berlin, March 14, 1908.

(1). The Brain Commission has suffered a serious loss in the death in April of this year (1908) of Herr Guldberg, of Christiania. Herr Guldberg was greatly interested in the matter of brain study and was endeavoring to develop a department for the investigation of the brain in the institute of which he was director. At the next meeting of the Brain Commission at Bologna, it will be necessary to choose his successor.

By vote of the members, Mr. I. D. Wilson of Sydney, Australia, has been made a member of the Brain Commission, so that with the successor to Herr Guldberg, who is to be chosen, there are 31 members of the Brain Commission.

(2). The recognized academic institutes for brain study are at present the following:

(A). The Neurological Institute at Vienna directed by Herr Obersteiner. This is at the same time officially recognized as the Central Institute for Austria (Cisleithan).

(B). The Institute at Leipzig, directed by Herr Flechsig. This is connected with the Neurological-Psychiatrical Clinic of the University.

(C). The Senckenberg Neurological Institute at Frankfurt a/M, directed by Herr Edinger.

(D). The Institute at Zürich, directed by Herr von Monakow. This is associated with the Neurological Clinic of the University.

(E). The Institute for brain study at Philadelphia, under the direction of Mr. H. H. Donaldson. This is a department of the Wistar Institute of Anatomy and Biology, Mr. M. J. Greenman, Director.

(F). The Institute at Madrid, under the direction of Senor Ramon-Cajal.

(G). The Psycho-Neurological Institute of the Imperial Academy of Military Medicine at St. Petersburg, under the direction of Herr Bechterew.

(3). Herr Bolk and Herr C. Winkler have reported that the establishment of an Institute for Brain Study at Amsterdam is assured. The building has already been begun and there has been appropriated for the equipment 25,000 Fl. and for the annual expenses 10,000 Fl.

(4). The association of the registered (Kartellierten) Academies has not approved the establishment of a Central Institute for all Germany and prefers that the establishment of such institutes be left with the individual states. As a result, the Royal Prussian Academy of Sciences has submitted to the present ministry of education a petition in which the establishment of a large institute representing all the lines of brain study is proposed. A decision has not yet been rendered.

(5). Herr Edinger has published in the Frankfurter Zeitschrift für Pathologie a report on the Senckenberg Neurological Institute since 1885, I may note from the report that the Institute possesses a collection of 10,000 preparations representing all lines of brain study, and further a library with 6,000 titles, which contains almost the complete literature on brain anatomy for the past twenty-five years, as well as the special periodicals, so far as these are not represented in the Senckenberg library. Further this report gives a complete list of the investigations published from the Institute under the direction of Herr Edinger.

The rooms are admirably arranged and adequately supplied with the necessary instruments.

In addition to the Director, Herr Edinger, there are at work at the Institute two heads of departments, two assistants (women), one preparator and a janitor skilled in photography.

(6). At the meeting of the Executive Committee in Berlin, on the 14th of March, all the members were present, *i. e.,* Herrn Ehlers, Flechsig, H. Munk, Obersteiner and the undersigned.

Herr Flechsig and Herr Obersteiner reported concerning their respective institutes.

Both institutes are fully equipped. In the Institute of Herr Flechsig, at Leipzig, there has been begun a collection of brains from persons known during life. From these, suitable cases will be described. In addition, there is a large pathological-anatomical collection of the brains of persons suffering from speech defects, and also brains of anthropoids, among which are two gorilla brains; also a collection of 60,000 brain sections. Finally, there is a department for experimental psychology and for chemical work. Moreover, Herr Flechsig stated that Professor Held had in the Anatomical Institute a large collection of miscroscopical preparations, among which were preparations showing the development of nerve fibrillæ.

Herr Obersteiner stated that the Neurological Institute directed by him would this year celebrate the twenty-fifth anniversary of its founding. The plan of the new institute which will be erected in the Schwarzspanierstrasse has been determined upon. As mentioned above, the Institute has been officially recognized as the Central Institute for Austria. All lines of brain study, especially embryological and histological investigations, will be fostered there, The library contains 60,000 volumes of which Herr Obersteiner has given 30,000 (reprints included). The collection contains, among other things, complete series of sections of the Orang brain, series of spinal cord sections mainly from mammals, and a large number of models.

The undersigned reported on the previously mentioned petition from the Prussian Academy of Sciences to the Ministry of Education. Further he reported that the Academy had granted him 1,000 M. for the preparation of an anatomical nomenclature of the brain. This nomenclature will apply primarily to the human brain and only incidentally include comparative anatomy. The terms are to be chosen as impartially as possible and these will be accompanied by a list of synonyms. Professor Dr. W. Krause and the undersigned have undertaken the preparation. This list will be submitted first to Herr Flechsig, then to the members of the Brain Commission and to the Chairmen of the special commissions, *i. e.,* Herrn Ehlers, Golgi, Retzius, H. Munk and Obersteiner. (The Chairman of the Anatomical Commission is the undersigned.)

(7). It was further decided:

(A). To send the association of united academies a note thanking them for the interest thus far shown in the matter of brain study, and asking them to continue their interest. In those countries where Institutes do not yet exist, they are to be especially urged to petition their respective governments, in the same way as has been done by the Berlin Academy, for the establishment of Institutes for brain study.

(B). To request the recognized Institutes for brain study to send in as soon as possible a short report of their status, similar to those furnished by Herrn Edinger, Flechsig and Obersteiner.

(C). In view of the fact that in the year 1909, Rome will be the place of meeting for the associated academies, and that it does not seem desirable that the Brain Commission and the associated academies meet at the same place, Bologna has been chosen as the place for the next meeting of the Brain Commission.

The undersigned will confer with Herr Luciani in Rome, concerning the appropriate time—immediately preceding the meeting of the academies at Rome,—and the other arrangements.

(D). Finally it was decided to send this report

(1). To the Academia dei Lincei in Rome as the presiding academy of the association at this time.

(2). To all the members of the Brain Commission.

(3). To the previously mentioned Chairmen of the special commissions.

WALDEYER,
President of the Brain Commission.

A New Device for Maintaining a Uniform Temperature of a Warm Stage for Microscopic Work.

BY

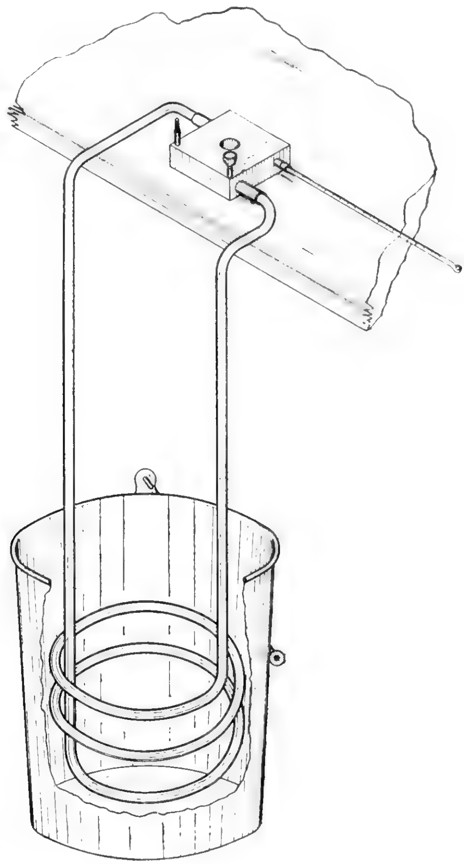
GEORGE WALKER, M.D.
Associate in Surgery, Johns Hopkins University.

By employing this device I have found it possible to keep a warm microscopic stage at a uniform temperature. The principle involved is similar to that made use of in the hot water heating apparatus of houses. The coil is made of half-inch brass piping continuous with which are two upright arms about 50 cm. in length, which are connected to a box made of thin copper sheeting and measuring 8.5 cm. square, by 2.5 cm. in thickness. In the centre is a perforation 1.7 cm. in diameter, through which light comes upward to the specimen. On the upper surface are two other openings connected with the chamber, through which the apparatus can be filled with water. On the right and left lateral surfaces respectively is an opening for connection with the pipe, and on the right a second perforation for a thermometer. A bucket for holding the hot water and a tripod complete the apparatus.

The coil and box are completely filled with water, care being taken that every particle of air is expelled; otherwise the circulation of the water will not be satisfactory, nor the temperature regular. The coil is then placed in the bucket of water, which in turn rests on a tripod with a Bunsen burner under it. A thermometer is placed in the bucket and the temperature of the water raised to a point three degrees higher than that required for the box. After this has been reached, the flame is lowered and regulated so that the temperature of the water in the bucket remains practically the same. As the water in the bucket becomes hot it flows upward through one pipe to the box. There it is slightly cooled and then descends through the other pipe. This circulation is continuous, and thus a constant temperature of the stage is maintained.

As each apparatus varies slightly in shape, a test wil have to be made to ascertain the difference between the temperature in the box and that in the bucket below. After this has been established, it can easily be maintained.

I have found that the temperature in the box can be kept without varying more than half a degree for any length of time after the flame



has been suitably adjusted. This adjustment is very easy and does not require more than two or three inspections, and a slight lowering or turning up until the proper temperature is reached.

A Note on the Technique of the Nissl Stain for Nerve Cells.

BY

VICTOR C. MYERS.
From the Laboratory of the Connecticut Hospital for Insane.

The Nissl stain for the coloration of the chromophile substance of the nerve cells has aided more than any other in throwing light upon changes of structure in the central nervous system. This method has been modified in innumerable ways by various workers; indeed, it has been stated[1] that the original methylene blue method is now used by no one excepting Nissl and his pupils.

Of the five hundred autopsies which have been made in this laboratory during the past ten years, sections of the brain have been stained with the Nissl method in practically all cases. It has been our experience that the original procedure of Nissl,[2] with several modifications to be described, works admirably when it is possible to remove the brain shortly after death and there is present no marked degeneration of the nervous system, such as is found in paresis. Here it is often impossible to obtain anything but very thick sections with Nissl's method of cutting, in which case, if thin sections are desired, it is necessary to embed and cut in paraffin.

The Method Employed Has Been as Follows:

1. Sections, taken from four areas of the brain, are hardened in 96 per cent alcohol for two weeks, the alcohol being changed daily during this time. It is well to allow the sections to stand at least a month in the alcohol before cutting, and longer does no harm. The sections are then mounted on blocks with acacia, replaced in the alcohol over night to allow the acacia to harden and then sectioned on the sliding microtome in alcohol by means of a long knife having a very sharp and smooth edge. It is essential for good results to always remove the pia before mounting the gross brain sections on the blocks; otherwise the sections will curl

[1]Lugaro: Monitore Zoölogico Italiano. No. 1, 1904. Quoted from abstract in Rev. of Neur. and Psychiat., Vol. III, p. 339, 1905.

[2]Nissl: Report in Allg. Zeitschr. f. Psychiat., Bd. XLVIII. S. 197, 1902. The procedure is given in detail in Pollack: Methods of Staining the Nervous System. English translation by W. R. Jack, Glasgow, 1898, p. 61.

when immersed in the hot staining solution. Sections 12-18 microns are thin enough and can easily be manipulated with a very small sable hair brush.

2. The sections are stained in the usual methylene blue solution in a watch glass over a spirit lamp until bubbles are given off.

Methylene blue B (patent)	3.75
Grated Venice soap	1.75
Distilled water	1000.

In making up the stain it is convenient to dissolve the soap in warm water before adding the methylene blue. Furthermore, it is well to always have a sufficient quantity made up and on hand, as the quality of the stain appears to improve with age.

3. The sections are differentiated in a mixture of freshly distilled aniline oil 10 parts and 96 per cent alcohol 90 parts. The differentiation is carried out in Syracuse solid watch crystals, three changes of fluid being made, so that when the sections are placed in the third crystal they are in a perfectly clear solution.

4. After placing a section upon the slide by means of a sable hair brush, it is thoroughly blotted with smooth filter paper and rendered transparent with several drops of cajuput oil.

5. The oil of cajuput is removed from the slide as much as possible with a cloth, after which benzol is poured on the section to wash out the remaining oil. This is then followed by xylol as soon as the excess of benzol has been removed. After wiping off the surplus xylol, a small drop of xylol-colophonium is added and a thin warm cover glass pressed tightly against the specimen.

In case it is necessary to cut the tissue in paraffin, the above method may be followed, after removing the paraffin from the sections with xylol, by placing in 96 per cent alcohol and proceeding as above. Sometimes, owing to the friability of these sections, it is advisable to carry out the process directly upon the slide, and this may readily be done. Though paraffin sections may be cut much thinner than those cut without embedding, the unembedded sections are as a rule sufficiently thin, and there is the added advantage, and an important one, that the material has been subjected to fewer manipulations.

No other anilin dye seems to bring out the differentiation in structure of the cell protoplasm quite as well as methylene blue, prepared according to Nissl's formula. This seems to be especially true when the stain becomes old. It colors deeply, requiring considerable differentiation in the aniline oil mixture, but this seems to add to the quality of the stain. It has been our experience that the plasma cells in paresis are always distinctly stained.

For the ordinary routine work of the pathological laboratory a contrast stain to the methylene blue, such as is found in Held's modification of Nissl's method, detracts rather than adds to the general advantages of the stain.

Starting from Giemsa's view that the active stain produced by the combination of methylene blue and Venetian soap could only be azure, Rodenwaldt[3] has suggested the replacement of Nissl's stain by 1-750 watery azure. Azure II is employed and to 10 c.c., just before use, 4 drops of a saturated potassium carbonate solution are added. This author stains for only one minute, and without warming.

As aniline becomes dark on standing, especially if exposed to light, it is well to frequently redistill it. All the apparatus necessary is a small distillation flask, a thermometer and a long glass tube (the inside tube of a long condenser). Since the boiling point of aniline is 183 degrees C. when pure, the flask may be placed on wire gauze and the distillation carried on over the open flame. One hundred cubic centimeters of the aniline oil and alcohol mixture, 10 c.c. aniline and 90 c.c. 96 per cent alcohol, is a sufficient quantity to make up at one time for ordinary usage. This will differentiate well for several days.

As a clearing agent cajuput oil (Grübler) is unsurpassed. The oil we have obtained from sources other than Grübler has been found unreliable.

The cajuput oil has been removed first with benzol,[4] because it is thinner than the xylol and seems to remove the oil more quickly.

After this the xylol has been added preparatory to the xylol-colophonium. For mounting, xylol-colophonium appears preferable to either benzin-colophonium or xylol-balsam. The benzin-colophonium of the original method is objectionable, owing to its frequent crystallization and

[3]Rodenwaldt: Monatschr. f. Psychiat. u. Neur., Bd. XXIII, S. 287, 1908.

[4]It should perhaps be stated that considerable confusion has apparently arisen among histologists in regard to the terms benzin or benzine and benzene or benzol. Benzine or petroleum ether is the most volatile portion of crude American petroleum, containing chiefly the hydrocarbons C_6H_{14}—C_8H_{18}, while benzol, having the formula C_6H_6, is a coal-tar product and the first of the aromatic or cyclic series of compounds. In Germany the terms benzin and benzol appear to have been employed somewhat synonymously among

its drying in such a way as to often allow the passage of air under the cover glass. Furthermore, it is much more difficult to manipulate than the xylol preparation. Benzin-colophonium was discarded in this laboratory some time ago, and xylol-balsam substituted with much more satisfactory results. It was found that if a small drop of thin xylol-balsam were employed the color would be preserved nearly as well as with the benzin-colophonium and the objectionable features of the latter avoided. More recently, however, we have employed the xylol preparation of colophonium with uniformly good results. Xylol-colophonium hardens almost at once and remains nearly colorless, in contrast to xylol-balsam. Furthermore, the color of the specimen is much better preserved with the xylol preparation of colophonium than of balsam. Farrar[5] in his excellent article on the growth of histologic technique records the discarding of benzin-colophonium and the substitution of xylol-colophonium. Comparing colophonium and balsam, he states that colophonium does not subsequently run when exposed to heat, the slide thus being available for projection, while balsam preparations, on the other hand, will hardly endure the arc light. Here again colophonium possesses advantages over balsam. For ordinary work, however, where there is no great delay in examining the specimens after their preparation, xylol-balsam may be used instead of xylol-colophonium, if the latter is not at hand.

An always important consideration in histological technique is the amount of time required to carry out the procedure. With the method described, one will experience little difficulty in preparing at least forty sections a day, *i. e.,* material from five brains, sections being made from four areas and allowing two slides to each.

histologists, but in this case benzol has, without doubt, been the compound employed. Reference would not be made to the subject, were it not that a number of workers have employed benzine instead of benzol in their manipulation of the Nissl stain and have obtained unsatisfactory results until their mistake was discovered, this being especially the case before the use of xylol and xylol-colophonium.

[5]Farrar: Rev. of Neur. and Psychiat., Vol. III, p. 578, 1905.

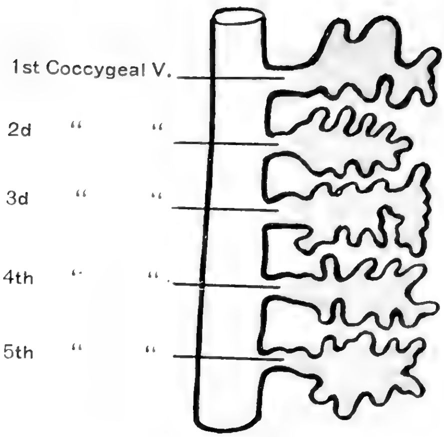


FIG. 1

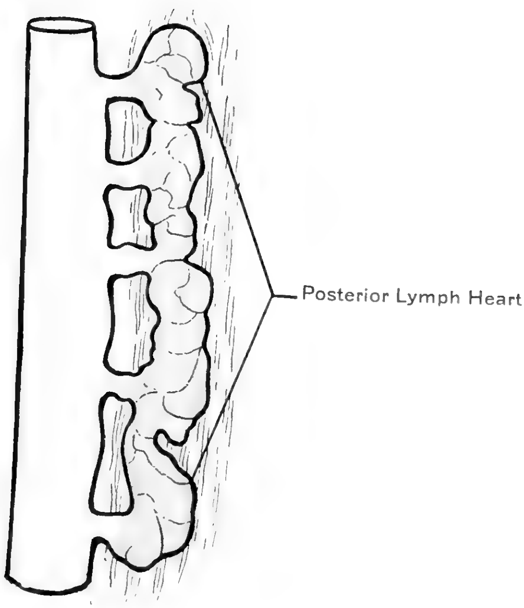


FIG. 2

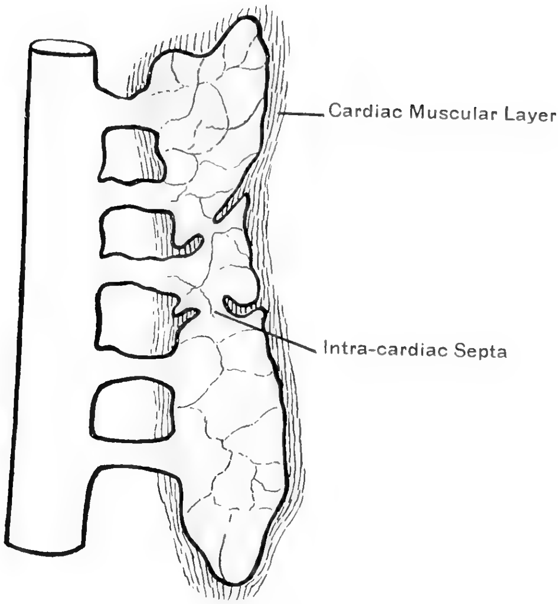


FIG. 3

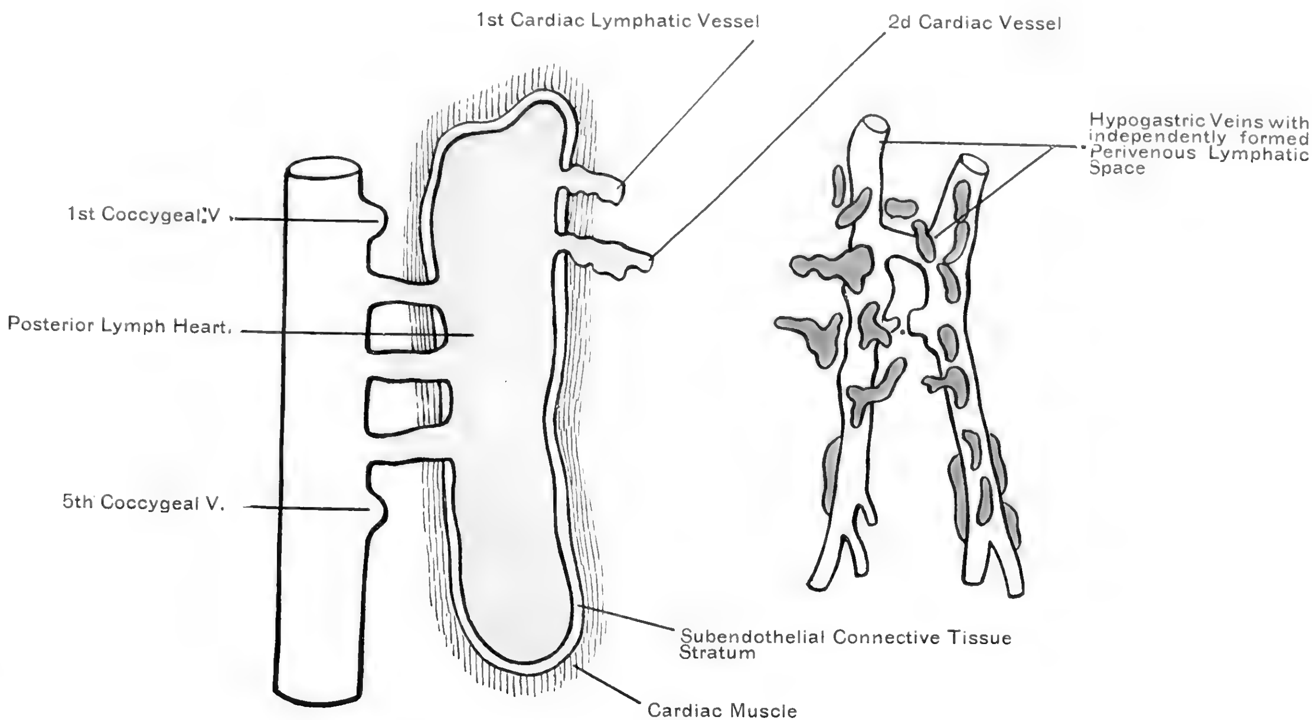

1st Cardiac Lymphatic Vessel
2d Cardiac Vessel
Hypogastric Veins with independently formed Perivenous Lymphatic Space
1st Coccygeal V.
Posterior Lymph Heart.
5th Coccygeal V.
Subendothelial Connective Tissue Stratum
Cardiac Muscle

FIG. 4

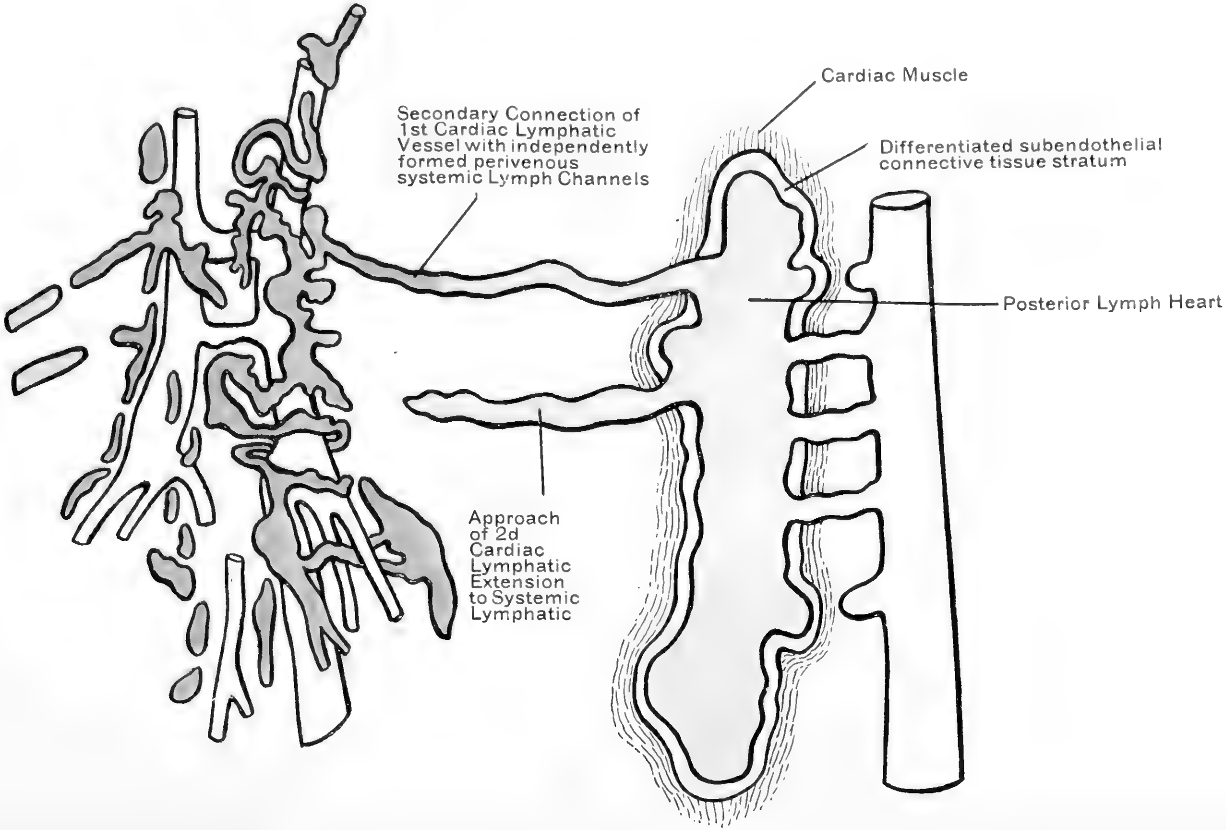

Cardiac Muscle
Secondary Connection of 1st Cardiac Lymphatic Vessel with independently formed perivenous systemic Lymph Channels
Differentiated subendothelial connective tissue stratum
Posterior Lymph Heart
Approach of 2d Cardiac Lymphatic Extension to Systemic Lymphatic

FIG. 5

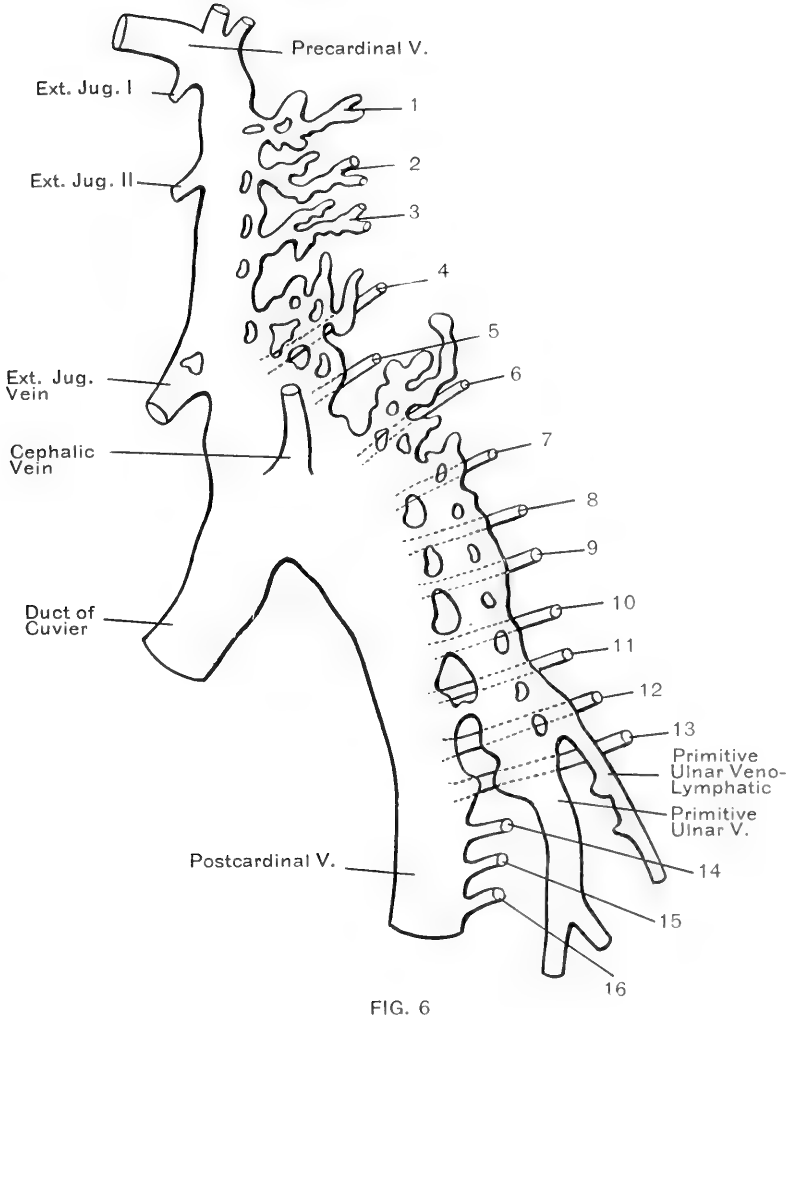

Precardinal V.
Ext. Jug. I
Ext. Jug. II
Ext. Jug. Vein
Cephalic Vein
Duct of Cuvier
Postcardinal V.
Primitive Ulnar Veno-Lymphatic
Primitive Ulnar V.
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16

FIG. 6

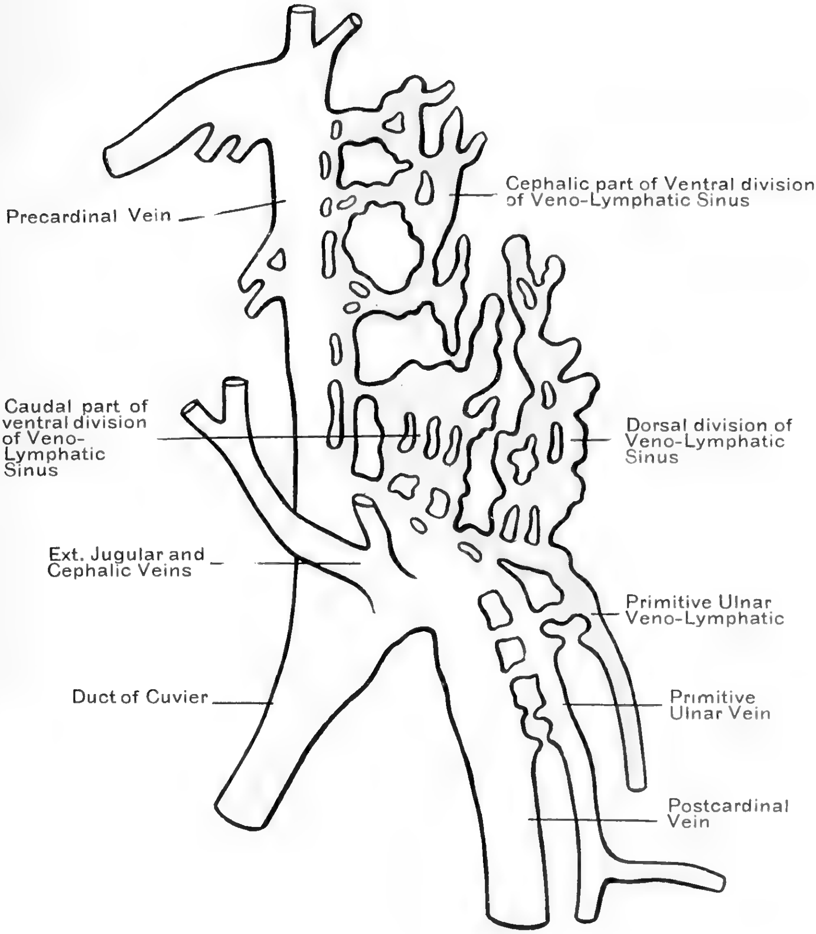
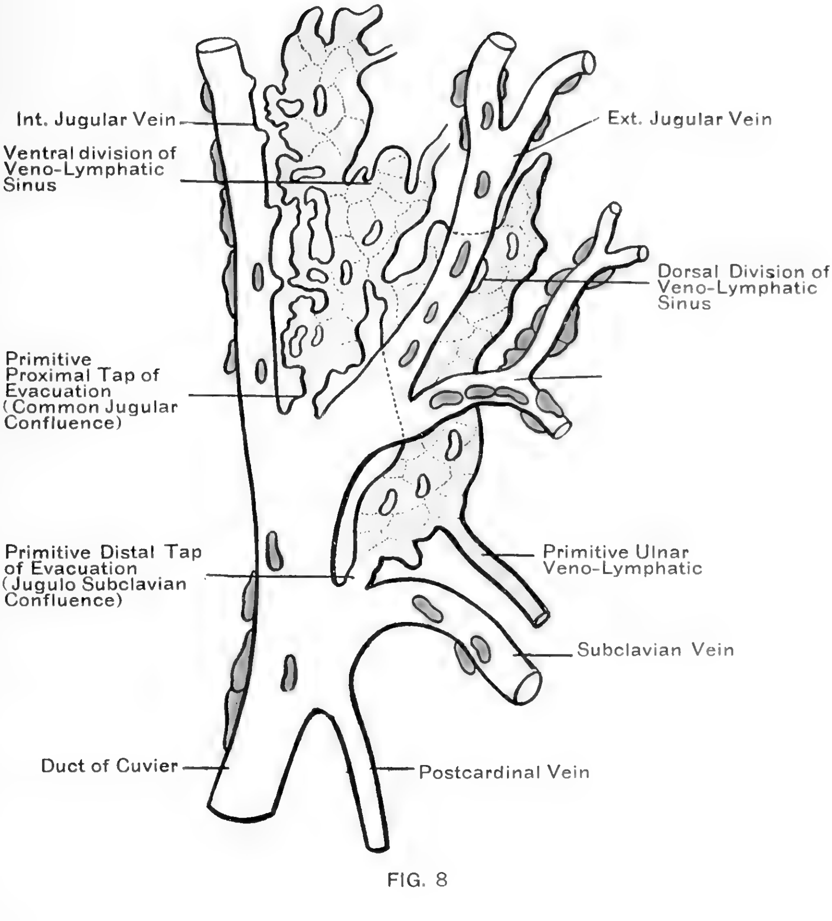

Cephalic part of Ventral division of Veno-Lymphatic Sinus
Precardinal Vein
Caudal part of ventral division of Veno-Lymphatic Sinus
Dorsal division of Veno-Lymphatic Sinus
Ext. Jugular and Cephalic Veins
Primitive Ulnar Veno-Lymphatic
Duct of Cuvier
Primitive Ulnar Vein
Postcardinal Vein

FIG. 7



Int. Jugular Vein
Ventral division of Veno-Lymphatic Sinus
Primitive Proximal Tap of Evacuation (Common Jugular Confluence)
Primitive Distal Tap of Evacuation (Jugulo Subclavian Confluence)
Duct of Cuvier
Ext. Jugular Vein
Dorsal Division of Veno-Lymphatic Sinus
Primitive Ulnar Veno-Lymphatic
Subclavian Vein
Postcardinal Vein

FIG. 8

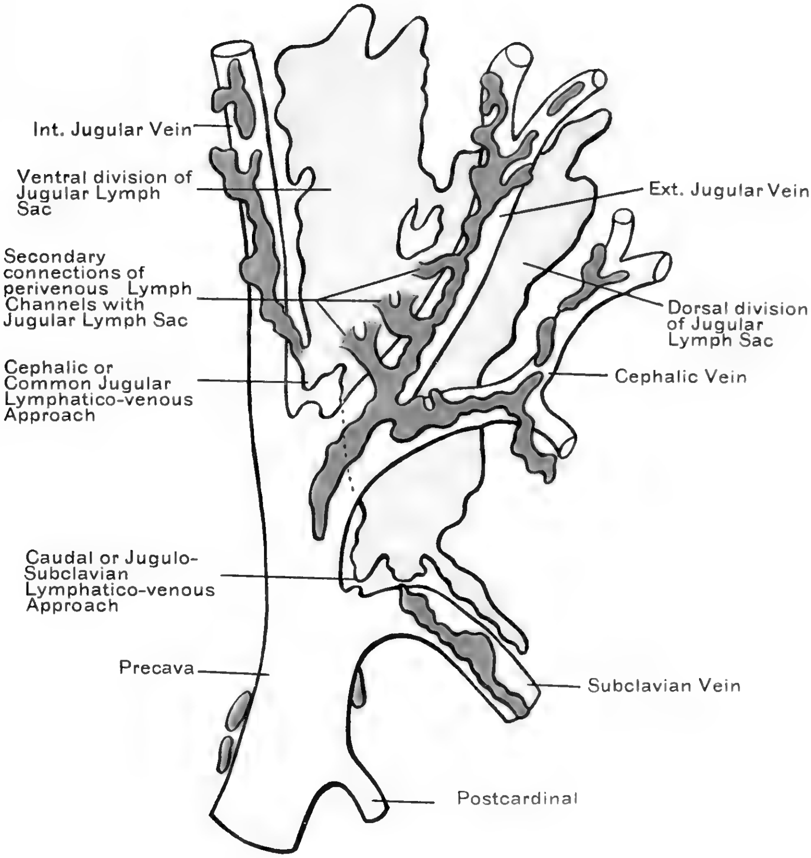

Int. Jugular Vein
Ventral division of Jugular Lymph Sac
Secondary connections of perivenous Lymph Channels with Jugular Lymph Sac
Cephalic or Common Jugular Lymphatico-venous Approach
Caudal or Jugulo-Subclavian Lymphatico-venous Approach
Precava
Ext. Jugular Vein
Dorsal division of Jugular Lymph Sac
Cephalic Vein
Subclavian Vein
Postcardinal

FIG. 9

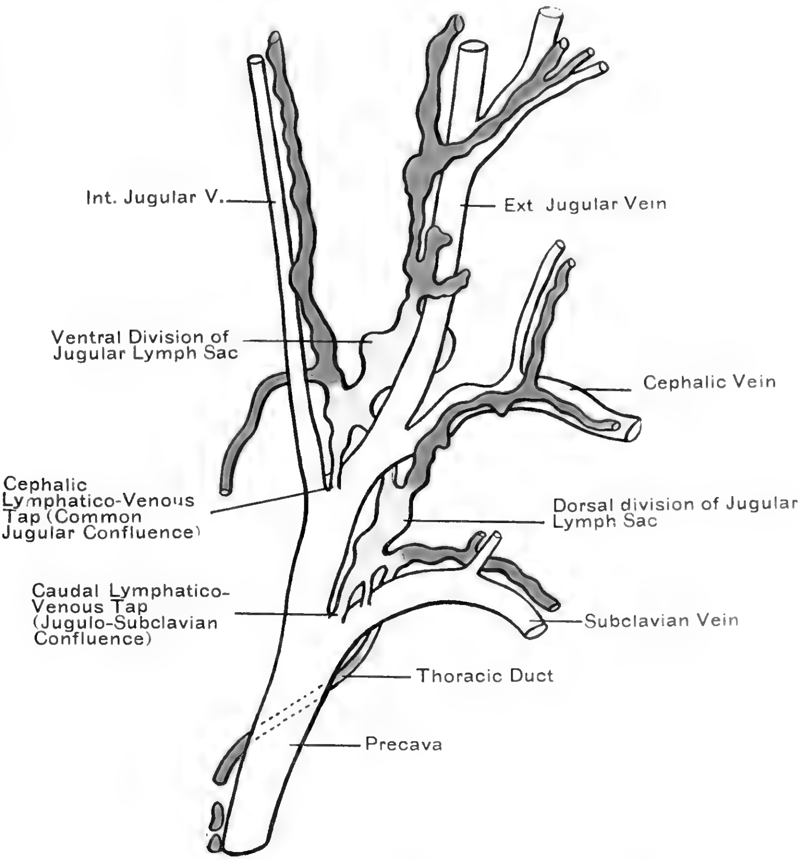

Int. Jugular V.
Ext Jugular Vein
Ventral Division of Jugular Lymph Sac
Cephalic Vein
Cephalic Lymphatico-Venous Tap (Common Jugular Confluence)
Dorsal division of Jugular Lymph Sac
Caudal Lymphatico-Venous Tap (Jugulo-Subclavian Confluence)
Subclavian Vein
Thoracic Duct
Precava

FIG. 10

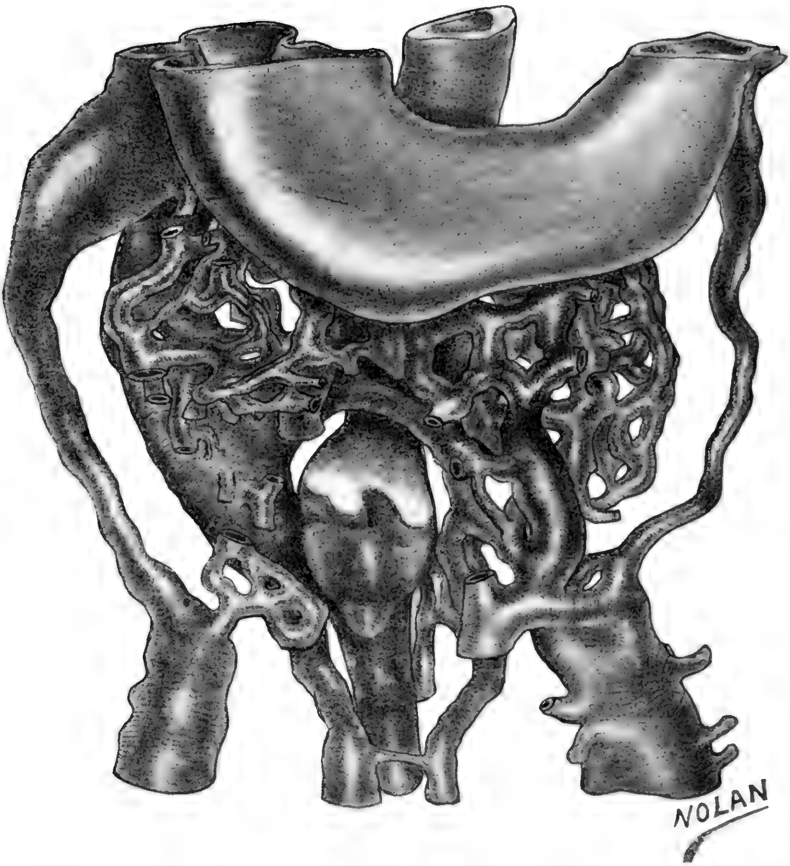


PLATE I.—Model of veins, ventral view, the connection of the liver and gut has been severed just above the gall-bladder anlage. Just above this is seen the ventral half of the cranial venous ring in connection with both omphalo-mesenteric, and the left umbilical veins. × 100.

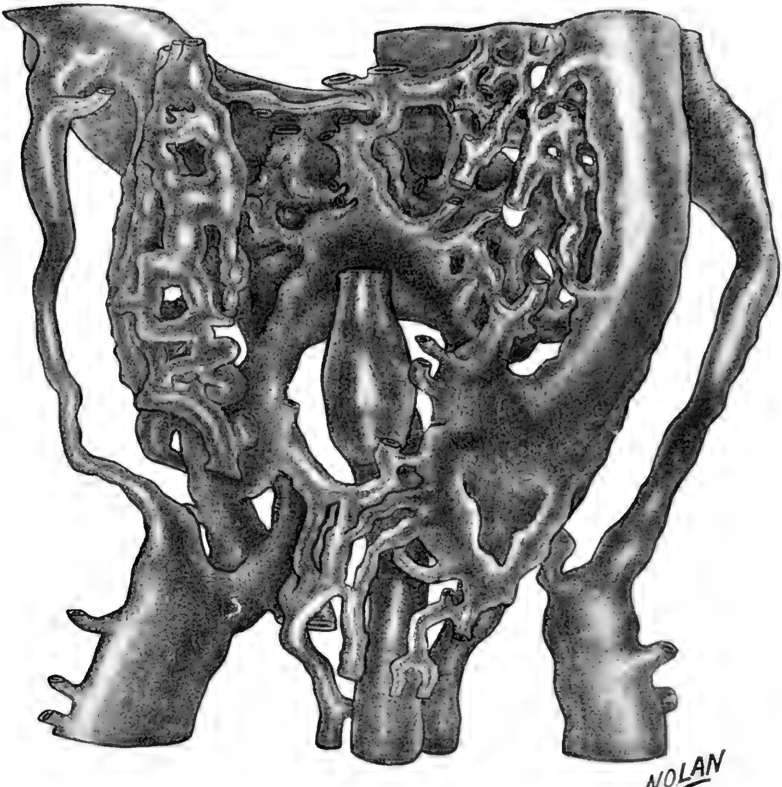


PLATE II.—Dorsal view of same model, the stomach has been removed, thereby exposing the ductus venosus and the veins of Broman. × 100.

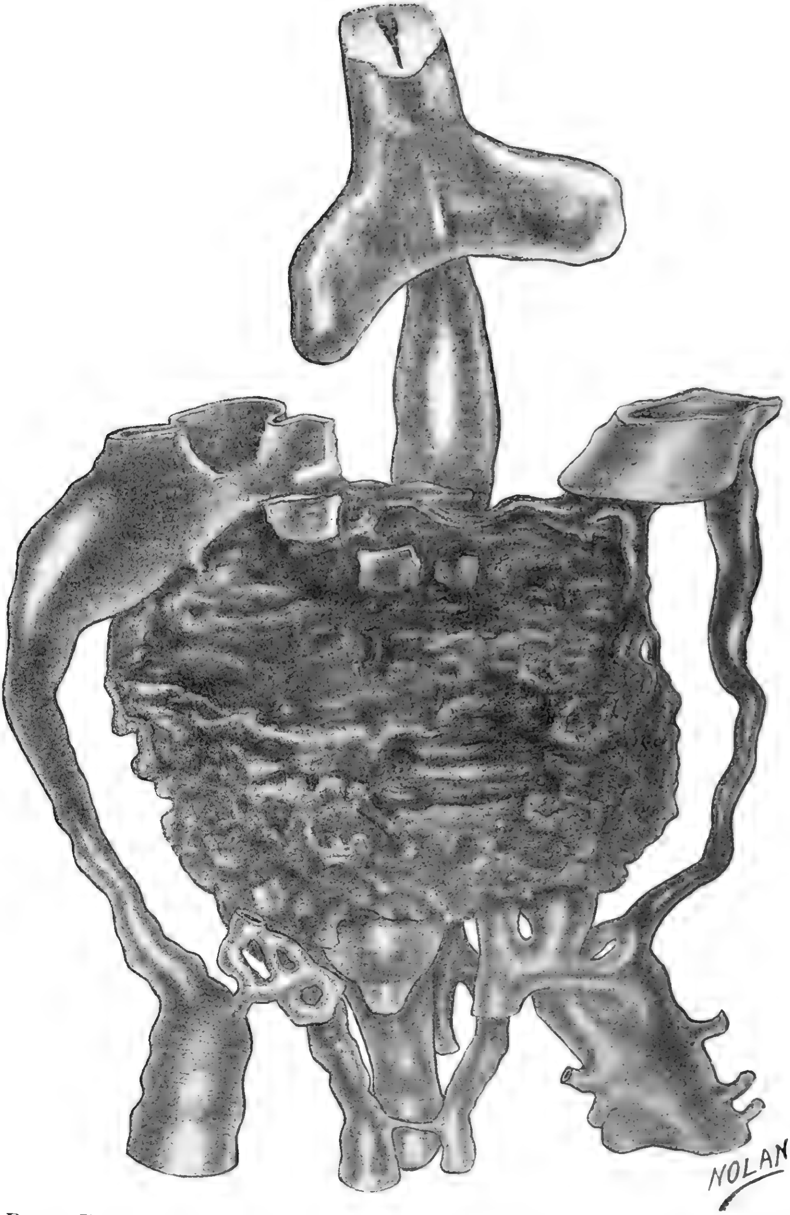


PLATE III.—Liver and veins. Lung anlage above. Immediately below the terminal horizontal portion of the ductus venosus appear three portions of the posterior wall of the sinus venosus where empty veins coming from the liver. Below the liver is seen the gall-bladder anlage and beneath this the ventral pancreas. × 100.

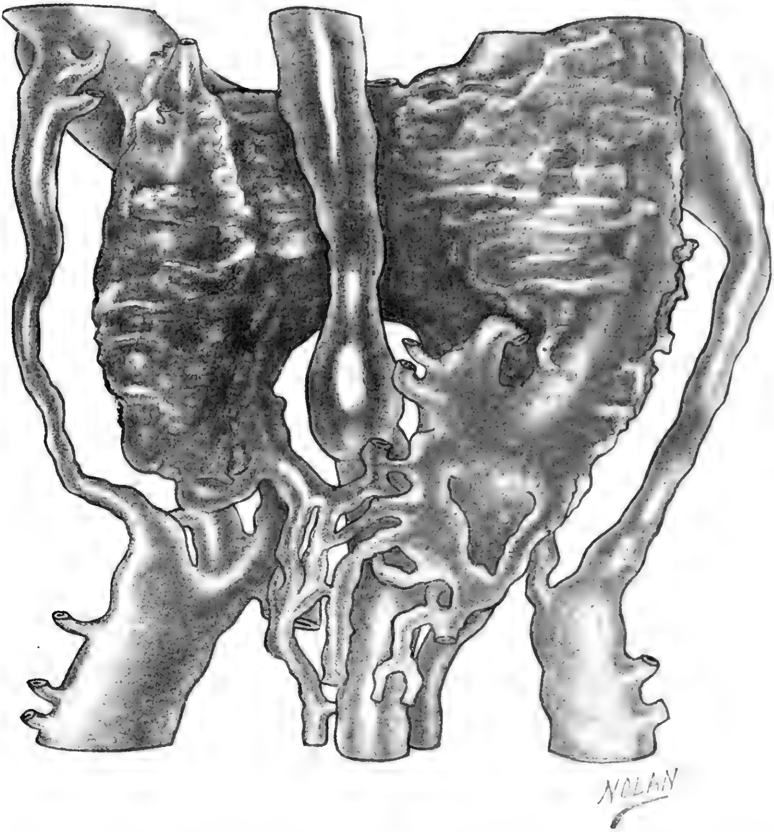


PLATE IV.—Dorsal view of same. To the right of the stomach and partly hidden by it is seen the ductus venosus; the connection of liver and gut has been omitted for the sake of clearness; just above the dorsal plexiform anastomosis is seen the dorsal pancreas. × 100.

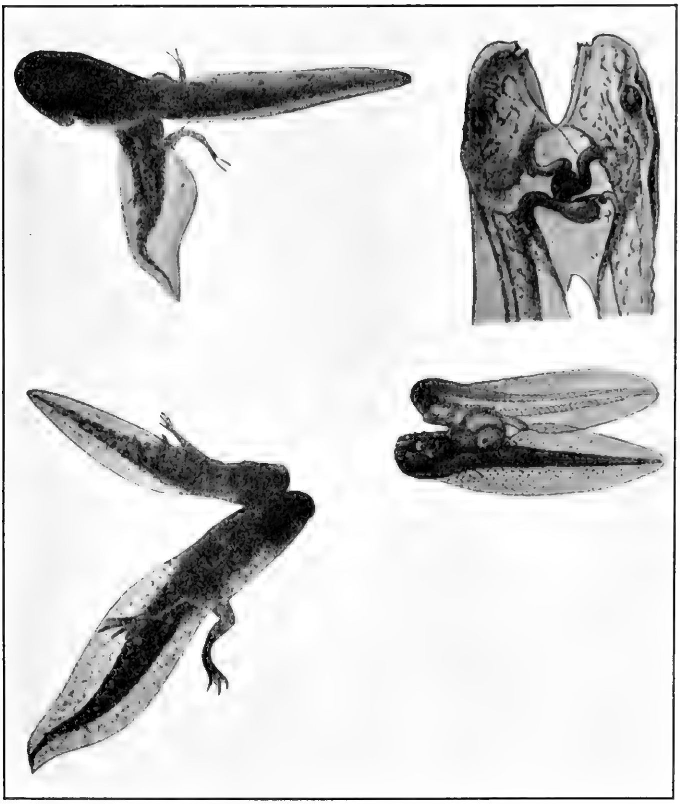


Fig. 1.—Composite tadpoles. (After Born, from Hertwig's Handbuch der Entwickelungsgeschichte.)

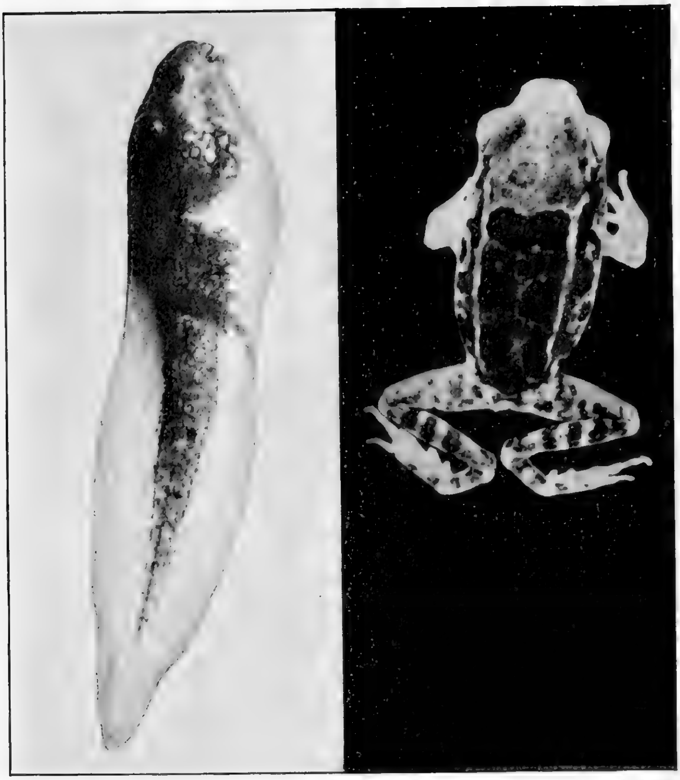


Fig. 2.—Composite individual, as tadpole and as frog; anterior portion, Rana pipiens (virescens); posterior portion, Rana palustris.

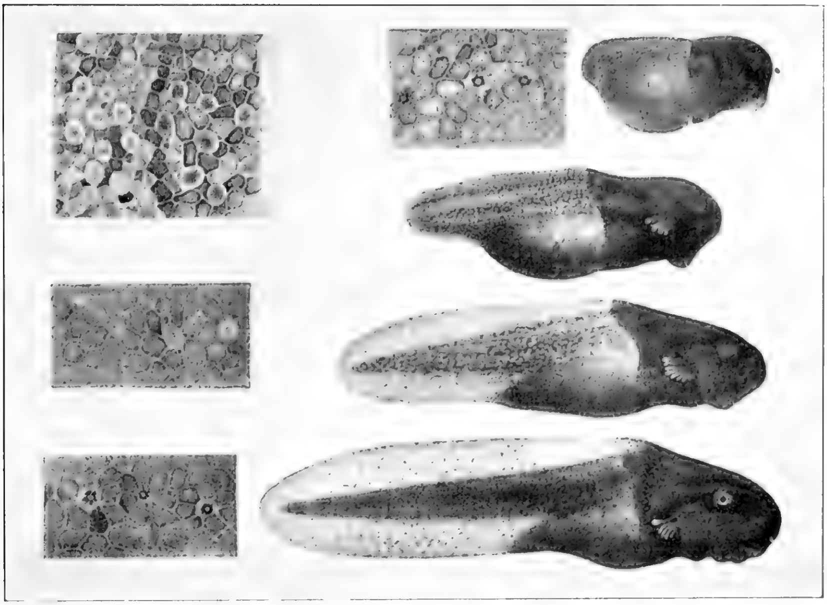


Fig. 3.—Composite embryo; anterior half, Rana sylvatica; posterior half, Rana palustris. The four figures on the right show the same individual at two hours, one day, two days and four days, respectively, after grafting together. The figures on the left show the finer surface markings of the epidermis and the sense organs of the lateral line.

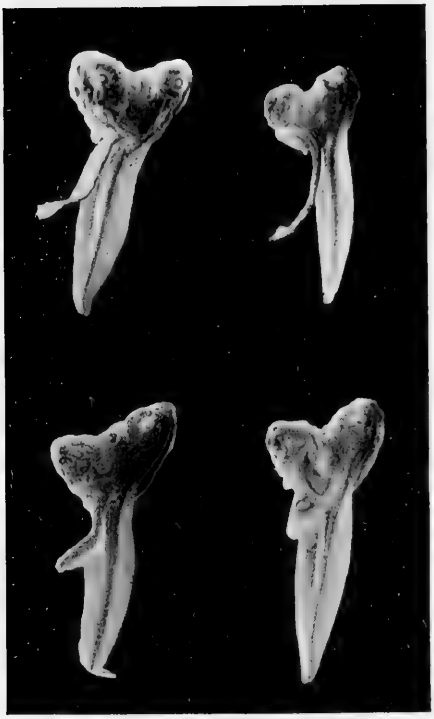


Fig. 4.—Nerveless tadpoles attached to normal individuals which serve as nurses.

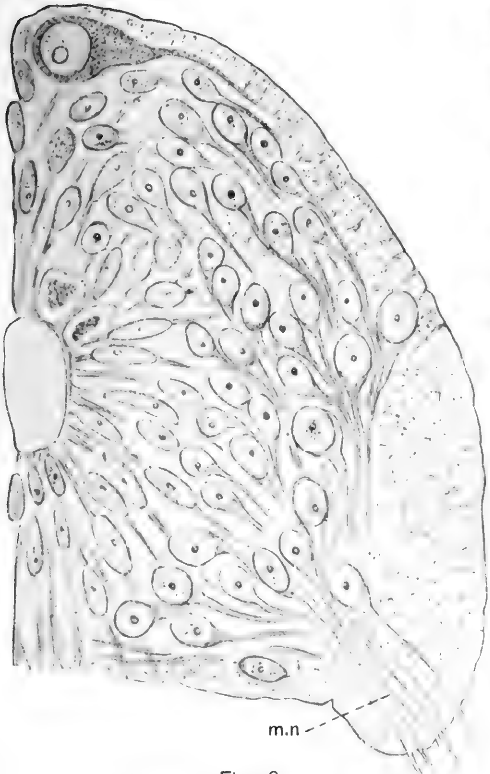


Fig. 6

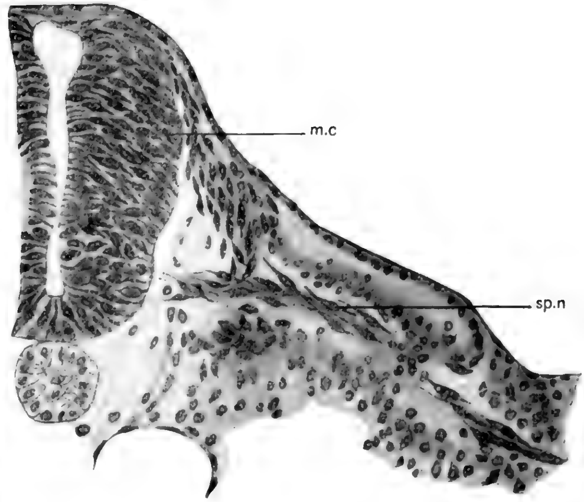


Fig. 5

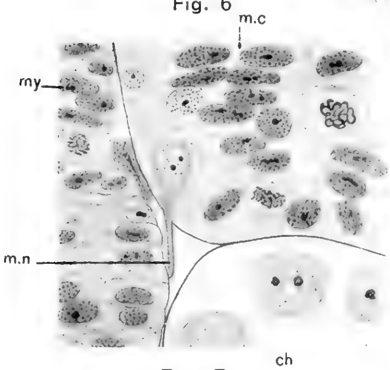


Fig. 7a

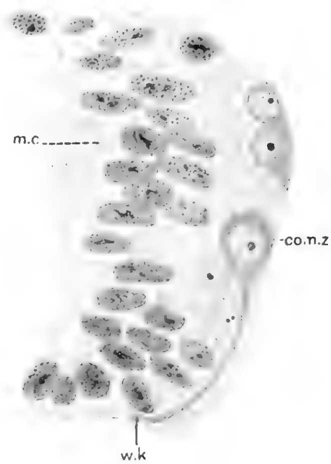


Fig. 7b

FIG. 5.—Cross section through a chick embryo of 73 hours to show the beginning of a spinal nerve (*Sp.n*) ; *m.c.*, medullary cord. (After Bethe.)

FIG. 6.—Cross section through the medullary cord of a salmon embryo to show neuroblasts and motor nerve fibers (*m.n.*). (After His.)

FIG. 7.—Cross sections showing part of medullary cord of a salmon embryo. Fig. 7a shows a motor root (*m.n*) consisting of a single fiber proceeding from a single cell within the cord. Fig. 7b shows several neuroblasts and a commissural fiber growing out from one of them, *com. z.*

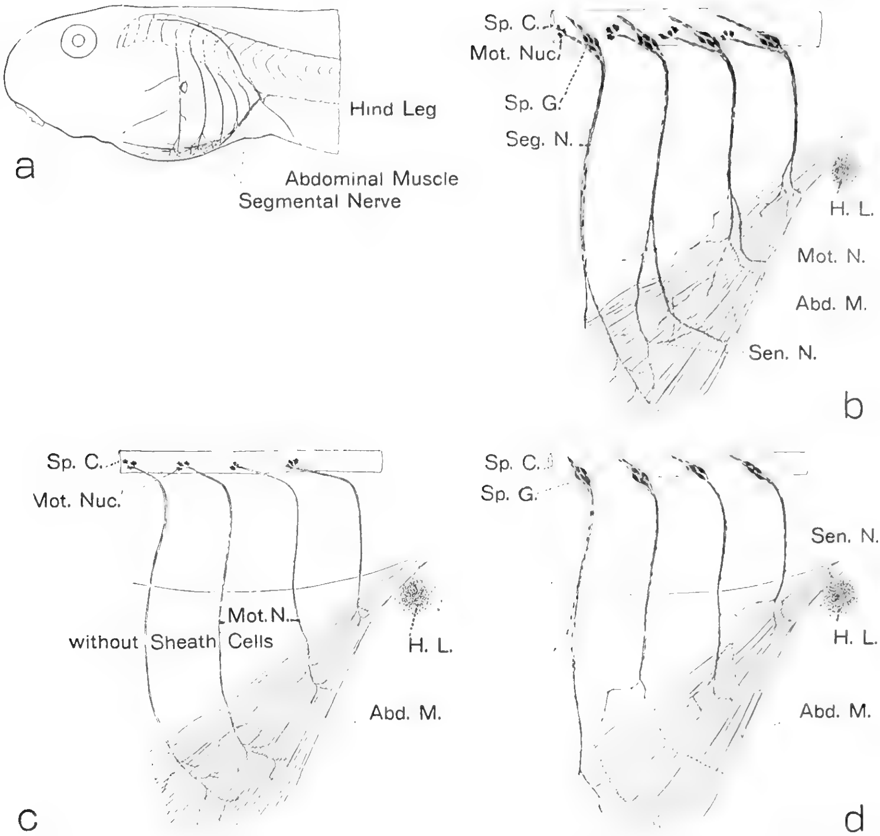


Fig. 11.—Diagrammatic views of the nerves in the abdominal walls of tadpole. a, body of larva showing general arrangement of nerves; b, arrangement in normal larva; c, arrangement in larva from which ganglion crest has been removed, only the motor nerves showing; d, arrangement in larva from which the ventral half of the spinal cord had been removed, showing only sensory nerves. *Abd.M.*, primary abdominal muscles; *H.L.*, hind limb; *Mot.N.*, motor nerve; *Mot.Nuc.*, motor nucleus; *Seg.N.*, segmental nerve; *Sen.N.*, sensory nerve; *Sp.C.*. spinal cord; *Sp.G.*, spinal ganglion.

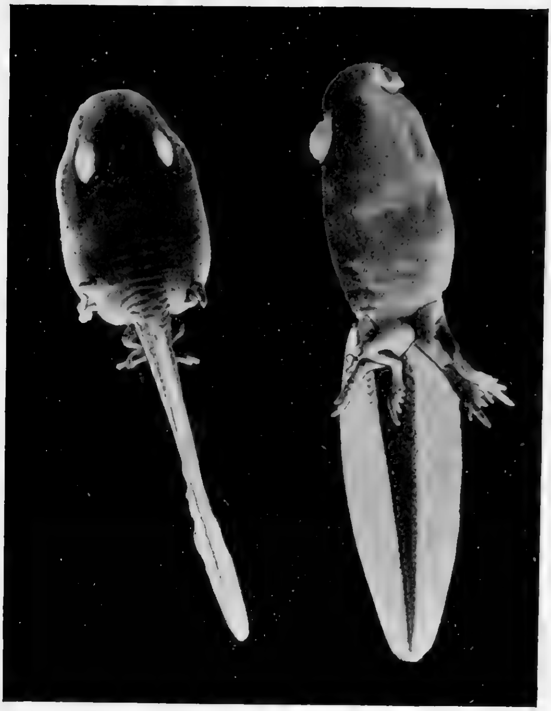


Fig. 13.—Two tadpoles with supernumerary transplanted limbs.

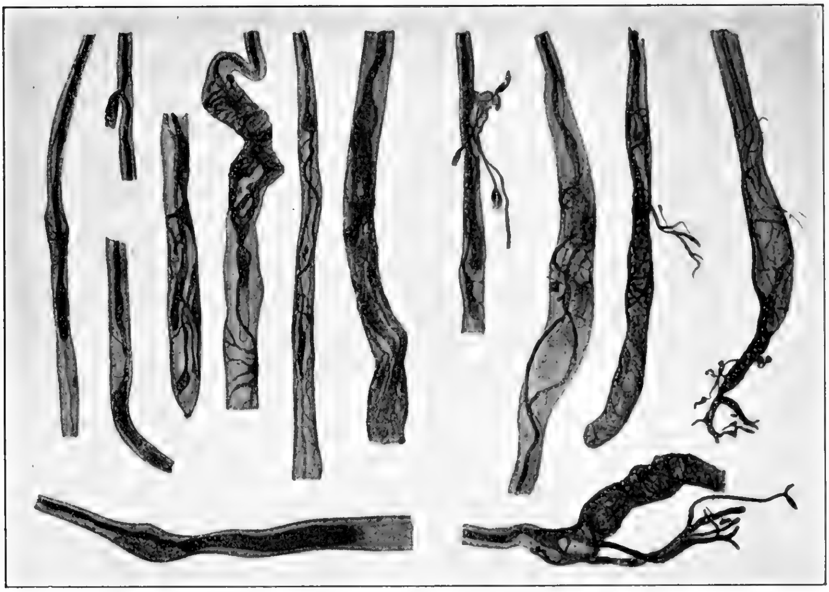


FIG. 16.—Regenerating nerve fibers from the end of the central nerve stump of the sciatic nerve of a dog, taken from six to forty-eight hours after cutting the nerve. (After Perroncito.)

66.

0

BINDING SECT. FEB 15 1971

QL
8 1
A45
v.2
cop.3

The Anatomical Record

Biological
& Medical
Serials

PLEASE DO NOT REMOVE
CARDS OR SLIPS FROM THIS POCKET

UNIVERSITY OF TORONTO LIBRARY

STORAGE