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PROF. CHARLES A. KOFOID AND
MRS. PRUDENCE W. KOFOID
PART II.

THE HISTORY OF THE MAMMALIAN EMBRYO.
INTRODUCTION.

The most important difference between the development of Mammalia and Aves depends upon the amount and distribution of the food-yolk in the ovum. In birds, as we have seen (Ch. 1.), the ovum is large and the greater part of it so heavily charged with food-yolk that it is unable to segment. The segmentation is confined to one small portion, the germinial disc, the protoplasm of which is less burdened with food-yolk than that of the remainder of the ovum. Such partial segmentation is known as meroblastic.

In Mammals, on the other hand, the ovum is small and contains but a slight amount of food-yolk; the little there is being distributed uniformly throughout. In consequence of this the whole ovum is able to segment, the segmentation therefore belongs to the holoblastic type. This fundamental difference in the constitution of the ovum of Birds and Mammals is accompanied not only by differences in the segmentation but also by important differences, as we shall see, in the stages of development which immediately follow segmentation. Finally, in

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1 The human ovum ovum is about 0.02 inch in diameter.
INTRODUCTION.

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¹ The human ovarian ovum is \( \frac{1}{15} \) to \( \frac{1}{8} \) of an inch in diameter.
birds, as we have seen, the nutrition of the developing embryo is entirely effected at the expense of the food-yolk and albumen with which the ovum was charged in the ovary and oviduct respectively, and the eggs leave the parent very soon after the close of segmentation. In the Mammalia the absence of sufficient food-yolk necessitates the existence of some other source of nutriment for the embryo, and that source is mainly the maternal blood.

The development of Mammalia may be divided into two periods: 1. the development within the uterus; 2. the development after birth.

In all the higher Mammalia the second period is very unimportant, as compared with the first; for the young are born in a condition closely resembling that of the adult of the species to which they belong. The development during the first period takes place in the uterus of the mother, and nutriment passes from the maternal blood to that of the embryo by means of a structure, to be described in detail hereafter, known as the placenta. This difference between the development of Birds and Mammals may be briefly expressed by saying that the former are oviparous, while the latter are viviparous.

The source of nutriment during the second period is the Mammary glands. In certain of the lower Mammalia (Marsupials) the young are born in a very immature condition, and become attached by their mouths to the nipples of these glands. They are carried about, usually in a special pouch (marsupium) by the mother, and undergo in this position the greater part of the remainder of their development.
CHAPTER X.

GENERAL DEVELOPMENT OF THE EMBRYO.

There is a close agreement in the history of the development of the embryo of the various kinds of Mammals. We may therefore take one, the Rabbit, as a type. There are without doubt considerable variations to be met with in the early development even of species nearly allied to the Rabbit, but at present the true value of these variations is not understood, and they need not concern us here.

The ovarian ovum. Mammals possess two ovaries situated in the body cavity, one on either side of the vertebral column immediately posterior to the kidneys. They are somewhat flattened irregularly oval bodies, a portion of the surface being generally raised into protuberances due to projecting follicles.

In an early stage of development the follicles in the mammalian ovary is similar to that of the fowl and is formed of flat cells derived from the germinal cells adjoining the ovum. As development proceeds however it becomes remarkably modified. These flat cells surrounding the ovum become columnar and then one or two layers deep. Later they become thicker on one side of the ovum than on the other, and there appears
birth, as we have seen, the continuous development of the developing embryo is actively assisted by the entrance of the food-soft and albumen, while the ovum was changed in the ovary and utricle respectively, and the egg leaves the parent very soon after the close of segmentation. In the Mammalia the action of the latter analysis necessitates the existence of some other source of nourishment for the embryo, and that source is mainly the maternal blood.

The development of Mammalia may be divided into two periods: 1. the development within the uterus; and 2. the development after birth.

In all the higher Mammalia the second period is very unimportant as compared with the first, for the young are born in a condition closely resembling that of the adult of the species to which they belong. The development during the first period takes place in the uterus of the mother and nourishment passes from the maternal vessels into those of the embryo by means of a structure known as the placenta, or placental organ, known as the placenta. Each difference in the development of Marsupials and placentals is usually referred to as showing that the former are more primitive while the latter are more perfect.

The methods of rearing differ in the second period in the Mammalia. Chemical assistance of the latter Mammalia (Marsupiata), in general are born in a very immature condition, and usually sustained by their mouths to the nipples of their mother. They are carried about usually in a special pouch (marsupium) by the mother, and wean themselves during the greater part of the remainder of the period of pregnancy.
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In an early stage of development the follicle in the mammalian ovary is similar to that of the fowl, and is formed of flat cells derived from the germinal cells adjoining the ovum. As development proceeds however it becomes remarkably modified. These flat cells surrounding the ovum become columnar and then one or two layers deep. Later they become thicker on one side of the ovum than on the other, and there appears
in the thickened mass a cavity which gradually becomes more and more distended and filled with an albuminous fluid.

As the cavity enlarges, the ovum, around which are several layers of cells, forms a prominence projecting into it. The follicle cells are known as the membrana granulosa, and the projection in which the ovum lies as the discus or cumulus proligerus. The whole structure with its tunic is known as the Graafian follicle.

If the ovary of a mature female during the breeding season be examined, certain of the protuberances on its surface may be seen to be considerably larger than others; they are more transparent than their fellows and their outer covering appears more tense; these are Graafian follicles containing nearly or quite ripe ova. Upon piercing one of these follicles with a needle-point the ovum contained therein spirits forth together with a not inconsiderable amount of clear fluid.

Egg Membranes. The ovum is surrounded by a radiately striated membrane, the zona radiata, internal to which in the nearly ripe egg a delicate membrane has been shown, by Ed. v. Beneden, to exist. The cells of the discus are supported upon an irregular granular membrane external to the zona radiata. This membrane is more or less distinctly separated from the zona, and the mode of its development renders it probable that it is the remnant of the first formed membrane in the young ovum and is therefore the vitelline membrane.

Maturation and impregnation of the ovum. As the ovum placed in the Graafian follicle approaches maturity the germinal vesicle assumes an excentric
position and undergoes a series of changes which have not been fully worked out, but which probably are of the same nature as those which have been observed in other types (p. 17). The result of the changes is the formation of one or more polar bodies and the nucleus of the mature ovum (female pronucleus).

As certain periods one or more follicles containing a free ovum bud, and their remnants are received by the simplified cavity of the Fallopian tube which appears according to Hensen to clasp the ovary at the time. The follicles after the exit of the ovum becomes filled with blood and remains as a conspicuous object on the surface of the ovary for some days. It becomes eventually a corpus luteum. The ovum travels slowly down the Fallopian tube. It is still invested by the zona radiata, and in the rabbit an albuminous envelope is formed around it. In its passage downwards, impregnation takes place in the upper part of the Fallopian tube, and is speedily followed by the segmentation, which is remarkable amongst the Amniota for being complete.  

The entrance of the spermatogonia into the ovum and its subsequent fate have not been observed. Van Beneden describes in the rabbit the formation of the first segmentation nucleus (i.e., the nucleus of the ovum after fertilisation) from two nuclei, one peripheral and the other central, and deduces from his observations that it is to be inferred that there is no relation between the bursting of the follicle and the act of ovulation.

It is stated by Bijschot that shortly after impregnation and before the commencement of the segmentation, the sex of the rabbit and guinea pig are covered with silk and awaits the performance of rotation. This has not been noticed by other observers.
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As the cavity enlarges, the ovum, around which are several layers of cells forms a prominence projecting into it. The follicle cells are known as the membrana granulosa, and the projection in which the ovum lies as the discus or annulus protrudens. The whole structure with its hood is known as the Graafian follicle.

If the ovary of a mature female during the breeding season be examined, certain of the protrusions on its surface may be seen to be enlarged only larger than others; they are more transparent than their fellows and their outer covering appears more tense, these are Graafian follicles containing nearly or quite ripe eggs. Upon piercing one of these follicles with a needle point the ovum contained therein spits forth together with a not inconsiderable amount of clear fluid.

**Egg Membranes.** The ovum is surrounded by a radiately oriented membrane, the zona radiata, internal to which in the near vicinity of a delicate membrane has been shown, by Felix Henle, to exist. The cells of the discus are supported upon an irregular granular membrane external to the zona radiata. This membrane is more or less distinctly separated from the zona, and the mode of its development renders it probable that it is the remnant of the first formed membrane in the young ovum and is therefore the vitelline membrane.

**Fertilization and Impregnation of the Ovum.** At the time placed in the Graafian follicle, the ovum assumes an extension...
position and undergoes a series of changes which have not been fully worked out, but which probably are of the same nature as those which have been observed in other types (p. 17). The result of the changes is the formation of one or more polar bodies, and the nucleus of the mature ovum (female pronucleus).

At certain periods one or more follicles containing a ripe ovum burst, and their contents are received by the fimbriated extremity of the Fallopian tube which appears according to Hensen to clasp the ovary at the time. The follicle after the exit of the ovum becomes filled with blood and remains as a conspicuous object on the surface of the ovary for some days. It becomes eventually a corpus luteum. The ovum travels slowly down the Fallopian tube. It is still invested by the zona radiata, and in the rabbit an albuminous envelope is formed around it in its passage downwards. Impregnation takes place in the upper part of the Fallopian tube, and is shortly followed by the segmentation, which is remarkable amongst the Amniota for being complete.

The entrance of the spermatozoon into the ovum and its subsequent fate have not been observed. Van Beneden describes in the rabbit the formation of the first segmentation nucleus (i.e. the nucleus of the ovum after fertilization) from two nuclei, one peripheral and the other ventral, and deduces from his observations.

1 So far as is known there is no relation between the bursting of the follicle and the act of coition.

2 It is stated by Bischoff that shortly after impregnation, and before the commencement of the segmentation, the ova of the rabbit and guinea-pig are covered with cilia and exhibit the phenomenon of rotation. This has not been noticed by other observers.
that the peripheral nucleus was derived from the spermatic element.

**Segmentation.** The process of segmentation occupies in the rabbit about 72 hours; but the time of this and all other stages of development varies considerably in different animals.

The details of segmentation in the rabbit are differently described by various observers; but at the close of segmentation the ovum appears undoubtedly to be composed of an outer layer of cubical hyaline cells, almost entirely surrounding an inner mass of highly granular rounded or polygonal cells.

![Optical Sections of a Rabbit's Ovum at Two Stages Closely Following Upon the Segmentation.](image)

*OPTICAL SECTIONS OF A RABBIT'S OVUM AT TWO STAGES CLOSELY FOLLOWING UPON THE SEGMENTATION.*

*(After E. van Beneden.)*

*ep.* outer layer; *hy.* inner mass; *bp.* Van Beneden's blastopore.

The shading of the outer and inner layers is diagrammatic.

In a small circular area however the inner mass of cells remains exposed at the surface (Fig. 95, A). This
exposed spot may for convenience be called with v. Beneden the blastopore, though, as will be seen by the account given of the subsequent development, it in no way corresponds with the blastopore of other vertebrates.

In the following account of the segmentation of the rabbit's ovum v. Beneden's description is followed as far as the details are concerned, his nomenclature is however not adhered to.

According to v. Beneden the ovum first divides into two nearly equal spheres, of which one is slightly larger and more transparent than the other. The larger sphere and its products will be spoken of as the outer sphere, and the smaller one and its products as the inner spheres, in accordance with their different destinations.

Both the spheres are next divided into two, and each of the four so formed into two again, and thus a stage with eight spheres ensues. At the moment of their first separation these spheres are spherical, and arranged in two layers, one of them formed of the four outer, and the other of the four inner spheres. This position is not long maintained, for one of the inner spheres passes to the centre, and the whole ovum again takes a spherical form.

In the next stages of segmentation each of the four outer spheres divides into two, and the ovum thus becomes constituted of twelve spheres, eight outer and four inner. The outer spheres have now become considerably smaller than the inner.

The four inner spheres next divide giving rise, together with the eight outer spheres, to sixteen spheres in all, which are nearly uniform in size. Of the eight inner spheres four accrete to the centre, while the eight now superficial outer spheres form a kind of cup partially enclosing the inner spheres. The outer sphere now divide in their turn, giving rise to sixteen.

1 The cells successively as the outer layer correspond to Van Beneden's epithelium, whilst those cells spoken of as the inner correspond to his primitive hypoblast.
that the peripheral nucleus was derived from the spermatic element.

Segmentation. The process of segmentation occupies in the rabbit about 78 hours; but the time of this and all other stages of development varies considerably in different animals.

The details of segmentation in the rabbit are differently described by various observers; but at the close of segmentation the ovum appears undoubtedly to be composed of an outer layer of cubical hyaline cells, almost entirely surrounding an inner mass of highly granular rounded or polygonal cells.

Fig. 95.

OPTICAL SECTIONS OF A RABBIT'S EGG AT TWO STAGES CLOSERLY FOLLOWING FROM THE SEGMENTATION.

(After E. van Beneden.)

1. outer layer; 2. inner mass; 3. Van Beneden's blastopore.

The shading of the outer and inner layers is diagrammatic.

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In the following account of the segmentation of the rabbit's ovum, v. Beneden's description is followed as far as the details are concerned, his nomenclature is however not adhered to.

According to v. Beneden the ovum first divides into two nearly equal spheres, of which one is slightly larger and more transparent than the other. The larger sphere and its products will be spoken of as the outer spheres, and the smaller one and its products as the inner spheres, in accordance with their different destinations.

Both the spheres are soon divided into two, and each of the four so formed into two again; and thus a stage with eight spheres ensues. At the moment of their first separation these spheres are spherical, and arranged in two layers, one of them formed of the four outer, and the other of the four inner spheres. This position is not long retained, for one of the inner spheres passes to the centre; and the whole ovum again takes a spherical form.

In the next phase of segmentation each of the four outer spheres divides into two, and the ovum thus becomes constituted of twelve spheres, eight outer and four inner. The outer spheres have now become markedly smaller than the inner.

The four inner spheres next divide giving rise, together with the eight outer spheres, to sixteen spheres in all; which are nearly uniform in size. Of the eight inner spheres four soon pass to the centre, while the eight now superficial outer spheres form a kind of cup partially enclosing the inner spheres. The outer spheres now divide in their turn, giving rise to sixteen

1 The cells spoken of as the outer layer correspond to Van Beneden's epiblast, whilst those cells spoken of as the inner correspond to his primitive hypoblast.
spheres which largely enclose the inner spheres. The segmentation of both outer and inner spheres continues, and in the course of it the outer spheres spread further and further over the inner, so that at the close of segmentation the inner spheres constitute a central solid mass almost entirely surrounded by the outer spheres. In a small circular area however the inner mass of spheres remain for some time exposed at the surface (Fig. 95 A).

**The blastodermic vesicle.** After its segmentation the ovum passes into the uterus. The outer cells soon grow over the blastopore and thus form a complete superficial layer. A series of changes next take place which result in the formation of what has been called the *blastodermic vesicle.*

These changes commence with the appearance of a narrow cavity between the outer and inner layers, which extends so as completely to separate them except in the region adjoining the original site of the blastopore (Fig. 95 B). The cavity so formed rapidly enlarges, and with it the ovum also; so that this soon takes the form of a thin walled vesicle with a large central cavity. This vesicle is the blastodermic vesicle. The greater part of its walls are formed of a single row of flattened outer layer cells; while the inner mass of cells forms a small lens-shaped mass attached to the inner side of the outer layer (Fig. 96).

Although by this stage, which occurs in the rabbit between seventy and ninety hours after impregnation, the blastodermic vesicle has by no means attained its greatest dimensions, it has nevertheless grown from

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1 Van Beneden regards it as probable that the blastopore is situated somewhat excentrically in relation to the area of attachment of the inner mass to the outer layer.
about 0.09 mm.—the size of the ovum at the close segmentation—to about 9.28 in diameter. It is enclosed by the zona radiata and the albuminous layer.

RABBIT'S OVUM BETWEEN 26—28 HOURS AFTER FERTILIZATION

(After R. van Beneden.)

bc cavity of blastodermic vesicle (yolk-sac); sp outer layer; bs inner mass; ab albuminous envelope.

around it. The blastodermic vesicle continues to enlarge rapidly, and during the process the inner mass undergoes important changes. It spreads out on the inner side of the outer layer and at the same time loses its lens-like form and becomes flattened. The central
spheres which largely enclose the inner spheres. The segmentation of both outer and inner spheres continues, and in the course of it the outer spheres spread farther and farther over the inner, so that at the close of segmentation the inner spheres constitute a central solid mass almost entirely surrounded by the outer spheres. In a small circular area however the inner mass of spheres remains for some time exposed at the surface (Fig. 25 A).

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about 0.09 mm.—the size of the ovum at the close segmentation—to about 0.28 in diameter. It is enclosed by the zona radiata and the albuminous layer around it. The blastodermic vesicle continues to enlarge rapidly, and during the process the inner mass undergoes important changes. It spreads out on the inner side of the outer layer and at the same time loses its lens-like form and becomes flattened. The central
part of it remains however thicker, and is constituted of two rows of cells, while the peripheral part, the outer boundary of which is irregular, is formed of an imperfect layer of amœboid cells which continually spread further and further beneath the outer layer. The central thickening of the inner layer forms an opaque circular spot on the blastoderm, which constitutes the commencement of the embryonic area.

The formation of the layers. The history of the stages immediately following, from about the commencement of the fifth day to the seventh day, when a primitive streak makes its appearance, is not perfectly understood, and has been interpreted very differently by various observers. The following account must therefore be considered as a tentative one.

About five days after impregnation the cells of the inner mass in the embryonic area become divided into two distinct strata, an upper stratum of rounded cells adjoining the flattened outer layer and a lower stratum of flattened cells. This lower stratum is the true hypoblast (Fig. 97). At the edge of the embryonic area the hypoblast is continuous with a peripheral ring of the amœboid cells of the earlier stage, which now form, except at the edge of the ring, a continuous layer of flattened cells in contact with the outer layer. During the sixth day the middle layer becomes fused with the outer layer, and gives rise to a layer of cells which are columnar and are arranged in the rabbit in a single row (Fig. 98). They form together the true epiblast of the embryonic area.

At this stage therefore the embryonic area, which is circular, is formed throughout of two single layers of
cells, a columnar epithelium and a layer of flattened hypoblast.

**Fig. 91.**

**Section through the nearly circular embryonic area of a rabbit of six days.**

(from Allen Thomson, after E. van Beneden.)

act. upper layer; mes. middle layer; act. true hypoblast.

**Fig. 92.**

**Section through the blastoderm of a rabbit on the seventh day, taken in front of the primitive streak.**

Half of the area is represented.

Towards the end of the sixth day the embryonic area of the rabbit, which has hitherto been round, becomes oval.

A diagrammatic view of the whole blastodermal region at about the beginning of the seventh day is given in Fig. 92. The embryonic area is represented in white. The line 2b in B shows the extension of the hypoblastic round the inside of the vesicle. The blast-
part of it remaining however thin, and is constituted of two rows of cells, while the pregnant part, the outer boundary of which is irregular in form, is an imperfect layer of ameboid cells which continually spread further and further beneath the outer layer. The central thickening of the inner layer forms an opaque circular spot on the blastoderm, which constitutes the commencement of the embryo area.

The formation of the layers. The history of the stages immediately following, from about the commencement of the fifth day to the seventh day, when a primitive heart makes its appearance, is not perfectly understood, and has been interpreted very differently by various observers. The following account must therefore be considered as a tentative one.

About two days after propagation the cells of the inner mass in the embryonic area become divided into two distinct strata: an upper stratum of rounded cells adjoining the flattened outer layer and a lower stratum of flattened cells. The lower stratum is the true hypoblast (Fig. 97). At the edge of the embryonic area the hypoblast is continuous with a peripheral ring of the ameboid cells of the earlier stage, which now form, except at the edge of the ring, a continuous layer of flattened cells in contact with the outer layer. During the sixth day the needle layer becomes fused with the outer layer, and gives rise to a layer of cells which are columnar and are arranged in the rabbit in a single row (Fig. 98). They form together the true epiblast of the embryonic area.

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cells, a columnar epiblast and a layer of flattened hypoblast.

Fig. 97.

SECTION THROUGH THE NEARLY CIRCULAR EMBRYONIC AREA OF A RABBIT OVUM OF SIX DAYS.
(From Allen Thomson, after E. van Beneden.)

*oct.* upper layer; *mes.* middle layer; *ent.* true hypoblast.

Fig. 98.

SECTION THROUGH THE BLASTODERM OF A RABBIT ON THE SEVENTH DAY: TAKEN IN FRONT OF THE PRIMITIVE STREAK.

Half of the area is represented.

Towards the end of the sixth day the embryonic area of the rabbit, which has hitherto been round, becomes oval.

A diagrammatic view of the whole blastodermic vesicle at about the beginning of the seventh day is given in Fig. 99. The embryonic area is represented in white. The line *ge* in B shows the extension of the hypoblast round the inside of the vesicle. The blas-
Views of the Blastodermic Vesicle of a Rabbit on the Seventh Day without the Zona. A. from above, B. from the side. (From Kölliker.)

*ag.* embryonic area; *ge.* boundary of the hypoblast.
fibrinous vesicle is therefore formed of three areas, (1) the embryonic area with two layers, a columnar epiblast and flat hypoblast; (2) the region around the embryonic area where the walls of the vesicle are formed of flattened epiblast and flat hypoblast; (3) the area beyond this again where the vesicle is formed of flattened epiblast only.

The changes which next take place begin with the formation of a primitive streak, homologous with, and in most respects similar to, the primitive streak in Birds.

**Fig. 108.**

Embryonic Area of an Eight Days' Rabbit

(After Kölliker.)

The formation of the streak is preceded by that of a dark spot near the middle of the blastoderm, forming the nodal point of Hensen. This spot subsequently constitutes the front end of the primitive streak.

Early on the seventh day the embryonic area becomes pyriform and at its posterior and narrower end

The epiblast of the blastodermal vesicle beyond the embryonic area is formed of the outer layer only.
Views of theplanets or Vortex of a nucleus in the
Lamella but within the Zona. A. from above, B.
From the side. (From Rinkove.)

Note: the outer circle is the boundary of the hypothen.
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Early on the seventh day the embryonic area becomes pyriform, and at its posterior and narrower end

1 The epiblast of the blastodermic vesicle beyond the embryonic area is formed of the outer layer only.
the primitive streak makes its appearance; it is due to a proliferation of rounded cells from the epiblast.

**Fig. 101.**

Section through an oval blastoderm of a rabbit on the seventh day. The length of the area was about 1.2 mm. and its breadth about 0.86 mm.

Through the front part of the primitive streak; ep. epiblast; m. mesoblast; hy. hypoblast; pr. primitive streak.

These cells give rise to a part of the mesoblastic layer of the embryo, and may be termed from their origin the primitive streak mesoblast.

During the seventh day the primitive streak becomes a more pronounced structure (Fig. 101), the mesoblast in its neighbourhood increases in quantity, while an axial groove (Fig. 100)—the primitive groove—is formed on its upper surface.

**The formation of the medullary groove.** In the part of the embryonic area in front of the primitive streak there arise during the eighth day two folds bounding a shallow median groove, which meet in front, but diverge behind, and enclose between them the foremost end of the primitive streak (Fig. 103). These folds are the medullary folds and they constitute the first definite traces of the embryo. The medullary plate bounded by them rapidly grows in length, the primitive streak always remaining at its hinder end. While the
Two Transverse Sections Showing the Embryonic Area of an Exencephalic Embryo of Unborn Man.

The embryo has merely the appearance represented in Fig. 100. A, is taken through the anterior part of the embryonic area. It represents about half the lines of the area, and there is no trace of a medullary groove in the area. B, is taken through the posterior part of the primitive streak.

Lateral epiblast is formed of several rows of cells, that of the medullary plate is at first formed of but a single row (Fig. 104, m). The mesoblast and endoderm. The mesoblast in the mammalia has, as in the chick, a double origin, and the details of its development appear to resemble essentially those in the chick. It arises (1) from the epiblast of the primitive streak; this has been already described; (2) from the primitively hypoblast in front and at the sides of the primitive streak. The latter is known as the mesoblastic mesoblast, and as in the chick appears to originate as two lateral plates split off from the primitive hypoblast. These two plates are at first continuous.
The primitive streak makes its appearance; it is due to a proliferation of rounded cells from the epiblast.

During the seventh day the primitive streak becomes a more pronounced structure (Fig. 101), the mesoblast in its neighbourhood increases in quantity, while an axial groove (Fig. 100)—the primitive groove—is formed on its upper surface.

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The embryo has nearly the appearance represented in Fig. 100.

A. is taken through the anterior part of the embryonic area. It represents about half the breadth of the area, and there is no trace of a medullary groove or of the mesoblast.

B. is taken through the posterior part of the primitive streak.

ep. epiblast; hy. hypoblast.

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**The mesoblast and notochord.** The mesoblast in mammalia has, as in the chick, a double origin, and the details of its development appear to resemble essentially those in the chick. It arises (1) from the epiblast of the primitive streak; this has been already described; (2) from the primitive hypoblast in front and at the sides of the primitive streak. The latter is known as hypoblastic mesoblast, and as in the chick appears to originate as two lateral plates split off from the primitive hypoblast. These two plates are at first continuous.
EMBRYONIC AREA OF A SEVEN DAYS' EMBRYO RABBIT.

(From Kölliker.)

$o$. place of future area vasculosa; $rf$. medullary groove; $pr$. primitive streak; $ag$. embryonic area.

In the region $o$, a layer of mesoblast has already grown; there are however as yet no signs of blood-vessels in it.

This mesoblast is derived from the mesoblast of the primitive streak (Kölliker).

In the axial line with the primitive hypoblast. When the medullary groove is formed the lateral bands of mesoblast become separate from the axial hypoblast and give rise to two independent lateral plates of mesoblast.
(Fig. 104). The axial band of hypoblast eventually gives rise to the notochord.

Fig. 105.

Transverse Section through an Embryo Rabbit of Eighth Day.

ep. epiblast; mep. mesoblast; Ay. hypoblast; mgy. medullary groove.

The mesoblastic elements from these two sources, though at first characterised by the difference in the appearance of their cells (Fig. 105, B), those of the primitive streak mesoblast being more rounded, soon become blended and indistinguishable from one another; so that it is difficult to say to what parts of the fully formed mesoblast they severally contribute.

In tracing the changes which take place in the relations of the layers, while passing from the region of the embryo to that of the primitive streak, it will be convenient to follow the account given by Schäfer for the guinea-pig, which on this point is far fuller and more satisfactory than that of other observers. In doing so we shall leave out of consideration the fact that the layers in the guinea-pig are inverted. Fig. 106 represents a series of sections through this part in the guinea-pig. The anterior section (1) passes through the medullary groove near its hinder end. The commencement of the primitive streak is marked by a slight prominence on the floor of the medullary groove between the two diverg-
ANATOMICAL CLARA OF A SEVEN-DAY EMBRYO HAMY: (FROM KOLLMANN.)

The area vitellina is seen as a layer of vascularised mesenchyme. The primitive streak is evident. The mesoderm is developing.

In the cephalic end, a layer of mesoblast has already grown. These are termed by yet no signs of blood vessels in it.

The mesoblast is derived from the mesoblast of the epidermal region (KOLLMANN).

in the axial line with the primitive hypoblast. When the modulatory groove is formed, the lateral bands of mesoblast become separate from the axial hypoblast and give rise to two independent lateral plates of mesoblast.
The axial band of hypoblast eventually gives rise to the notochord.

**Fig. 104.**

**Transverse Section through an Embryo Rabbit of Eight Days.**

*ep.* epiblast; *me.* mesoblast; *hy.* hypoblast; *mg.* medullary groove.

The mesoblastic elements from these two sources, though at first characterised by the difference in the appearance of their cells (Fig. 102, B), those of the primitive streak mesoblast being more rounded, soon become blended and indistinguishable from one another; so that it is difficult to say to what parts of the fully formed mesoblast they severally contribute.

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ing medullary folds (Fig. 105 C, ae). Where this prominence becomes first apparent the epiblast and hypoblast

A Series of Transverse Sections through the Junction of the Primitive Streak and Medullary Groove of a Young Guinea-Pig. (After Schäfer.)

A. is the posterior section.

e. epiblast; m. mesoblast; h. hypoblast; ae. axial epiblast of the primitive streak; ah. axial hypoblast attached in B. and C. to the epiblast at the rudimentary blastopore; ng. medullary groove; f. rudimentary blastopore.
are united together. The mesoblast plates at the two sides remain in the meantime quite free. Slightly further back, but before the primitive groove is reached, the epiblast and hypoblast are connected together by a cord of cells (Fig. 165 B, F), which in the section next following becomes detached from the hypoblast and forms a solid keel projecting from the epiblast. In the following section the hitherto independent mesoblast plates become united with this keel (Fig. 165 A); and in the posterior sections, through the part of the primitive streak with the primitive groove, the epiblast and mesoblast continue to be united in the axial line, but the hypoblast remains distinct. These peculiar relations may shortly be described by saying that in the axial line the hypoblast becomes united with the epiblast at the posterior end of the embryo; and that the cells which connect the hypoblast and epiblast are posteriorly continuous with the fused epiblast and mesoblast of the primitive streak, the hypoblast in the region of the primitive streak having become distinct from the other layers.

The notochord. The thickened axial portion of the hypoblast in the region of the embryo becomes separated, as we have already pointed out, from the lateral parts as the notochord.

Very shortly after the formation of the notochord, the hypoblast grows in from the two sides, and becomes quite continuous across the middle line. The formation of the notochord takes place from before backwards, and at the hinder end of the embryo it is continued into the mass of cells which forms the axis of the primitive streak, becoming therefore at this point continuous
A Series of Transverse Sections Through the Junction of the Primitive Streak and Mesoblastic Grown of a Young Guinea-Pig. (Fig. Schöffer.)

A. In the anterior section.

A. epiblast; a. mesoblast; a'. hypoblast; a'. axial epiblast of the primitive streak; a'. axial hypoblast; attached in B. and C. to the epiblast at the rudimentary blastopore; a'. mediolateral groove; a. rudimentary blastopore.
are united together. The mesoblast plates at the two sides remain in the meantime quite free. Slightly further back, but before the primitive groove is reached, the epiblast and hypoblast are connected together by a cord of cells (Fig. 105 B, f), which in the section next following becomes detached from the hypoblast and forms a solid keel projecting from the epiblast. In the following section the hitherto independent mesoblast plates become united with this keel (Fig. 105 A); and in the posterior sections, through the part of the primitive streak with the primitive groove, the epiblast and mesoblast continue to be united in the axial line, but the hypoblast remains distinct. These peculiar relations may shortly be described by saying that in the axial line the hypoblast becomes united with the epiblast at the posterior end of the embryo; and that the cells which connect the hypoblast and epiblast are posteriorly continuous with the fused epiblast and mesoblast of the primitive streak, the hypoblast in the region of the primitive streak having become distinct from the other layers.

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with the epiblast. The notochord in fact behaves exactly as did the axial hypoblast in the earlier stage.

The peculiar relations just mentioned are precisely similar to those we have already described in the chick (p. 60). They receive their explanation by comparison with the lower types.

The cells which form the junction between the epiblast and the axial hypoblast constitute in the lower types the front wall of a passage perforating the blastoderm and leading from the exterior into the alimentary canal. This passage is the vertebrate blastopore.

In the chick we have seen (p. 72) this passage is present at a certain stage of development as the neurenteric canal; and in the duck at a still earlier stage. It is also present at an early stage in the mole.

The presence of this blastopore renders it clear that the blastopore discovered by Ed. van Beneden cannot have the meaning he assigned to it in comparing it with the blastopore of the frog.

To recapitulate. At the stage we have now reached the three layers are definitely established.

The epiblast is derived partly from the outer layer of segmentation spheres and partly from the larger proportion of those segmentation spheres which constitute the inner mass. The hypoblast arises from the few remaining cells of the inner mass; while the mesoblast has its origin partially from the epiblast of the primitive streak and partially from the hypoblast cells anterior to the primitive streak.

During the period in which these changes have been taking place, the rudiments of a vascular area become formed, and while as Kölliker has shewn, the mesoblast of this portion is to some extent derived from the mesoblast of the primitive streak, it is possible that a portion of it owes its origin to hypoblastic mesoblast.
General growth of the embryo. We have seen that the blastodermic vesicle becomes divided at an early stage of development into an embryonic area and a non-embryonic portion. The embryonic area gives rise to the whole of the body of the embryo, while the non-embryonic part forms an appendage known as the umbilical vesicle, which becomes gradually folded off from the embryo, and has precisely the relations of the yolk-sac of the chick. It is almost certain that the Mammals are descended from ancestors, the embryos of which had large yolk-sacs, but that the yolk has become reduced in quantity owing to the nutriment received from the wall of the uterus taking the place of that originally supplied by the yolk. A rudiment of the yolk-sac being thus retained in the umbilical vesicle, this structure may be called indifferently umbilical vesicle or yolk-sac.

The yolk which fills the yolk-sac in Birds is replaced in Mammals by a susceptible fluid, while the gradual extension of the hypoblast round the wall of the blastodermic vesicle, which has already been described, is of the same nature as the growth of the hypoblast round the yolk-sac in Birds.

The whole embryonic area would seem to be employed in the formation of the body of the embryo. Its long axis has no very definite relation to that of the blastodermic vesicle. The first external trace of the embryo to appear is the medullary plate, bounded by the medullary folds, and occupying at first the anterior half of the embryonic area (Fig. 108). The two medullary folds diverge behind and enclose the front end of the primitive streak. As the embryo elongates the
with the epiblast. The notochord is in fact believed exactly in the animal hypoblast in the earlier stage.

The peculiar relations just mentioned are precisely similar to those we have already described in the chick (p. 167). They necessitate an explanation by comparison with the lower types.

The tube which forms the junction between the epiblast and the animal hypoblast constitutes in the lower types the front wall of a passage particularly the blastoderm and leading from the exterior into the alimentary canal. This passage is the yolk sac of the lower types.

In the chick we have seen (p. 73) this passage is present at a certain stage of development as the mesenteric canal; and in the chick at a still earlier stage. It is also present at an earlier stage in the frog.

The process of the blastopore region it clear that the blastopore does not by L. van Beneden cannot have the meaning he assigns to it in connection with the blastopore of the frog.

To recapitulate. At the stage we have now reached the three layers are definitely established.

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medullary folds nearly meet behind and so cut off the front portion of the primitive streak, which then appears as a projection in the hind end of the medullary groove. At the hind end of the medullary groove (mole) a deep pit perforates its floor and enters the mass of mesoblast cells lying below. The pit is a rudiment of the blastopore (described on p. 326) which has been enclosed by the medullary folds.

Henceforward the general course of development is very similar to that in the chick and so will be only briefly described. The special features in the development of particular organs will be described later. In an embryo rabbit, eight days after impregnation, the medullary groove is about 1.80 mm. in length. At this stage a division may be clearly seen in the lateral plates of mesoblast into a vertebral zone adjoining the embryo and a more peripheral lateral zone; and in the vertebral zone indications of two somites, about 0.37 mm. from the hinder end of the embryo, become apparent. The foremost of these somites marks the junction, or very nearly so, of the cephalic region and trunk. The small size of the latter as compared with the former is very striking, but is characteristic of Vertebrates generally. The trunk gradually elongates relatively to the head, by the addition behind of fresh somites. The embryo has not yet begun to be folded off from the yolk-sac.

In a slightly older embryo of nine days there appears (Hensen, Köllicher) round the embryonic area a delicate clear ring which is narrower in front than behind (Fig. 106 A. ap). This ring is regarded by these authors as representing the peripheral part of the area pellucida of
Birds, which does not become converted into the body of the embryo. Outerly the area pellucida, an area vasculara has become very well defined. In the embryo itself (Fig. 106 A) the disproportion between head and trunk is less marked than before; the medullary plate dilates anteriorly to form a spatula-shaped cephalic enlargement; and three or four somites are established. In the lateral parts of the mesoblast of the head there may be seen on each side a tube-like structure (hz). Each of these is part of the heart, which arises as two independent tubes. The remains of the primitive streak (pr) are still present behind the medullary groove.

In somewhat older embryos (Fig. 106 B) with about eight somites, in which the trunk considerably exceeds the head in length, the first distinct traces of the folding off of the head end of the embryo become apparent, and somewhat later a fold also appears at the hind end. In the formation of the hind end of the embryo the primitive streak gives rise to a tail swelling and to part of the ventral wall of the post-anal gut. In the region of the head the rudiments of the heart (h) are far more definite. The medullary groove is still open for its whole length, but in the head it exhibits a series of well-marked dilatations. The foremost of these (ab) is the rudiment of the fore-brain from the sides of which there project the two optic vesicles (ab); the next is the mid-brain (ab) and the last is the hind brain (ab), which is again divided into smaller lobes by successive constrictions. The medullary groove behind the region of the somites dilates into an embryonic sinus rhomboïdale like that of the bird. Traces of the
medullary folds nearly meet behind and so cut off the front portion of the primitive streak, which then appears as a projection in the hind end of the medullary groove. At the hind end of the medullary groove (not a deep pit perforates its floor and enters the mass of blastoderm cells lying below. The pit is a rudiment of the halse pore (described on p. 326) which has been enclosed by the medullary folds.

Here fore the general course of development is very similar to that in the chick and so will be only briefly described. The special features in the development of particular organs will be described later. In an embryo rabbit, eight days after impregnation, the medullary groove is about 160 mm. in length. At this stage a division may be clearly seen in the lateral plates of mesoderm into a vertebral zone adjoining the embryo cord and a more peripheral lateral zone, and in the vertebral zone, indications of two somites, about 0.37 mm. from the hinder end of the embryo, become apparent. The formation of these somites marks the junction, or very nearly so, of the cephalic region and trunk. The small size of the latter as compared with the former is very striking but is characteristic of Vertebrates generally. The trunk gradually elongates relatively to the head, by the addition behind of fresh somites. The embryo has not yet begun to be folded off from the yolk-sac.

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Embryo Rabbits of about Nine Days from the Dorsal Side.
(From Kölliker.)

A. magnified 22 times, and B. 21 times.

*ap.* area pellucida; *rf.* medullary groove; *h.* medullary plate in the region of the future fore-brain; *h''.* medullary plate in the region of the future mid-brain; *vh.* fore-brain; *ab.* optic vesicle; *mh.* mid-brain; *hh.* and *h''.* hind-brain; *uw.* mesoblastic somite; *stz.* vertebral zone; *pz.* lateral zone; *hz.* and *h.* heart; *ph.* pericardial section of body-cavity; *vo.* vitelline vein; *af.* amnion fold.
amnion (ef) are now apparent both in front of and behind the embryo.

The structure of the head and the formation of the heart at this age are illustrated in Fig. 107. The widely open medullary groove (ef) is shown in the centre. Below it the hypoblast is thickened to form the notochord (ii); and at the sides are seen the two tubes which, on the folding-in of the fore-gut, give rise to the unpaired heart. Each of these is formed of an outer muscular tube of splanchnic mesoblast (dhh), not quite closed towards the hypoblast, and an inner epithelial layer (dhh), and is placed in a special section of the body cavity (pô), which afterwards forms the pericardial cavity.

Before the tenth day is completed great external changes are usually effected. The medullary groove becomes closed for its whole length with the exception of a small posterior portion. The closure commences, as in Birds, in the region of the mid-brain. Anteriorly the folding-off of the embryo proceeds so far that the head becomes quite free and a considerable portion of the throat, ending blindly in front, becomes established. In the course of this folding the, at first widely separated, halves of the heart are brought together, coalesce on the ventral side of the throat, and so give rise to a median un divided heart. The fold at the tail end of the embryo progresses considerably, and during its advance the aorta and is formed in the same way as in Birds. The somites increase in number to about twelve. The aortic fold nearly meet above the embryo.

The details of the development of the heart are described below (ch. xx).
Embryo Hex een or About Nine Days From the Lornal Side.

(From Kellicott)

A. magnified 22 times, and B. 21 times.

ap. area pedunc. ; af. medullary groove ; b. medullary plate in the region of the future fore-brain ; c. fore-brain ; de. optic vesicle ; ef. mid-brain ; fh. and th. hind-brain ; mb. meso-chondral somite ; mf. venticuloi zone ; d. lateral zone ; h. and k. heart ; m. postero-dorsal section of body-cavity ; mc. vitelline

point ; mc. region of.
amnion (af) are now apparent both in front of and behind the embryo.

The structure of the head and the formation of the heart at this age are illustrated in Fig. 107. The widely open medullary groove (rf) is shewn in the centre. Below it the hypoblast is thickened to form the notochord dd'; and at the sides are seen the two tubes, which, on the folding-in of the fore-gut, give rise to the unpaired heart. Each of these is formed of an outer muscular tube of splanchnic mesoblast (ahh), not quite closed towards the hypoblast, and an inner epithelioid layer (ihh); and is placed in a special section of the body cavity (ph), which afterwards forms the pericardial cavity.

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1 The details of the development of the heart are described below (ch. xii.).
**Fig. 107.**

Transverse Section through the Head of a Rabbit of the same age as Fig. 106 B. (From Kölliker.)

B. is a more highly magnified representation of part of A.

rf. medullary groove; mp. medullary plate; rw. medullary fold; h. epiblast; dd. hypoblast; dd'. notochordal thickening of hypoblast; sp. undivided mesoblast; hp. somatic mesoblast;
The later stages in the development proceed in the main in the same manner as in the Bird. The cranial flexures soon become very marked, the mid-brain forming the end of the long axis of the embryo (Fig. 103). The sense organs have the usual development. Under the fore-brain appears an embryonic involution giving

**Fig. 103.**

ADVANCED EMBRYO OF A RABBIT (ABOUT TWELVE DAYS).

mb. mid-brain; th. thalamus cerebral; ac. cerebral hemisphere; op. op. cerebro; ivy. fourth ventricle; na. maxillary process; ma. mandibular arch; hy. hyoid arch; fl. fore-limb; hl. hind-limb; hy. umbilical stalk.

This figure was drawn by Mr. Weldon.
Transverse Section through the Head of a Rabbit of the Same Age as Fig. 100 H. (From Bivilker.)

It is a more highly magnified representation of part of A.

g. medullary groove; np. medullary plate; mv. medullary fold;

h. amphiblast; dh. hypoblast; df. notochordal thickening of hypoblast; sp. undivided medoblast; sp'. somatic mesoblast;
dfp. splanchnic mesoblast; ph. pericardial section of body-cavity; ahh. muscular wall of heart; ihh. epithelioid layer of heart; mes. lateral undivided mesoblast; sw. fold of hypoblast which will form the ventral wall of the pharynx; sr. commencing throat.

The later stages in the development proceed in the main in the same manner as in the Bird. The cranial flexure soon becomes very marked, the mid-brain forming the end of the long axis of the embryo (Fig. 108). The sense organs have the usual development. Under the fore-brain appears an epiblastic involution giving

**Fig. 108.**

**ADVANCED EMBRYO OF A RABBIT (ABOUT TWELVE DAYS).**

mb. mid-brain; th. thalamencephalon; ce. cerebral hemisphere; op. eye; iv.v. fourth ventricle; mx. maxillary process; md. mandibular arch; hy. hyoid arch; fl. fore-limb; hl. hind-limb; um. umbilical stalk.

1. This figure was drawn by Mr Weldon.
rise both to the mouth and to the pituitary body. Behind the mouth are three well marked pairs of visceral arches. The first of these is the mandibular arch (Fig. 108 md), which meets its fellow in the middle line, and forms the posterior boundary of the mouth. It sends forward on each side a superior maxillary process (mx) which partially forms the anterior margin of the mouth. Behind the mandibular arch are present a well-developed hyoid (hy) and a first branchial arch (not shewn in Fig. 108). There are four clefts, as in the chick, but the fourth is not bounded behind by a definite arch. Only the first of these clefts persists as the tympanic cavity and Eustachian tube.

At the time when the cranial flexure appears, the body also develops a sharp flexure immediately behind the head, which is thus bent forwards upon the posterior straight part of the body (Fig. 108). The amount of this flexure varies somewhat in different forms. It is very marked in the dog (Bischoff). At a later period, and in some species even before the stage figured, the tail end of the body also becomes bent (Fig. 108), so that the whole dorsal side assumes a convex curvature, and the head and tail become closely approximated. In most cases the embryo, on the development of the tail, assumes a more or less definite spiral curvature (Fig. 108). With the more complete development of the lower wall of the body the ventral flexure partially disappears, but remains more or less persistent till near the close of intra-uterine life. The limbs are formed as simple buds in the same manner as in Birds. The buds of the hind-limbs are directed somewhat forwards, and those of the fore-limb backwards.
The human embryo. Our knowledge as to the early development of the human embryo is in an unsatisfactory state. The positive facts we know are comparatively few, and it is not possible to construct from them a history of the development which is capable of satisfactory comparison with that in other forms, unless all the early embryos known are to be regarded as abnormal. The most remarkable feature in the development, which was first clearly brought to light by Allen Thomson in 1839, is the very early appearance of branched villi. In the last few years several ova, even younger than those described by Allen Thomson, have been met with, which exhibit this peculiarity.

The best preserved of these ova is one described by Reichert. This ovum, though probably not more than thirteen days old, was completely enclosed by a decidua reflexa. It had (Fig. 109 A and B) a flattened oval form, measuring in its two diameters 5.5 mm. and 8.5 mm. The edge was covered with branched villi, while in the centre of each of these flattened surfaces there was a spot free from villi. On the surface adjoining the uterine wall was a darker area (c) formed of two layers of cells. Nothing certain has been made out about the structure of ova of this age.

The villi, which at first leave the flattened plane free, seem soon to extend first over one of the flat sides and finally over the whole ovum (Fig. 109 C).

Unless the two-layered region of Reichert's ovum is the embryonic area, nothing which can clearly be identified as an embryo has been detected in these
run back to the mouth and to the palatary body. Enfold the mouth are three well-marked pairs of visceral arches. The first of these is the mandibular arch (Fig. 108, a), which meets its fellow in the middle line and forms the posterior boundary of the mouth. It moves forward on each side a superior maxillary process (br) which partially forms the anterior margin of the mouth. Behind the mandibular arch are present a well-developed hyoid (by) and a first branchial arch (not shown in Fig. 108). There are four clots, as in the chick, but the fourth is not bounded behind by a definite arch. Only the first of these clots persists as the tyrogran cartilag and Eustachian tube.

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Unless the two-layered region of Reichert's ovum is the embryonic area, nothing which can clearly be identified as an embryo has been detected in these

A. and B. Front and side view of an ovum figured by Reichert, supposed to be about thirteen days. e. embryonic area.

C. An ovum of about four or five weeks shewing the general structure of the ovum before the formation of the placenta. Part of the wall of the ovum is removed to shew the embryo in situ. (After Allen Thomson.)

early ova. In an ovum described by Breus, and in one described long ago by Wharton-Jones, a mass found in the interior of the ovum may perhaps be interpreted (His) as the remains of the yolk. It is, however, very probable that all the early ova so far obtained are more or less pathological.

The youngest ovum with a distinct embryo is one described by His. This ovum, which is diagrammatically represented in Fig. 111 in longitudinal section, had the form of an oval vesicle completely covered by villi, being about 8·5 mm. and 5·5 mm. in its two diameters, and flatter on one side than on the other. An embryo with a yolk-sac was attached to the inner side of the flatter wall of the vesicle by a stalk, which must be regarded as the allantoic stalk; the embryo
THREE EARLY HUMAN EMBRYOS. (Copied from Hla.)

A. Side view of an early embryo described by Hla.
B. Embryo of about 12—14 days described by Allen Thom.
son.
C. Young embryo described by Hla.

ae. amnion; md. metulary groove; uu. uniliocol vesicle;
ch. chorion, to which the embryo is attached by a stalk.

and yolk-sac filled up but a very small part of the whole cavity of the vesicle.

The embryo, which was probably not quite normal (Fig. 119 A), was very imperfectly developed; a medulitary plate was hardly indicated, and though the mesoblast was unsegmented, the head fold, separating the embryo from the yolk-sac (uu), was already in

...
THE HUMAN EGG, DURING EARLY STAGES OF DEVELOPMENT.

(Fraca Quain’s Anatomy.)

A and B. Front and side view of an ovum figured by Reibert, supposed to be about thirteen days. a. embryonic area.

C. An ovum of about four or five weeks showing the general structure of the ovum before the formation of the placenta. Part of the wall of the ovum is removed to show the embryo in situ. (After Allen Thomson.)

early ovum. In an ovum described by Breus, and in one described long ago by Wharton-Jones, a mass found in the interior of the ovum may perhaps be interpreted (His) as the remains of the yolk. It is, however, very probable that all the early ovum so far obtained are more or less pathological.

The youngest ovum with a distinct embryo is one described by His. This ovum, which is diagrammatically represented in Fig. 111 in longitudinal section, had the form of an oval vesicle completely covered by villi, being about 6 to 7 mm. and 5 to 6 mm. in its two diameters and flatter on one side than on the other. An embryo with a yolk-sac was attached to the inner side of the flatter wall of the vesicle by a stalk, which must be regarded as the allantoic stalk; the embryo
THE HUMAN EMBRYO.

Fig. 110.

THREE EARLY HUMAN EMBRYOS. (Copied from His.)

A. Side view of an early embryo described by His.
B. Embryo of about 12—14 days described by Allen Thomson.
C. Young embryo described by His.

*am.* amnion; *md.* medullary groove; *um.* umbilical vesicle; *ch.* chorion, to which the embryo is attached by a stalk.

and yolk-sac filled up but a very small part of the whole cavity of the vesicle.

The embryo, which was probably not quite normal (Fig. 110 A), was very imperfectly developed; a medullary plate was hardly indicated, and, though the mesoblast was unsegmented, the head fold, separating the embryo from the yolk-sac (*um*), was already in-
Dicated. The amnion (am) was completely formed, and vitelline vessels had made their appearance.

Two embryos described by Allen Thomson are but slightly older than the above embryo of His. Both of them probably belong to the first fortnight of pregnancy. In both cases the embryo was more or less folded off from the yolk-sac, and in one of them the medullary groove was still widely open, except in the region of the neck (Fig. 110 B). The allantoic stalk, if present, was not clearly made out, and the condition of the amnion was also not fully studied. The smaller of the two ova was just 6 mm. in its largest diameter, and was nearly completely covered with simple villi, more developed on one side than on the other.

In a somewhat later period, about the stage of a chick at the end of the second day, the medullary folds are completely closed, the region of the brain already marked, and the cranial flexure commencing. The mesoblast is divided up into numerous somites, and the mandibular and first two branchial arches are indicated.
The embryo is still but incompletely folded off from the yolk sac below.

In a still older stage the cranial flexure becomes still more pronounced, placing the mid-brain at the end of the long axis of the body. The body also begins to be ventrally curved (Fig. 110 C).

Externally human embryos at this age are characterized by the small size of the anterior end of the head.

The flexure goes on gradually increasing, and in the third week of pregnancy in embryos of about 4 cm. the limbs make their appearance.

The embryo at this stage (Fig. 112) which is about

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**Fig. 112.**

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**Two views of a human embryo of between the third and fourth week.**

A. Side view. (From Körber, after Allen Thomson.)
- a, anterior; b, middle-branch vessel; c, branchial arch; d, yolk sac; e, commencing anterior branch; f, primitive auditory vesicle; g, yolk; h, heart.

B. Dorsal view to show the attachment of the allantois-allantoic stalk to the chorion. (From a sketch by Allen Thomson.)
- c, ciliated; all, allantois; y, yolk-sac.
diagrammatic longitudinal section of the ovum to which the embryo (Fig. 110 A.) referred. (After Hse.)

1. allantois; 2. umbilical vessels.

diagnosed. The amnion (see) was completely formed, and vitelline vessels had made their appearance.

Two embryos described by A. C. Thomas are but slightly older than the above embryo of Hse. Both of these probably belong to the first fortnight of pregnancy. In both cases the embryo was more or less folded off from the yolk-sac, and in one of them the medullary groove was still widely open, except in the region of the neck (Fig. 110 B). The allantoic stalk, if present, was not clearly made out, and the condition of the amnion was also not fully studied. The smaller of the two ova was just 6 mm. in its largest diameter, and was nearly completely covered with simple villi; more developed on one side than on the other.

In a somewhat later period, about the stage of a chick at the end of the second day, the medullary folds are completely closed, the region of the brain already marked, and the cranial flexure commencing. The mesenchyme is divided up into numerous somites, and the mandibular and first two branchial arches are indicated.
The embryo is still but incompletely folded off from the yolk-sac below.

In a still older stage the cranial flexure becomes still more pronounced, placing the mid-brain at the end of the long axis of the body. The body also begins to be ventrally curved (Fig. 110 C).

Externally human embryos at this age are characterized by the small size of the anterior end of the head.

The flexure goes on gradually increasing, and in the third week of pregnancy in embryos of about 4 mm. the limbs make their appearance.

The embryo at this stage (Fig. 112), which is about

**Fig. 112.**

**Two Views of a Human Embryo of between the Third and Fourth Week.**

**A.** Side view. (From Kölliker; after Allen Thomson.)
- a. amnion
- b. umbilical vesicle
- c. mandibular arch
- e. hyoid arch
- f. commencing anterior limb
- g. primitive auditory vesicle
- h. eye
- i. heart

**B.** Dorsal view to shew the attachment of the dilated allantoic stalk to the chorion. (From a sketch by Allen Thomson.)
- am. amnion
- all. allantois
- ys. yolk-sac
equivalent to that of a chick on the fourth day, resembles in almost every respect the normal embryos of the Amniota. The cranial flexure is as pronounced as usual, and the cerebral region has now fully the normal size. The whole body soon becomes flexed ventrally, and also somewhat spirally. The yolk-sac (B; ys) forms a small spherical appendage with a long wide stalk, and the embryo is attached by an allantoic stalk with a slight swelling, probably indicating the presence of a small hypoblastic diverticulum, to the inner face of the chorion.

A detailed history of the further development of the human embryo does not fall within the province of

**Fig. 113.**

**Figures shewing the early changes in the form of the human head.** (From Quain's Anatomy.)

A. Head of an embryo of about four weeks. (After Allen Thomson.)
B. Head of an embryo of about six weeks. (After Ecker.)
C. Head of an embryo of about nine weeks.

1. mandibular arch; 1'. persistent part of hyomandibular cleft; a. auditory vesicle.
this work; while the later changes in the embryonic
membranes will be dealt with in the next chapter. For
the changes which take place on the formation of the
face we may refer the reader to Fig. 118. For a full dis-
cussion as to the relation between the human embryos
just described and those of other Mammals, we refer the
reader to the Comp. Embryology, Vol. ii, p. 224 et seq.

The guinea pig, rat and mouse present a pecu-
liar method of development, the details of which are
not entirely understood, and we do not propose to
examine them here. Sufficient to say that the mode of
development gives rise to the so-called inversion of the
layers; so called because the outer layer of the em-
byronic vesicle appears to the older observers to be
formed of hypoblast and the embryonic epiblast to be
enclosed within.
The mesoderm is as pronounced as usual, and the median cleft has now fully the normal width. The entire head now becomes flexed ventrally, and the face is recognizable. The paraspinal cells form a small cleft at this region with a long midline stalk, and the yolk sac is connected by an allantoic stalk with a slit joining, probably indicating the presence of a duct in the posterior direction, to the inner face of the embryo.

A detailed history of the further development of the human embryo does not fall within the province of

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**Figures Illustrating Early Changes in the Form of the Human Head. (From Gruber's Anatomy.)**

A. Head of an embryo of about four weeks. (After Alan Thomson.)

B. Head of an embryo of about six weeks. (After Ecker.)

C. Head of an embryo of about nine weeks.

1. m. oculomotor, 2. m. persistent part of hyomandibular cleft; 3. auditory vesicle.
this work; while the later changes in the embryonic membranes will be dealt with in the next chapter. For the changes which take place on the formation of the face we may refer the reader to Fig. 113. For a full discussion as to the relation between the human embryos just described and those of other Mammals, we refer the reader to the *Comp. Embryology*, Vol. II. p. 224 et seq.

The guinea pig, rat and mouse present a peculiar method of development, the details of which are not entirely understood, and we do not propose to examine them here. Suffice it to say that the mode of development gives rise to the so-called inversion of the layers; so called because the outer layer of the embryonic vesicle appeared to the older observers to be formed of hypoblast and the embryonic epiblast to be enclosed within.
CHAPTER XI.

EMBRYONIC MEMBRANES AND YOLK-SAC.

In the Mammalia the early stages in the development of the embryonic membranes are nearly the same as in Aves; but during the later stages the allantois enters into peculiar relations with the uterine walls, and the two, together with the interposed portion of the subzonal membrane or false amnion (the nature of which will be presently described), give rise to a very characteristic Mammalian organ—theplacenta—into the structure of which it will be necessary to enter at some length. The embryonic membranes vary so considerably in the different forms that it will be advantageous to commence with a description of their development in an ideal case.

We may commence with a blastodermic vesicle closely invested by the delicate remnant of the zona radiata at the stage in which the medullary groove is already established. Around the embryonic area a layer of mesoblast would have extended for a certain distance; so as to give rise to an area vasculosa, in which however the blood-vessels would not have become definitely
established. Such a flexure is represented diagrammatically in Fig. 114, a. Somewhat later the embryo begins to be folded off first in front and then behind (Fig. 114, b). These folds result in a constriction separating the embryo and the yolk-sac (ds), or as it is called in Mammalian embryology the abdominal cavity. The splitting of the mesoblast into a splanchnic and a somatic layer has taken place; and at the front and hind end of the embryo a fold (ds) of the somatic mesoblast and epiblast begins to rise up and grow over the head and tail of the embryo. These two folds form the commencement of the amnion. The head and tail folds of the amnion are continued round the two sides of the embryo till they meet and unite into a continuous fold. This fold grows gradually upwards, but before it has completely enveloped the embryo the blood-vessels of the area vasculosa become fully developed. They are arranged in a manner not very different from that in the chick.

The following is a brief account of their arrangement in the rabbit:

The outer boundary of the area, which is continually extending further and further round the umbilical vessels, is marked by a venous sinus terminalis (Fig. 114, a). The area is not, as in the chick, a nearly complete circle, but is in front divided by a deep indentation extending inwards to the level of the heart. In consequence of this indentation, the sinus terminalis ends in front in two branches, which become inwards and fall directly into the main vitelline veins. The blood is brought from the dorsal aorta by a series of lateral vitelline arteries, and not by a single pair as in the chick. These arteries break up into a more deeply situated arterial network, from which the blood is continued partly into the sinus terminalis, and partly into a superficial venous
CHAPTER XI.

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established. Such a vesicle is represented diagrammatically in Fig. 114, 1. Somewhat later the embryo begins to be folded off first in front and then behind (Fig. 114, 2). These folds result in a constriction separating the embryo and the yolk-sac (ds), or as it is called in Mammalian embryology, the umbilical vesicle. The splitting of the mesoblast into a splanchnic and a somatic layer has taken place, and at the front and hind end of the embryo a fold (ks) of the somatic mesoblast and epiblast begins to rise up and grow over the head and tail of the embryo. These two folds form the commencement of the amnion. The head and tail folds of the amnion are continued round the two sides of the embryo till they meet and unite into a continuous fold. This fold grows gradually upwards, but before it has completely enveloped the embryo the blood-vessels of the area vasculosa become fully developed. They are arranged in a manner not very different from that in the chick.

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The outer boundary of the area, which is continually extending further and further round the umbilical vesicle, is marked by a venous sinus terminalis (Fig. 114, st). The area is not, as in the chick, a nearly complete circle, but is in front divided by a deep indentation extending inwards to the level of the heart. In consequence of this indentation the sinus terminalis ends in front in two branches, which bend inwards and fall directly into the main vitelline veins. The blood is brought from the dorsal aorta by a series of lateral vitelline arteries, and not by a single pair as in the chick. These arteries break up into a more deeply situated arterial network, from which the blood is continued partly into the sinus terminalis, and partly into a superficial venous
EMBRYONIC MEMBRANES AND YOLK-SAC. [CHAP.

Fig. 114.
FIVE DIAGRAMS. FIGURES ILLUSTRATING THE FORMATION OF THE FETAL MEMBRANES OF A MAMMAL. (From Kolliker.)

In 1, 2, 3, 4 the embryo is represented in longitudinal section.

1. Ovum with zone pellucida, blastodermic vesicle, and amnionic area.

2. Ovum with commencing formation of umbilical vesicle and amnion.

3. Ovum with uterus about to open, and commencing allantoid.

4. Ovum with villous subzonal membrane, larger allantoid, and mouth and face.

5. Ovum in which the mesenchyme of the allantoid has extended round the inner surface of the subzonal membrane, and united with it to form the chorioallantoic membrane. The cavity of the allantoid is absent. This fig. is a diagram of an early human ovum.

α. seen radiata; β' and β: processes of zona; γ. subzonal membrane; δ. outer fold of amnion; ε. amnion; η. chorioallantois; θ. amnionic villi; θ'. amnion; ι. head-fold of amnion; μ.tail-fold of amnion; ν. epithelium of embryo; ο. cytotroph of embryonic part of the blastodermic vesicle; π. embryonic mesoblast; ρ. non-embryonic mesoblast; σ. extra vasculosa; τ. amnian terminals; υ. embryonic hypoblast; χ. non-embryonic hypoblast; ψ. cavity of blastodermic vesicle; τ. cavity of celiac vesicle; μ. cavity of umbilical vesicle; ν. walls of umbilical vesicle; π. allantoid; ο. embryo; ρ. space between chorio and amnion; containing amnionic fluid; θ. central body wall; ϖ. perinatal cavity.
FIVE DIAGRAMMATIC FIGURES ILLUSTRATING THE FORMATION OF THE FOETAL MEMBRANES OF A MAMMAL. (From Kölliker.)

In 1, 2, 3, 4 the embryo is represented in longitudinal section.

1. Ovum with zona pellucida, blastodermic vesicle, and embryonic area.

2. Ovum with commencing formation of umbilical vesicle and amnion.

3. Ovum with amnion about to close, and commencing allantois.

4. Ovum with villous subzonal membrane, larger allantois, and mouth and anus.

5. Ovum in which the mesoblast of the allantois has extended round the inner surface of the subzonal membrane and united with it to form the chorion. The cavity of the allantois is aborted. This fig. is a diagram of an early human ovum.

*d.* zona radiata; *d'* and *sz.* processes of zona; *sh.* subzonal membrane, outer fold of amnion, false amnion; *ch.* chorion; *ch.* z. chorionic villi; *am.* amnion; *ks.* head-fold of amnion; *ss.* tail-fold of amnion; *a.* epiblast of embryo; *a'* epiblast of non-embryonic part of the blastodermic vesicle; *m.* embryonic mesoblast; *m'.* non-embryonic mesoblast; *df.* area vasculosa; *st.* sinus terminalis; *dd.* embryonic hypoblast; *i.* non-embryonic hypoblast; *kh.* cavity of blastodermic vesicle, the greater part of which becomes the cavity of umbilical vesicle *ds.*; *dg.* stalk of umbilical vesicle; *al.* allantois; *e.* embryo; *r.* space between chorion and amnion containing albuminous fluid; *vl.* ventral body wall; *hh.* pericardial cavity.
network. The hinder end of the heart is continued into two vitelline veins, each of which divides into an anterior and a posterior branch. The anterior branch is a limb of the sinus terminalis, and the posterior and smaller branch is continued towards the hind part of the sinus, near which it ends. On its way it receives, on its outer side, numerous branches from the venous network. The venous network connects by its anastomoses, the posterior branch of the vitelline vein and the sinus terminalis.

Shortly after the establishment of the circulation of the yolk-sac the folds of the amnion meet and coalesce above the embryo (Fig. 114, 3 and 4, _am_). After this the inner or true amnion becomes severed from the outer or false amnion, though the two sometimes remain connected by a narrow stalk. The space between the true and false amnion is a continuation of the body cavity. The true amnion consists of a layer of epiblastic epithelium and generally also of somatic mesoblast, while the false amnion consists as a rule of epiblast only; though it is possible that in some cases (the rabbit?) the mesoblast may be continued along its inner face.

Before the two limbs of the amnion are completely severed the epiblast of the umbilical vesicle becomes separated from the subjacent mesoblast and hypoblast of the vesicle (Fig. 114, 3), and, together with the false amnion (_sh_) with which it is continuous, forms a complete lining for the inner face of the zona radiata. The space between this membrane and the umbilical vesicle with the attached embryo is obviously continuous with the body cavity (vide Figs. 114, 4 and 115). To this membrane Turner has given the appropriate name of _sub-zonal membrane_ : by Von Baer it was called the serous
envelope. It soon fuses with the zona radiata, or at any rate the zona ceases to be distinguishable.

While the above changes have been taking place the whole blastodermic vesicle, still enclosed in the zona, has become attached to the walls of the uterus. In the case of the typical uterus with two tubular horns, the position of each embryo, when there are several, is marked by a swelling in the walls of the uterus, preparatory to the changes in the wall which take place on the formation of the placenta. In the region of each swelling the zona around the blastodermic vesicle is closely embraced in a ring-like fashion by the epithelium of the uterine wall. The whole vesicle assumes an oval form, and it lies in the uterus with its two ends free. The embryonic area is placed close to the mesometrical attachment of the uterus. In many cases peculiar processes or villi grow out from the ovum (Fig. 144, 4, 59) which fit into the folds of the uterine epithelium. The nature of these processes requires further elucidation, but in some instances they appear to proceed from the zona (rabbit) and in other instances from the subzonal membrane (dog).

In any case the attachment between the blastodermic vesicle and the uterine wall becomes so close at the time when the body of the embryo is first formed out of the embryonic area, that it is hardly possible to separate them without laceration; and at this period—from the 8th to the 9th day in the rabbit—it requires the greatest care to remove the ovum from the uterus without injury. It will be understood of course that the attachment above described is at first purely superficial and not vascular.
The hinder end of the heart is continued into two vitelline veins, each of which divides into an anterior and a posterior branch. The anterior branch is a limit of the sinus venosus, and the (anterior and smaller branch is continued towards the head part of the sinus, near which it ends. On its way it sends, on its outer side, numerous branches from the venous network. The venous network connects, by its anastomoses, the posterior branch of the vitelline vein and the sinus venosus.

Shortly after the establishment of the circulation of the yolk-sac, the folds of the amnion meet and conjoin above the embryo (Fig. 114, 3 and 4, dm). After this the inner or true amnion becomes severed from the outer or false amnion, though the two sometimes remain connected by a narrow stalk. The space between the true and false amnion is a continuation of the body cavity. The true amnion consists of a layer of epithelial epithelium and generally also of somatic mesoblast, while the false amnion consists as a rule of epithelial only; though it is possible that in some cases (the rabbit?) the mesoblast may be continued along its inner face.

Before the two limbs of the amnion are completely severed the epiblast of the umbilical vessels becomes separated from the adjacent mesoblast and hypoblast of the vessels (Fig. 114, 3) and, together with the false amnion (a6), with which it is continuous, forms a complete lining for the inner face of the zona radiata. The space between this membrane and the umbilical vessels with the attached embryo is obviously continuous with the body cavity (side Figs. 114, 4 and 115). To this membrane Peters has given the appropriate name of subamniotic membrane; by von Baer it was called the serous
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While the above changes have been taking place the whole blastodermic vesicle, still enclosed in the zona, has become attached to the walls of the uterus. In the case of the typical uterus with two tubular horns, the position of each embryo, when there are several, is marked by a swelling in the walls of the uterus, preparatory to the changes in the wall which take place on the formation of the placenta. In the region of each swelling the zona around the blastodermic vesicle is closely embraced in a ring-like fashion by the epithelium of the uterine wall. The whole vesicle assumes an oval form, and it lies in the uterus with its two ends free. The embryonic area is placed close to the mesometric attachment of the uterus. In many cases peculiar processes or villi grow out from the ovum (Fig. 114, 4, sz) which fit into the folds of the uterine epithelium. The nature of these processes requires further elucidation, but in some instances they appear to proceed from the zona (rabbit) and in other instances from the subzonal membrane (dog). In any case the attachment between the blastodermic vesicle and the uterine wall becomes so close at the time when the body of the embryo is first formed out of the embryonic area, that it is hardly possible to separate them without laceration; and at this period—from the 8th to the 9th day in the rabbit—it requires the greatest care to remove the ovum from the uterus without injury. It will be understood of course that the attachment above described is at first purely superficial and not vascular.
During the changes above described as taking place in the amnion, the allantois grows out from the hind-gut as a vesicle lined by hypoblast, but covered externally by a layer of splanchnic mesoblast (Fig. 114, 3 and 4, al). It soon becomes a flat sac, projecting into the now largely developed space between the subzonal membrane and the amnion, on the dorsal side of the embryo (Fig. 115, ALC). In some cases it extends so as to cover the whole inner surface of the subzonal membrane; in other cases again its extension is much more limited. Its lumen may be retained or may become nearly or wholly aborted. A fusion takes place between the subzonal membrane and the adjoining mesoblastic wall of the allantois, and the two together give rise to a secondary membrane round the ovum known as the chorion. Since however the allantois does not always come in contact with the whole inner surface of the subzonal membrane the term chorion is apt to be somewhat vague; in the rabbit, for instance, a considerable part of the so-called chorion is formed by a fusion of the wall of the yolk-sac with the subzonal membrane (Fig. 116). The region of the chorion which gives rise to the placenta may in such cases be distinguished as the true chorion from the remaining part which will be called the false chorion.

The mesoblast of the allantois, especially that part of it which assists in forming the chorion, becomes highly vascular; the blood being brought to it by two allantoic arteries continued from the terminal bifur-

1 The hypoblastic element in the allantois is sometimes very much reduced, so that the allantois may be mainly formed of a vascular layer of mesoblast.
Diagram of the Placental Membranes of a Mammal. (From Turner.)

Structures which either are or have been at an earlier period of development continuous with each other are represented by the same character of shading.

ac., villous; en., umbilical membrane; E, epiblast of embryo; en., umbilical; AC, amniotic cavity; AN, mesoblast of embryo; W, hypoblast of embryo; UV, umbilical vessels; A, allantois; ALC, allantoic cavity.

...vation of the dorsal aorta, and returned to the body by one, or rarely two, umbilical veins, which join the vitelline veins from the yolk sac. From the outer membrane of the true chorion (Fig. 114, 5, ch. 7, 116) will grow and fill into crypts or depressions which have in the...
During the changes above described as taking place in the umbilicus, the allantois grows out from the hind-gut as a vesicle lined by hypoblast, but covered externally by a layer of splanchic mesoblast (Fig. 110, 3 and 4, at). It soon becomes a flat sac, projecting into the newly largely developed space between the submucous membrane and the amnion on the dorsal side of the embryo (Fig. 110, ABC). In some cases it extends so as to cover the whole inner surface of the submucous membrane; in other cases again its extension is much more limited, its hinder may be retained or may become nearly or wholly aborted. A fusion takes place between the submucous membrane and the adjoining mesoblastic wall of the allantois, and the two together give rise to a secondary membrane round the ovum known as the chorion. Since however the allantois does not always come in contact with the whole inner surface of the submucous membrane the term chorion is apt to be somewhat vague; in the rabbit, for instance, a considerable part of the so-called chorion is formed by a fusion of the wall of the yolk-sac with the submucous membrane (Fig. 110). The region of the chorion which gives rise to the placenta may in such cases be distinguished as the true chorion from the remaining part which will be called the false chorion.

The mesoblast of the allantois, especially that part of it which assists in forming the chorion, becomes highly vascular; the blood being brought to it by two allantoic arteries continued from the terminal bifurcation of hypoblast...
Diagram of the Fetal Membranes of a Mammal. (From Turner.)

Structures which either are or have been at an earlier period of development continuous with each other are represented by the same character of shading.

*pc.* zona with villi; *sz.* subzonal membrane; *E.* epiblast of embryo; *am.* amnion; *AC.* amniotic cavity; *M.* mesoblast of embryo; *H.* hypoblast of embryo; *UV.* umbilical vesicle; *al.* allantois; *ALC.* allantoic cavity.

cation of the dorsal aorta, and returned to the body by one, or rarely two, allantoic veins, which join the vitelline veins from the yolk-sac. From the outer surface of the true chorion (Fig. 114, 5, ch. 2, 116) villi grow out and fit into crypts or depressions which have in the
meantime made their appearance in the walls of the uterus. The villi of the chorion are covered by an epithelium derived from the subzonal membrane, and are provided with a connective-tissue core containing an artery and vein and a capillary plexus connecting them. In most cases they assume a more or less arborescent form, and have a distribution on the surface of the chorion varying characteristically in different species. The walls of the crypts into which the villi are fitted also become highly vascular, and a nutritive fluid passes from the maternal vessels of the placenta to the foetal vessels by a process of diffusion; while there is probably also a secretion by the epithelial lining of the walls of the crypts, which becomes absorbed by the vessels of the foetal villi. The above maternal and foetal structures constitute together the organ known as the placenta. The maternal portion consists essentially of the vascular crypts in the uterine walls, and the foetal portion of more or less arborescent villi of the true chorion fitting into these crypts.

While the placenta is being developed the folding off of the embryo from the yolk-sac becomes more complete; and the yolk-sac remains connected with the ileal region of the intestine by a narrow stalk, the vitelline duct (Fig. 114, 4 and 5 and Fig. 115), consisting of the same tissues as the yolk-sac, viz. hypoblast and splanchnic mesoblast. While the true splanchnic stalk

1 These crypts have no connection with the openings of glands in the walls of the uterus. They are believed by Ercolani to be formed to a large extent by a regeneration of the lining tissue of the uterine walls.
of the yolk-sac is becoming narrow, a somatic stalk connecting the amnion with the walls of the embryo is also formed, and closely envelopes the stalk both of the allantois and the yolk-sac. The somatic stalk together with its contents is known as the umbilical cord. The mesoblast of the somatopleure layer of the cord de- velops into a kind of gelatinous tissue which cements together the whole of the contents. The allantoic arteries in the cord wind in a spiral manner round the allantoic vein. The yolk-sac in many cases atrophies completely before the close of intra-uterine life, but in other cases it, like the other embryonic membranes, is not removed till birth. The intra-embryonic portion of the allantoic stalk gives rise to two structures, viz. to (1) the urinary bladder formed by a dilatation of its proximal extremity, and to (2) a cord known as the urachus connecting the bladder with the wall of the body at the umbilicus. The urachus, in cases where the cavity of the allantois persists till birth, remains as an open passage connecting the intra- and extra-embryonic parts of the allantois. In other cases it gradually closes, and becomes nearly solid before birth, though a delicate but interrupted lamina would appear to persist in it. It eventually gives rise to the ligamentum vesicae medium.

At birth the fetal membranes, including the fetal portion of the placenta, are shed; but in many forms the interlocking of the fetal villi with the uterine crypts is so close that the uterine mucous membrane is carried away with the fetal part of the placenta. It thus comes about that in some placenta the maternal and fetal parts simply separate from each other at birth.
measurements made their appearance in the walls of the uterus. The villi of the chorion are covered by an epithelium derived from the subchoral membrane, and are provided with a connective-tissue core containing an artery and vein and a capillary plexus connecting them. In most cases they assume a more or less arborescent form, and have a distribution on the surface of the chorion varying characteristically in different species. The walls of the crypts into which the villi are fitted also become highly vascular, and a nutritive fluid passes from the maternal vessels of the placenta to the fetal vessels by a process of diffusion; while there is probably also a secretion by the epithelial lining of the walls of the crypts, which becomes absorbed by the vessels of the fetal villi. The above mentioned and fetal structures constitute together the organ known as the placenta. The maternal portion consists essentially of the vascular crypts in the uterine walls, and the fetal portion of more or less arborescent villi of the true chorion fitting into these crypts.

While the placenta is being developed the folding off of the embryo from the yolk-sac becomes more complete, and the yolk-sac remains connected with the ileal region of the intestine by a narrow stalk, the vitelline duct (Fig. 114, 4 and 7 and Fig. 113), consisting of the same tissues as the yolk-sac, viz., hypoblast and splanchnic mesoblast. While the true splanchnic stalk

* These crypts have no connection with the openings of glands in the walls of the uterus. They are believed by Brodel to be formed to a large extent by a regeneration of the lining tissue of the uterine wall.
of the yolk-sac is becoming narrow, a somatic stalk connecting the amnion with the walls of the embryo is also formed, and closely envelopes the stalk both of the allantois and the yolk-sac. The somatic stalk together with its contents is known as the *umbilical cord*. The mesoblast of the somatopleuric layer of the cord develops into a kind of gelatinous tissue which cements together the whole of the contents. The allantoic arteries in the cord wind in a spiral manner round the allantoic vein. The yolk-sac in many cases atrophies completely before the close of intra-uterine life, but in other cases it, like the other embryonic membranes, is not removed till birth. The intra-embryonic portion of the allantoic stalk gives rise to two structures, viz. to (1) the urinary bladder formed by a dilatation of its proximal extremity, and to (2) a cord known as the urachus connecting the bladder with the wall of the body at the umbilicus. The urachus, in cases where the cavity of the allantois persists till birth, remains as an open passage connecting the intra- and extra-embryonic parts of the allantois. In other cases it gradually closes, and becomes nearly solid before birth, though a delicate but interrupted lumen would appear to persist in it. It eventually gives rise to the ligamentum vesicae medium.

At birth the foetal membranes, including the foetal portion of the placenta, are shed; but in many forms the interlocking of the foetal villi with the uterine crypts is so close that the uterine mucous membrane is carried away with the foetal part of the placenta. It thus comes about that in some placentae the maternal and foetal parts simply separate from each other at birth,
and that in others the two remain intimately locked together, and both are shed together as the after-birth. These two forms of placenta are distinguished as non-deciduate and deciduate, but no sharp line can be drawn between the two types. Moreover, a larger part of the uterine mucous membrane than that actually entering into the maternal part of the placenta is often shed in the deciduate Mammalia, and in the non-deciduate Mammalia it is probable that the mucous membrane (not including vascular parts) of the maternal placenta is either shed or absorbed.

Comparative history of the Mammalian fœtal membranes.

Two groups of Mammalia—the Monotremata and the Marsupialia—are believed not to be provided with a true placenta. Nothing is known of the arrangement of the fœtal membranes in the former group of animals (Monotremata). In the latter (Marsupialia) the yolk-sac is large and vascular, and is, according to Owen, attached to the subzonal membrane. The allantois on the other hand is but small, and is not attached to the subzonal membrane; it possesses however a vascular supply.

Observations have hitherto been very limited with regard to the fœtal membranes of this group of animals, but it appears highly probable that both the yolk-sac and the allantois receive nutriment from the walls of the uterus.

All Mammalia other than the Monotremata and Marsupialia have a true allantoic placenta. The pla-
The placenta presents a great variety of forms, and we propose to treat the most important of these in succession, and then to give a general exposition of their mutual relations.

The discoidal placenta is found in the Rodentia, Insectivora, and Chiroptera. The Rabbit may be taken as an example of this type of placenta.

The Embryo is surrounded by the amnion, which is comparatively small. The yolk-sac is large and attached to the embryo by a long stalk. It has the form of a flattened sac closely applied to about two-thirds of the surface of the umbilical membra. The outer wall of the sac, adjoining the subamnial membrane, is formed of hyaline cartilage, but the inner wall is covered by the endothelium of the yolk-vessels, as indicated by the thick black line (Fig. 116). The maternal area is bordered by the sinus terminalis (a). In an earlier stage of development the yolk-sac had not the compressed shape represented in the figure, and, however, remarkable that the vascular area never extends over the whole yolk-sac, but the outer vascular wall of the yolk-sac fuses with the outer wall, and with the umbilical umbilicus, and so forms a false chorioallantois, which receives its blood supply from the yolk-sac. This part of the chorion does not develop further.

The allantois (a) is a small, watery sac with a large cavity line of its cavity opposed to the subamnial membrane, and gives rise to the true chorion from which large project numerous vascular cords. These are interspersed with mucous crypts. It seems that from his observations, that the allantois membrane in the area of the placenta becomes attached to the umbilicus, and the chorion wall even before its fusion with the umbilicus in the later periods of gestation the mesodermal and fetal parts of the placenta become very
and that in others the two remain intimately locked together, and both are shed together as the utero-uterine. Those two series of placenta are distinguished as non-ovoviviparous and ovoviviparous, but no sharp line can be drawn between the two types. However, a larger part of the marine mammals, especially than that actually entering into the gravidinal part of the placenta is often shed in the decidua. Marsupialia and in the non-lactating Marsupialia it is probable that the mucus membrane (not including vascular parts) of the subternal placenta is either shed or absorbed.

Observations on the Mammalian Fetal Membranes.

Two groups of Marsupialia—the Monotremata and the Marsupialia—are believed not to be provided with a true placenta. Nothing is known of the arrangements of the fetal membranes in the former group of animals (Monotremata). In the latter (Marsupialia) the yolk-sac is large and yolk-sac, and is, according to Owen, attached to the subternal membrane. The allantois on the other hand is fastened, and is not attached to the subternal membrane, possesses however a vascular supply.

Observations have latterly been very limited with regard to the fetal membranes of this group of animals, but it appears highly probable that both the yolk-sac and the allantois receive attachment from the walls of the uterus.

All Mammalia other than the Monotremata and Marsupialia have a true allantoic placenta.
centa presents a great variety of forms, and we propose first to treat the most important of these in succession, and then to give a general exposition of their mutual affinities.

The discoidal placenta is found in the Rodentia, Insectivora, and Cheiroptera. The Rabbit may be taken as an example of this type of placenta.

The Rabbit. In the pregnant female Rabbit several ova are generally found in each horn of the uterus. The general condition of the foetal-membranes at the time of their full development is shewn in Fig. 116. The embryo is surrounded by the amnion, which is comparatively small. The yolk-sac (ds) is large and attached to the embryo by a long stalk. It has the form of a flattened sac closely applied to about two-thirds of the surface of the subzonal membrane. The outer wall of this sac, adjoining the subzonal membrane, is formed of hypoblast only; but the inner wall is covered by the mesoblast of the area vasculosa, as indicated by the thick black line (fd). The vascular area is bordered by the sinus terminalis (st). In an earlier stage of development the yolk-sac had not the compressed form represented in the figure. It is, however, remarkable that the vascular area never extends over the whole yolk-sac; but the inner vascular wall of the yolk-sac fuses with the outer wall, and with the subzonal membrane, and so forms a false chorion, which receives its blood supply from the yolk-sac. This part of the chorion does not develop vascular villi.

The allantois (al) is a simple vascular sac with a large cavity. Part of its wall is applied to the subzonal membrane, and gives rise to the true chorion from which there project numerous vascular villi. These fit into corresponding uterine crypts. It seems probable, from Bischoff's and Kölliker's observations, that the subzonal membrane in the area of the placenta becomes attached, by means of villi, to the uterine wall even before its fusion with the allantois. In the later periods of gestation the intermingling of the maternal and foetal parts of the placenta becomes very

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close, and the placenta is truly deciduate. The cavity of the allantois persists till birth. Between the yolk-sac, the allantois, and the embryo, there is left a large cavity filled with an albuminous fluid.

**Fig. 116.**

**Diagrammatic Longitudinal Section of a Rabbit's Ovum at an Advanced Stage of Pregnancy.** (From Kölliker after Bischoff.)

e. embryo; a. amnion; a. urachus; al. allantois with blood-vessels; sh. sub-zonal membrane; pl. placental villi; fd. vascular layer of yolk-sac; ed. hypoblastic layer of yolk-sac; ed'. inner portion of hypoblast, and ed'' outer portion of hypoblast lining the compressed cavity of the yolk-sac; ds. cavity of yolk-sac; st. sinus terminalis; r. space filled with fluid between the amnion, the allantois and the yolk-sac.

The metadiscoidal type of placenta is found in Man and the Apes. The placenta of Man may be conveniently taken as an example of this type.
Man. The early stages in the development of the fetal membranes in the human embryo have not been satisfactorily observed; but it is known that the ovum, shortly after its entrance into the uterine cavi, is attached to the uterine wall, which in the meantime has undergone considerable preparatory changes. A fold of the uterine wall appears to grow round the blastodermic vesicle, and to form a complete capsule for it; but the exact mode of formation of this capsule is a matter of inference and not of observation. During the first fortnight of pregnancy the grown-out ovum is covered with an entire surface of the ovum. The further history of the early stages is extremely obscure; what is known with reference to it will be found on p. 385 et seq.; we will here take up the history at about the fourth week.

At this stage a complete chorion has formed, and is probably derived from a growth of the mesoderm of the allantois (unaccompanied by the hypoblast) round the whole inner surface of the uvean membrane. From the whole surface of the chorion there project branched vascular processes, covered by an epithelium. The allantois is without a cavity, but a hypoblastic epithelium is present in the allantoic stalk, though not forming a continuous tube. The blood-vessels of the chorion are derived from the several allantoic arteries and veins. The general condition of the embryo and of its membranes at this period is shown diagrammatically in Fig. 114: 5. Around the embryo is seen the amnion, already separated by a considerable interval from the embryo. The yolk-sac is shown at d. Relatively to the other parts it is considerably smaller than it was at an earlier stage. The allantoic stalk is shown at e, b, and the stalk of the yolk-sac at the common œs. The chorion with its vascular processes surrounds the whole embryo.

It may be noted that the condition of the chorion at this stage is very similar to that of the normal diffuse type of placenta, described in the sequel.

While the above changes are taking place in the embryonic apparatus, the blastodermic vesicle greatly increases in size, and forms a considerable projection from the upper wall of the ovum. Three regions of the uterine wall, in relation to the
close, and the placenta is truly cotyledonean. The cavity of the allantois persists till birth. Between the yolk-sac, the allantois, and the embryo, there is left a large cavity filled with an albuminous fluid.

![Diagram of embryonic membranes and yolk-sac]

**Diagrammatic Longitudinal Section of a Rabbit's Ovum at an Advanced Stage of Pregnancy.** (From Kolliker, after Haeckel)

- a. embryo; 9. amnion; 3. vitellus; 6. allantois with blood vessels; 4. umbilical membrane; 5. placental villi; 7. vascular layer of yolk-sac; 8. hypoblastic layer of yolk-sac; 9. inner portion of hypoblast; 10. outer portion of hypoblast lining the compressed cavity of the yolk-sac; 11. cavity of yolk-sac; 12. sinus terminalis; 13. space filled with fluid between the embryo, the allantois, and the yolk-sac.

The metadiscoidal type of placenta is found in Man and the Apes. The placenta of Man may be conveniently taken as an example of this type.
Man. The early stages in the development of the fetal membranes in the human embryo have not been satisfactorily observed; but it is known that the ovum, shortly after its entrance into the uterus, becomes attached to the uterine wall, which in the meantime has undergone considerable preparatory changes. A fold of the uterine wall appears to grow round the blastodermic vesicle, and to form a complete capsule for it, but the exact mode of formation of this capsule is a matter of inference and not of observation. During the first fortnight of pregnancy villi grow out, over the whole surface of the ovum. The further history of the early stages is extremely obscure: what is known with reference to it will be found on p. 335 et seq.; we will here take up the history at about the fourth week.

At this stage a complete chorion has become formed, and is probably derived from a growth of the mesoblast of the allantois (unaccompanied by the hypoblast) round the whole inner surface of the subzonal membrane. From the whole surface of the chorion there project branched vascular processes, covered by an epithelium. The allantois is without a cavity, but a hypoblastic epithelium is present in the allantoic stalk, though not forming a continuous tube. The blood-vessels of the chorion are derived from the usual allantoic arteries and vein. The general condition of the embryo and of its membranes at this period is shewn diagrammatically in Fig. 114, 5. Around the embryo is seen the amnion, already separated by a considerable interval from the embryo. The yolk-sac is shewn at ds. Relatively to the other parts it is considerably smaller than it was at an earlier stage. The allantoic stalk is shewn at al. Both it and the stalk of the yolk-sac are enveloped by the amnion, am. The chorion with its vascular processes surrounds the whole embryo.

It may be noted that the condition of the chorion at this stage is very similar to that of the normal diffused type of placenta, described in the sequel.

While the above changes are taking place in the embryonic membranes, the blastodermic vesicle greatly increases in size, and forms a considerable projection from the upper wall of the uterus. Three regions of the uterine wall, in relation to the
blastodermic vesicle, are usually distinguished; and since the superficial parts of all of these are thrown off with the after-birth, each of them is called a decidua. They are represented at a somewhat later stage in Fig. 117. There is (1) the part of the wall reflected over the blastodermic vesicle, called the decidua reflexa (dr); (2) the part of the wall forming the area round which the reflexa is inserted, called the decidua serotina (ds); (3) the general wall of the uterus, not related to the embryo, called the decidua vera (du).

The decidua reflexa and serotina together envelop the chorion (Fig. 114. 5), the processes of which fit into crypts in them. At this period both of them are highly and nearly uniformly vascular. The general cavity of the uterus is to a large extent obliterated by the ovum, but still persists as a space filled with mucus, between the decidua reflexa and the decidua vera.

The changes which ensue from this period onwards are fully known. The amnion continues to dilate (its cavity being tensely filled with amniotic fluid) till it comes very close to the chorion (Fig. 117, am); from which, however, it remains separated by a layer of gelatinous tissue. The villi of the chorion in the region covered by the decidua reflexa, gradually cease to be vascular, and partially atrophy, but in the region in contact with the decidua serotina increase and become more vascular and more arborescent (Fig. 117, z). The former region becomes known as the chorion laeve, and the latter as the chorion frondosum. The chorion frondosum, together with the decidua serotina, gives rise to the placenta.

The umbilical vesicle (Fig. 117, nb), although it becomes greatly reduced in size and flattened, persists in a recognisable form till the time of birth.

The decidua reflexa, by the disappearance of the vessels in the chorion laeve, becomes non-vascular. Its tissue and that of the decidua vera undergo changes which we do not propose to describe here; it ultimately fuses on the one hand with the chorion, and on the other with the decidua vera. The membrane resulting from its fusion with the latter structure becomes thinner and thinner as pregnancy advances, and is reduced to a thin layer at the time of birth.
Diagrammatic Section of Pregnant Human Uterus with Contained Fetus. (From Hurley after Langlet.)

a. allantoic stalk; ab. unattached vesicle; ac. amnion of chorion; ad. decidua necrotica; ae. decidua vera; af. decidua reflexa; ag. biliophas tube; ah. cervix uteri; ai. uterus; aj. villi of true placenta; ak. villi of non-placental part of chorion.

The placenta has a somewhat discoidal form, with a slightly convex uterine surface and a concave embryonic surface. At its edge it is continuous both with the decidua reflexa and decidua vera. Near the centre of the embryonic surface is implanted the umbilical cord. As has already been mentioned, the placenta is formed of the chorion necrotica and the basal villi of the chorion frondosum. The fetal and maternal tissues are far more closely united than in the placenta of the rabbit. The villi of the uterus, which were originally comparatively simple, become more and more complicated, and assume an extremely arborescent form. At birth the whole placenta, together with the fused de-
blastocelemic vessels, are usually distinguished; and when the superficial parts of all of these are thrown off with the after-limin. each of them is called a decidua. They are represented at a somewhat later stage in Fig. 147. There is (1) the part of the wall reflected over the blastocelemic vessel, called the decidua reflexa (de); (2) the part of the wall forming the area around which the reflexa is inserted, called the decidua reaction (dc); (3) the general wall of the uterus, not related to the embryo, called the decidua vera (dv).

The decidua reflexa and reaction together envelop the chorion (Fig. 144-9), the processes of which sink into crevices in them. At this period both of them are highly and nearly uniformly vascular. The general cavity of the uterus is to a large extent obliterated by the amnion, but still persists as a space filled with mucus between the decidua reflexa and the decidua vera.

The changes which ensue from this period onwards are fully known. The amnion continues to dilate (its cavity being tautly filled with amniotic fluid) till it comes very close to the chorion (Fig. 117, ab); from which, however, it remains separated by a layer of gelatinous tissue. The villi of the chorion in the region covered by the decidua reflexa, gradually cease to be vascular; and partially atrophy, but in the region in contact with the decidua reaction increase and become more vascular and more suberoseulent (Fig. 117, a). The former region becomes known as the chorion frondosum, and the latter as the chorion laeve. The chorion frondosum, together with the decidua reaction, grows near to the placenta.

The umbilical vessel (Fig. 117, ab), although it becomes greatly reduced in size and fastened, persists in a recognizable form till the time of birth.

The decidua vera, by the disappearance of the vessels in the chorion laeve, becomes non-vascular. Its inner and outer of the decidua vera undergo changes which we do not propose to describe here; it ultimately fuses on the one hand with the chorion, and on the other with the decidua vera. The membranes resulting from its union with the latter structure becomes thinner and thinner as pregnancy advances, and is reduced to a thin layer at the time of birth.
Diagrammatic Section of Pregnant Human Uterus with Contained Fetus. (From Huxley after Longet.)

al. allantoic stalk; nb. umbilical vesicle; am. amnion; ch. chorion; ds. decidua serotina; du. decidua vera; dr. decidua reflexa; l. fallopian tube; c. cervix uteri; u. uterus; z. fetal villi of true placenta; z'. villi of non-placental part of chorion.

The placenta has a somewhat discoidal form, with a slightly convex uterine surface and a concave embryonic surface. At its edge it is continuous both with the decidua reflexa and decidua vera. Near the centre of the embryonic surface is implanted the umbilical cord. As has already been mentioned, the placenta is formed of the decidua serotina and the fetal villi of the chorion frondosum. The fetal and maternal tissues are far more closely united than in the placenta of the rabbit. The villi of the chorion, which were originally comparatively simple, become more and more complicated, and assume an extremely arborescent form. At birth the whole placenta, together with the fused de-
cidua vera, and reflexa, with which it is continuous, is shed; and the blood-vessels thus ruptured are closed by the contraction of the uterine walls.

The metadiscoidal placenta of Man and Apes and the discoidal placenta of the Rabbit are usually classified by anatomists as discoidal placentae, but it must be borne in mind that they differ very widely.

In the Rabbit there is a dorsal placenta, which is co-extensive with the area of contact between the allantois and the subzonal membrane, while the yolk-sac adheres to a large part of the subzonal membrane. In Apes and Man the allantois spreads over the whole inner surface of the subzonal membrane; the placenta is on the ventral side of the embryo, and occupies only a small part of the surface of the allantois.

**Zonary placenta.** Another form of deciduate placenta is known as the zonary. This form of placenta occupies a broad zone of the chorion, leaving the two poles free. It is found in the Carnivora, Hyrax, Elephas, and Orycteropus.

In the Dog, which may be taken as a type, there is a large vascular yolk-sac formed in the usual way, which does not however fuse with the chorion. It has at first an oval shape, and persists till birth. The allantois first grows out on the dorsal side of the embryo, where it coalesces with the subzonal membrane, over a small discoidal area, and there is thus formed a rudimentary discoidal placenta closely resembling that of the Rabbit.

The area of adhesion between the outer part of the allantois and subzonal membrane gradually spreads over the whole interior of the subzonal membrane, and vascular villi are formed over the whole area of adhesion except at the two extreme poles of the ovum.

With the full growth of the allantois there is formed a broad placental zone, with numerous branched villi fitting into corresponding pits which are not true glands but special develop-
thickness of the uterine surface. The maternal and fetal structures become closely intermingled and highly vascular, and at birth a large part of the maternal part is carried away with the placenta; some of it however still remains attached to the muscular wall of the uterus. The scars of the placenta diminish greatly in proportion to the chorion as the latter elongates, and at the full time the breadth of the mesos is not more than about one-fifth of the whole length of the chorion.

At the edge of the potential space there is a very small portion of the uterine mucous membrane reflected over the non-placental part of the chorion, so as to form a small reflexa analogous with the reflexa in Man.

The most important of the remaining types of placentae are the diffuse and the polycotyledonary, and these placenta are for the most part non-deciduate. In the diffuse placenta, found in the Horse, Pig, Lemurs, etc., the allantois completely envelopes the embryo, and villi are formed on all parts of the chorion, excepting over a small area at the two poles.

In the polycotyledonary placenta, which is characteristic of the Primates, the allantois grows round the whole inner surface of the subamnial membrane; the placental villi are however not uniformly distributed, but collected into patches or cotyledons, which form as it were so many small placenta. The total villi of these patches fit into corresponding pits in thickened patches of the wall of the uterus.

Comparative Anatomy of the Placenta.

It does not fall within the province of this work to treat from a histological standpoint the changes which take place in the uterine walls during pregnancy. It will, however, be convenient to place before the reader
main ves.

d and vagina, with which is continuous, is shed, and the blood-vessels thus exposed are closed by the contraction of the uterine walls.

The metadiscal placenta of Man and Apes and the discoidal placenta of the Rabbit are usually classified by anatomists as discoidal placentae, but it must be borne in mind that they differ very widely.

In the Rabbit there is a discoidal placenta, which is an extensive with the area of contact between the allantois and the subamnion membrane, while the rest we adhere to a large part of the subamnion membrane. In Apes and Man the allantois extends over the entire outer surface of the subamnial membrane, but it only a small part of the surface of the allantois.

**Epithelial Placenta.** Another form of deciduate placenta is known as the epithelial placenta. This form of placenta occupies a smaller area of the allantois, leaving the two poles free. It is found in the Carnivora, Hyrax, Elephas, and Gryzomorpha.

In the Dog, which may be taken as a type, there is a large vascular peduncle formed in the usual way, which does not however fuse with the chorion. It has at first an oval shape, and persists till birth. The allantois first grows out on the dorsal side of the embryo, where it continues with the subamnial membrane, over a small discoidal area, and there is thus formed a rudimentary discoidal placenta closely resembling that of the Rabbit.

The area of adhesion between the outer part of the allantois and subamnial membrane gradually spreads over the whole interior of the subamnial membranes, and vascular villi are formed over the whole area of adhesion except at the two extreme poles of the ovum.

With the full growth of the allantois there is formed a broad placental zone, with numerous branched villi fitting into corresponding pits which are not true glands but special develop-
ments of the uterine surface. The maternal and foetal structures become closely interlocked and highly vascular; and at birth a large part of the maternal part is carried away with the placenta; some of it however still remains attached to the muscular wall of the uterus. The zone of the placenta diminishes greatly in proportion to the chorion as the latter elongates, and at the full time the breadth of the zone is not more than about one-fifth of the whole length of the chorion.

At the edge of the placental zone there is a very small portion of the uterine mucous membrane reflected over the non-placental part of the chorion, so as to form a small reflexa analogous with the reflexa in Man.

The most important of the remaining types of placenta are the diffuse and the polycotyledonary, and these placenta are for the most part non-deciduate. In the diffuse placenta, found in the Horse, Pig, Lemurs, etc., the allantois completely envelopes the embryo, and villi are formed on all parts of the chorion, excepting over a small area at the two poles.

In the polycotyledonary placenta, which is characteristic of the Ruminantia, the allantois grows round the whole inner surface of the subzonal membrane; the placental villi are however not uniformly distributed, but collected into patches or cotyledons, which form as it were so many small placenta. The foetal villi of these patches fit into corresponding pits in thickened patches of the wall of the uterus.

**Comparative histology of the Placenta.**

It does not fall within the province of this work to treat from a histological standpoint the changes which take place in the uterine walls during pregnancy. It will, however, be convenient to place before the reader
a short statement of the relations between the maternal and foetal tissues in the different varieties of placenta.

The simplest known condition of the placenta is that found in the pig (Fig. 118 II.). The papilla-like foetal villi fit into the maternal crypts. The villi (v) are formed of a connective tissue core with capillaries, and are covered by a layer of very flat epithelium (e) derived from the subzonal membrane. The maternal crypts are lined by the uterine epithelium (e'), immediately below which is a capillary plexus. The maternal and foetal vessels are here separated by a double epithelial layer. The same general arrangement holds good in the diffused placenta of other forms, and in the polycotyledonary placenta of the Ruminantia, but the foetal villi in the latter (III.) acquire an arborescent form. The maternal vessels retain the form of capillaries.

In the deciduate placenta a much more complicated arrangement is usually found. In the typical zonary placenta of the fox and cat (IV. and V.), the maternal tissue is broken up into a complete trabecular meshwork, and in the interior of the trabeculae there run dilated maternal capillaries (d'). The trabeculae are covered by a more or less columnar uterine epithelium (e'), and are in contact on every side with foetal villi. The capillaries of the foetal villi preserve their normal size, and the villi are covered by a flat epithelial layer (e).

In the Sloth (VI.) which has a discoidal placenta the maternal capillaries become still more dilated, and the epithelium covering them is formed of very flat polygonal cells.
a short statement of the relations between the maternal and fetal tissues in the different varieties of placenta.

The simplest known condition of the placenta is that found in the pig (Fig. 113 II). The papilla-like fetal villi fit into the maternal crypts. The villi (e) are formed of a connective tissue core with capillaries, and are covered by a layer of very flat epithelium (a) derived from the uterine membrane. The maternal crypts are lined by the uterine epithelium (a), immediately below which is a capillary plexus. The maternal and fetal vessels are here separated by a double epithelial layer. The same general arrangement holds good in the diffuse placenta of other forms, and in the polycapillary placentas of the Ruminants, but the fetal villi in the latter (III.) acquire an arborescent form. The maternal vessels retain the form of capillaries.

In the deciduate placenta a much more complicated arrangement is usually found. In the typical uterine placentas of the fox and cat (IV. and V.), the maternal tissue is broken up into a complete trabecular meshwork, and in the interior of the trabeculae there run dilated maternal capillaries (a'). The trabeculae are covered by a more or less columnar uterine epithelium (a'), and are in contact on every side with fetal villi. The capillaries of the fetal villi preserve their normal size, and the villi are covered by a flat epithelial layer (a).

In the Sloth (VII) which has a discoidal placenta, the maternal capillaries become still more dilated, and the epithelium covering them is formed of very flat polygonal cells.
HISTOLOGY OF THE PLACENTA.

Fig. 118.

I.

II.

III.

IV.
EMBRYONIC MEMBRANES AND YOLK-SAC. [CHAP.
DIAGRAMMATIC REPRESENTATION OF THE MINUTE STRUCTURE OF THE PLACENTA. (FROM TAYLOR)

F, the fetal; M, the maternal placenta; e, epithelium of chorion; e', epithelium of maternal placenta; d, fetal blood-vessels; d', maternal blood-vessels; w, villus.

I. Placentae in its most generalised form. II. Structure of placenta of a Pig. III. Of a Cow. IV. Of a Fox. V. Of a Cat.

VI. Structure of placentae of a Sloth. On the right side of the figure the flat maternal epithelial cells are shown in e'. On the left side they are removed, and the dilated maternal vessel with its blood-oesynecules is exposed.

VII. Structure of Human placenta. In addition to the letters already referred to, a, de. a represents the decidua serotina of the placenta; r, r', tractus umbilicalis sertolii passing to the fetal villi; en, curing artery; sp, uterine placental vein; a, a prolongation of maternal tissue on the exterior of the villus outside the cellular layer; x, which may represent either the endothelium of the maternal blood-vessel or delicate connective tissue belonging to the serotina, or both. The layer x represents maternal cells derived from the serotina. The layer of fetal epithelium cannot be seen on the villi of the fully formed human placenta.

In the human placenta (VII.), as in that of Apes, the greatest modification is found. Here the maternal vessels have completely lost their capillary form, and have become expanded into large freely communicating anuses (d'). In these anuses the fetal villi hang for the most part freely, though occasionally attached to their walls by strands of tissue (f). In the late stages of fetal life there is only one epithelial layer (e') between the maternal and fetal vessels, which closely invades the fetal villi, but is part of the uterine tissue. In the fetal villi the vessels retain their capillary form.
Diagrammatic Representations of the Minute Structure of the Placenta. (From Turner.)

F. the foetal; M. the maternal placenta; e. epithelium of chorion; e'. epithelium of maternal placenta; d. foetal blood-vessels; d'. maternal blood-vessels; v. villus.

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VI. Structure of placenta of a Sloth. On the right side of the figure the flat maternal epithelial cells are shewn in situ. On the left side they are removed, and the dilated maternal vessel with its blood-corpuscles is exposed.

VII. Structure of Human placenta. In addition to the letters already referred to, ds, ds. represents the decidua serotina of the placenta; t, t. trabeculae of serotina passing to the foetal villi; ca. curling artery; up. utero-placental vein; x. a prolongation of maternal tissue on the exterior of the villus outside the cellular layer e', which may represent either the endothelium of the maternal blood-vessel or delicate connective tissue belonging to the serotina, or both. The layer e' represents maternal cells derived from the serotina. The layer of foetal epithelium cannot be seen on the villi of the fully-formed human placenta.

In the human placenta (VII.), as in that of Apes, the greatest modification is found. Here the maternal vessels have completely lost their capillary form, and have become expanded into large freely communicating sinuses (d'). In these sinuses the foetal villi hang for the most part freely, though occasionally attached to their walls by strands of tissue (t). In the late stages of foetal life there is only one epithelial layer (e') between the maternal and foetal vessels, which closely invests the foetal villi, but is part of the uterine tissue. In the foetal villi the vessels retain their capillary form.
Evolution of the placenta. Excluding the marsupials whose placentation is not really known, the arrangement of the foetal membranes of the Rabbit is the most primitive observed. In this type the allantois and yolk-sac both function in obtaining nutriment from the mother; and the former occupies only a small discoidal area of the subzonal membrane. In all higher types the allantois gradually spreads out over the whole inner surface of the subzonal membrane and its importance increases; while that of the yolk-sac as a nutritive organ decreases. In the diffuse type of placenta simple villi are present over nearly the whole surface of the chorion. In the remaining types the villi become more complicated and restricted to a smaller area (meta-discoidal, zonary, &c.) of the chorion; though in the early stages they are more scattered and simpler, in some cases occupying nearly the whole surface of the chorion. It therefore seems probable that the placenta of Man has been derived not directly from the discoidal placenta of the Rabbit, but from the diffuse placenta such as is seen in the Lemurs, etc., and that generally the zonary, cotyledonary, &c. types of placenta have been derived from the diffuse by a concentration and increase in the complexity of the foetal villi.
CHAPTER XII.

THE DEVELOPMENT OF THE ORGANS IN MAMMALIA.

In chap. X. we have described the early stages and general development of the mammalian embryo. In the present chapter we propose to examine the formation of such mammalian organs as differ in their development from those of the chick. This will not be a work of any considerable extent, as in all essential points the development of the organs in the two groups is the same. They will be classified according to the germinal layers from which they originate.

THE ORGANS DERIVED FROM THE EPIBLAST.

Hairs are formed in solid processes of the deep (Malpighian) layer of the epidermis, which project into the subjacent dermis. The hair itself arises from a cornification of the cells of the axis of one of the above processes, and is invested by a sheath similarly formed from the more superficial epidermic cells. A small papilla of the dermis grows up the inner end of the epidermic process when the hair is first formed. The
Evolution of the placenta. Excluding the marsupials whose placentaion is not really known, the arrangement of the fetal membranes of the Rabbit is the most primitive observed. In this type the allantois and yolk-sac both function in obtaining nourishment from the mother; and the former occupies only a small discoidal area of the vitelline membrane. In all higher types the allantois gradually spreads out over the whole inner surface of the vitelline membrane and its importance increases; while that of the yolk-sac as a nutritive organ decreases. In the diffuse type of placenta simple villi are present over nearly the whole surface of the chorion. In the remaining types the villi become more complicated and restricted to a smaller area (meto-
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first trace of the hair appears close to this papilla, but soon increases in length, and when the end of the hair projects from the surface, the original solid process of the epidermis becomes converted into an open pit, the lumen of which is filled by the root of the hair.

The development of nails has been already described on p. 283.

Glands. The secretory part of the various glandular structures belonging to the skin is invariably formed from the epidermis. In Mammalia it appears that these glands are always formed as solid ingrowths of the Malpighian layer. The ends of these ingrowths dilate to form the true glandular part of the organs, while the stalks connecting the glandular portions with the surface form the ducts. In the case of the sweat-glands the lumen of the duct becomes first established; its formation is inaugurated by the appearance of the cuticle, and appears first at the inner end of the duct and thence extends outwards. In the sebaceous glands the first secretion is formed by a fatty modification of the whole of the central cells of the gland.

The muscular layer of the secreting part of the sweat-glands is said to be formed from a modification of the deeper layer of the epidermic cells.

The mammary glands arise in essentially the same manner as the other glands of the skin. The glands of each side are formed as a solid bud of the Malpighian layer of the epidermis. From this bud processes sprout out, each of which gives rise to one of the numerous glands of which the whole organ is formed.
The central nervous system.

The development of the spinal cord in Mammals differs in important respects from that of the chick, and we have nothing to add to the account we have already given of its general development and histogenesis in that animal. The development of the brain however will be described at greater length, and some additional facts relative to the development of the Avian brain will be mentioned.

The first differentiation of the brain takes place in Mammals before the closure of the medullary folds, and results as in the chick in the formation of the three cerebral vesicles, the fore-, mid- and hind-brain (Fig. 106, B). A cranial fissure precisely resembling that of the chick soon makes its appearance.

The hind brain early becomes divided into two regions, the rudimentary medulla oblongata and cerebellum.

The posterior section, the medulla, undergoes changes of a somewhat complicated character. In the first place its roof becomes very much extended and thinned out. At the raphe, where the two lateral halves of the brain originally united, a separation, as it were, takes place, and the two sides of the brain become reeled apart, remaining united by only a very thin layer of nervous matter, consisting of a single row of flattened cells (Fig. 40). As a result of this peculiar growth in the brain, the roots of the nerves of the two sides, which were originally in contact at the dorsal summit of the brain, become carried away from one another, and appear to rise at the sides of the brain.
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The muscular layer of the secreting part of the sweat-glands is able to be formed from a modification of the deeper layer of the epidermic cells.

The mammary glands arise in essentially the same manner as the other glands of the skin. The glands of each side are formed as a solid mass of the Malpighian layer of the epidermis. From this bud processes spring out, each of which gives rise to one of the numerous glands of which the whole organ is formed.
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The thin roof of the fourth ventricle thus formed is somewhat rhomboidal in shape.

At a later period the blood-vessels of the pia mater form a rich plexus over the anterior part of this thin roof which becomes at the same time somewhat folded. The whole structure is known as the *tela vasculosa* or *choroid plexus of the fourth ventricle* (Fig. 119, *chd 4*). The floor of the whole hind-brain becomes thickened, and there very soon appears on its outer surface a layer of longitudinal non-medullated nerve-fibres, similar to those which first appear on the spinal cord (p. 252). They are continuous with a similar layer of fibres on the floor of the mid-brain, where they constitute the *crura cerebri*. On the ventral floor of the fourth ventricle is a shallow continuation of the anterior fissure of the spinal cord.

Subsequently to the longitudinal fibres already spoken of, there develop first the olivary bodies of the ventral side of the medulla, and at a still later period the pyramids. The *fasciculi teretes* in the cavity of the fourth ventricle are developed shortly before the pyramids.

When the hind-brain becomes divided into two regions the roof of the anterior part does not become thinned out like that of the posterior, but on the contrary, becomes somewhat thickened and forms a band-like structure roofing over the anterior part of the fourth ventricle (Fig. 39 cb).

This is a rudiment of the cerebellum, and in all Craniate Vertebrates it at first presents this simple structure and insignificant size.

In Birds the cerebellum attains a very considerable development (Fig. 119 *cbl*), consisting of a folded central
With an axial view, into which the fourth ventricle prolonged. There are two small lateral lobes appropriate variations to the flocculi.

In Man and the mammalia, the cerebellum attains a still greater development. The median lobe or vermiciform process

**Fig. 139**

**CONTRALateral SECTION THROUGH THE BRAIN OF A Chicken OF Ten Days. (After M. I. B.)**

- cerebellum hemispheres: \( \text{cbl} \), olfactory, \( \text{dht} \); \( \text{dht} \), olfactory ventr.; \( \text{gth} \), corpus striatum, \( \text{cm} \), anterior commissure; \( \text{cm} \), choroid plexus of the third ventricle; \( \text{mnp} \), pineal gland; \( \text{mpc} \), posterior commissure; \( \text{mnp} \), lateral ventricle; \( \text{an} \), optic chiasma; \( \text{inb} \), infundibulum; \( \text{hbs} \), pituitary body; \( \text{an} \), commissure of Sylvius (root of fer dente subventricosum, \( \text{cm} \), conus medullaris, \( \text{cnc} \), ventr. medulla lateralis, \( \text{cnc} \), ventr. medulla anterior, \( \text{cnc} \), ventr. medullaris, \( \text{cnc} \), ventr. medullaris, \( \text{cm} \), medulla oblongata; \( \text{mna} \), cranial nerve; \( \text{mna} \), median artery; \( \text{mna} \), internal carotid.
The thin roof of the fourth ventricle thus formed is somewhat rhomboidal in shape.

At a later period the blood-vessels of the pia mater form a rich plexus over the anterior part of this thin roof which becomes at the same time somewhat folded. The whole structure is known as the tela choroidea or choroid plexus of the fourth ventricle (Fig. 119, obt. 4). The floor of the whole hind-brain becomes thickened, and there very soon appears on its outer surface a layer of longitudinal non-medullated nerve-fibres, similar to those which first appear on the spinal cord (p. 293). They are continuous with a similar layer of fibres on the floor of the mid-brain, where they constitute the crura cerebri. On the ventral floor of the fourth ventricle is a shallow continuation of the anterior flexure of the spinal cord.

Subsequently, in the longitudinal tubes already spoken of, these develop into the olivary bodies of the ventral side of the medulla, and at a still later period the pyramids. The fascial layers in the cavity of the fourth ventricle are developed shortly before the pyramids.

When the hind-brain becomes divided into two regions the roof of the anterior part does not become thinned out like that of the posterior, but on the contrary, becomes somewhat thickened and forms a band-like structure covering over the anterior part of the fourth ventricle (Fig. 29 c). This is a rudiment of the cerebellum, and in all Craniate Vertebrates at first presents this simple structure and insignificant size.

In Birds the cerebellum attains a very considerable development (Fig. 119 cef), consisting of a folded central
lobe with an arbor vitae, into which the fourth ventricle is prolonged. There are two small lateral lobes, apparently equivalent to the flocculi.

In Mammalia the cerebellum attains a still greater development. The median lobe or vermiciform process

LONGITUDINAL SECTION THROUGH THE BRAIN OF A CHICK OF TEN DAYS. (After Mihalkovics.)

hms. cerebral hemispheres; alf. olfactory lobe; alf, olfactory nerve; ggt. corpus striatum; oma. anterior commissure; chd 3. choroid plexus of the third ventricle; pin. pineal gland; cmp. posterior commissure; trm. lamina terminalis; chm. optic chiasma; inf. infundibulum; hph. pituitary body; bgm. commissure of Sylvius (roof of iter a tertio ad quartum ventriculum); vma. velum medullae anterius (valve of Vieussens); obl. cerebellum; chd 4. choroid plexus of the fourth ventricle; obt 4. roof of fourth ventricle; obl. medulla oblongata; pns. commissural part of medulla; inv. sheath of brain; bls. basilar artery; erts. internal carotid.
is first developed. In the higher Mammalia the lateral parts constituting the hemispheres of the cerebellum become formed as swellings at the sides at a considerably later period; these are hardly developed in the Monotremata and Marsupialia.

The cerebellum is connected with the roof of the mid-brain in front and with the choroid plexus of the fourth ventricle behind by delicate membranous structures, known as the velum medullæ anterius (valve of Vieussens) (Fig. 119 vma) and the velum medullæ posterius.

The pons Varolii is formed on the ventral side of the floor of the cerebellar region as a bundle of transverse fibres at about the same time as the olivary bodies. It is represented in Birds by a small number of transverse fibres on the floor of the hind-brain immediately below the cerebellum.

**The mid-brain.** The changes undergone by the mid-brain are simpler than those of any other part of the brain. It forms, on the appearance of the cranial flexure, *an unpaired vesicle* with a vaulted roof and curved floor, at the front end of the long axis of the body (Fig. 67, MB). It is at this period in Mammalia as well as in Aves relatively much larger than in the adult: its cavity is known as the *iter a tertio ad quartum ventriculunum* or *aqueductus Sylvii*.

The roof of the mid-brain is sharply constricted off from the divisions of the brain in front of and behind it, but these constrictions do not extend to the floor.

In Mammalia the roof and sides give rise to two pairs of prominences, the corpora quadrigemina.

These prominences, which are simply thickenings not containing any prolongations of the iter, become
first visible on the appearance of an oblique transverse furrow, by which the whole mid-brain is divided into an anterior and posterior portion. The anterior portion is further divided by a longitudinal furrow into the two anterior tubercles (nates); but it is not until later on that the posterior portion is similarly divided longitudinally into the two posterior tubercles (fetes).

The floor of the mid-brain, bounded posteriorly by the pons Varolii, becomes developed and thinned into the crura cerebri. The corpora geniculata interna also belong to this division of the brain.

Fore-brain. The early development of the fore-brain in Manmats is the same as in the chick. It forms at first a single vesicle without a trace of separate divisions, but very early buds off the optic vesicles, whose history is described with that of the eye. The anterior part becomes prolonged and at the same time somewhat dilated. At first there is no sharp boundary between the primitive fore-brain and its anterior prolongation, but there shortly appears a constriction which passes from above obliquely forwards and downwards.

Of these two divisions the posterior becomes the thalamencephalon, while the anterior and larger division forms the rudiment of the cerebral hemispheres (Fig. 69, see) and olfactory lobes. For a considerable period this rudiment remains perfectly simple and exhibits no signs, either externally or internally, of a longitudinal constriction dividing it into two lobes.

The thalamencephalon forms at first a simple vesicle, the walls of which are of a nearly uniform thickness and framed of the usual spindle-shaped cells.
In the higher Mammalia the latest parts constituting the hemispheres of the cerebrum have become, if not actually extended at the sides at a considerably later period, these are hardly developed in the Monotremata and Marsupialia.

The ventricle is connected with the roof of the mid-brain by a series of transverse fibres at the hinder part of the fourth ventricle. This is the intercommunist. It is represented in Birds by the crus cerebri. These transverse fibres on the floor of the mid-brain form the tegmentum.

The mid-brain. The changes undergone by the mid-brain are simpler than those of any other part of the brain. It forms the appearance of the cranial nerves are separated from it, a vaulted roof and a ventricle at the front and of the long axis of the body, and the cavity of the brain in front of and behind it, and these constrictions do not extend to the back.

In Mammalia the roof and sides give rise to cunei of commissures, the corpora quadrigemina.

These prominences, which are simply thickenings, do not contain any prolongations of the flexure, between
first visible on the appearance of an oblique transverse furrow, by which the whole mid-brain is divided into an anterior and posterior portion. The anterior portion is further divided by a longitudinal furrow into the two anterior tubercles (nates); but it is not until later on that the posterior portion is similarly divided longitudinally into the two posterior tubercles (testes).

The floor of the mid-brain, bounded posteriorly by the pons Varolii, becomes developed and thickened into the crura cerebri. The corpora geniculata interna also belong to this division of the brain.

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The thalamencephalon forms at first a simple vesicle, the walls of which are of a nearly uniform thickness and formed of the usual spindle-shaped cells.
The cavity it contains is known as the third ventricle. Anteriorly it opens widely into the cerebral rudiment, and posteriorly into the ventricle of the mid-brain. The opening into the cerebral rudiment becomes the foramen of Monro.

For convenience of description we may divide the thalamencephalon into three regions, viz. (1) the floor, (2) the sides, and (3) the roof.

The floor becomes divided into two parts: an anterior part, giving origin to the optic nerves, in which is formed the optic chiasma; and a posterior part, which becomes produced into a prominence at first inconspicuous—the rudiment of the infundibulum (Fig. 39 In). This comes in contact with the involution from the mouth which gives rise to the pituitary body (Fig. 39 pt).

In Birds, although there is a close connection between the pituitary body and the infundibulum, there is no actual fusion of the two. In Mammalia the case is different. The part of the infundibulum which lies at the hinder end of the pituitary body is at first a simple finger-like process of the brain (Fig. 120 inf); but its end becomes swollen, and the lumen in this part becomes obliterated. Its cells, originally similar to those of the other parts of the nervous system, and even containing differentiated nerve-fibres, partly atrophy and partly assume an indifferent form, while at the same time there grow in amongst them numerous vascular and connective-tissue elements. The process of the infundibulum thus metamorphosed becomes inseparably connected with the true pituitary body, of which it is usually described as the posterior lobe.
In the later stages of development the intraventricular portion of the infundibulum becomes gradually elongated and forms an elongated diverticulum of the third ventricle, the apex of which is in contact with the pituitary body (Fig. 120 A). The posterior part of the primitive infundibulum becomes the corpus albicans, which is double in Man and the Higher Apes; the ventral part of the posterior wall forms the tuber cinereum. Lateral to, at the junction of the optic thalami and infundibulum, there are contained some of the fibres of the crura cerebri, which are probably derived from the walls of the infundibulum.

The sides of the thalamencephalon become very early thickened to form the optic thalami, which constitute the most important section of the thalamencephalon. These are separated on their inner aspect from the infundibular region by a somewhat S-shaped groove, known as the sulcus of Monro, which ends in the foramen of Monro. They also become secondarily united by a transverse commissure, the grey or middle commissure, which passes across the cavity of the third ventricle.

The roof undergoes more complicated changes. It becomes divided, on the appearance of the pineal gland as a small papilloid outgrowth (the development of which is dealt with below), into two regions—a longer anterior in front of the pineal gland, and a shorter posterior. The anterior region becomes at an early period excessively thin, and at a later period, when the roof of the thalamencephalon is shortened by the approach of the cerebrat hemispheres to the mid-brain, it becomes (see Fig. 120 c and d) considerably folded, while at the same time a vascular plexus is formed in the pia mater.
The cavity it contains is known as the third ventricle. Anteriorly it opens widely into the cerebral rudiment, and posteriorly into the ventricles of the mid-brain. The opening into the cerebral rudiment becomes the fornix of Muro.

For convenience of description we may divide the thalamencephalon into three regions, viz. (1) the floor, (2) the sides, and (3) the roof.

The floor becomes divided into two parts: an anterior part, giving origin to the optic nerves, in which is formed the optic chiasma; and a posterior part, which becomes produced into a prominence at first inconspicuous—the rudiment of the infundibulum (Fig. 297). This comes in contact with the involution from the mouth which gives rise to the pituitary body (Fig. 29 p).

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In the later stages of development the unchanged portion of the infundibulum becomes gradually prolonged and forms an elongated diverticulum of the third ventricle, the apex of which is in contact with the pituitary body (Fig. 120 3).

The posterior part of the primitive infundibulum becomes the corpus albicans, which is double in Man and the higher Apes; the ventral part of the posterior wall forms the tuber cinereum. Laterally, at the junction of the optic thalami and infundibulum, there are continued some of the fibres of the crura cerebri, which are probably derived from the walls of the infundibulum.

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LONGITUDINAL VERTICAL SECTION THROUGH THE ANTERIOR PART OF THE BRAIN OF AN EMBRYO RABBIT OF FOUR CENTIMETRES. (After Mihalkovics.)

The section passes through the median line so that the cerebral hemispheres are not cut; their position is however indicated in outline.

spt. septum lucidum formed by the coalescence of the inner walls of part of the cerebral hemispheres; cma. anterior commissure; frx. vertical pillars of the fornix; cal. genu of corpus callosum; trm. lamina terminalis; hms. cerebral hemispheres; olf. olfactory lobes; ad. artery of corpus callosum; fmr. position of foramen of Monro; chd 3. choroid plexus of third ventricle; pin. pineal gland; cmp. posterior commissure; bgm. lamina uniting the lobes of the mid-brain; chm. optic chiasma; hph. pituitary body; inf. infundibulum; pns. pons Varolii; pde. cerebral peduncles; agd. iter a tertio ad quartum ventriculum.
above it. On the accomplishment of these changes it is known as the tela choroidea of the third ventricle.

In the roof of the third ventricle behind the pineal gland there appear transverse commissural sheets forming a structure known as the posterior commissure, which connects together the two optic thalami.

The most remarkable organ in the roof of the thalamencephalon is the pineal gland, which is developed as a hollow papilliform outgrowth of the roof, and is at first composed of cells similar to those of the other parts of the central nervous system (Fig. 120 pm). It is directed backwards over the hinder portion of the roof of the thalamencephalon.

In Birds (p. 116) the primitive outgrowth to form the pineal gland becomes deeply indented by vascular connective-tissue ingrowths, so that it assumes a dendritic structure (Fig. 119 pm). The proximal extremity attached to the roof of the thalamencephalon soon becomes solid and forms a special section, known as the infra-pineal process. The central portion of the inner part of the gland finally atrophies, but the branches still remain hollow. The infra-pineal process becomes reduced to a narrow stalk, connecting the branched portion of the body with the brain.

In Mammalia the development of the pineal gland is generally similar to that of Birds. The original outgrowth becomes branched, but the foliules or lobes to which the branching gives rise eventually become solid (Fig. 120 pm). An infra-pineal process is developed comparatively late, and is not sharply separated from the roof of the brain.

No satisfactory suggestions have yet been offered as
The figure shows a section of the nervous system in such a way that the nerve tracts can be seen clearly, and their position is however indicated in outline.

For example, the anterior commissure is shown on each of the inner walls of the optic chiasm, and the posterior commissure is placed in the lower part of the brain. The cerebral hemispheres are shown in section, with the pons, pyramids, and cerebellum. The thalami of the optic thalami are also indicated, as well as the brachium of the midbrain. The posterior commissure is shown as a thick line, and the rest of the brain is shown in outline.
above it. On the accomplishment of these changes it is known as the tela choroidea of the third ventricle.

In the roof of the third ventricle behind the pineal gland there appear transverse commissural fibres, forming a structure known as the posterior commissure, which connects together the two optic thalami.

The most remarkable organ in the roof of the thalamencephalon is the pineal gland, which is developed as a hollow papilliform outgrowth of the roof, and is at first composed of cells similar to those of the other parts of the central nervous system (Fig. 120 pin). It is directed backwards over the hinder portion of the roof of the thalamencephalon.

In Birds (p. 116) the primitive outgrowth to form the pineal gland becomes deeply indented by vascular connective-tissue ingrowths, so that it assumes a dendritic structure (Fig. 119 pin). The proximal extremity attached to the roof of the thalamencephalon soon becomes solid and forms a special section, known as the infra-pineal process. The central lumen of the free part of the gland finally atrophies, but the branches still remain hollow. The infra-pineal process becomes reduced to a narrow stalk, connecting the branched portion of the body with the brain.

In Mammalia the development of the pineal gland is generally similar to that of Birds. The original outgrowth becomes branched, but the follicles or lobes to which the branching gives rise eventually become solid (Fig. 120 pin). An infra-pineal process is developed comparatively late, and is not sharply separated from the roof of the brain.

No satisfactory suggestions have yet been offered as
to the nature of the pineal gland. It appears to possess in all forms an epithelial structure, but, except at the base of the stalk (infra-pineal process) in Mammalia, in the wall of which there are nerve-fibres, no nervous structures are present in it in the adult state.

The cerebral hemispheres. It will be convenient to treat separately the development of the cerebral hemispheres proper, and that of the olfactory lobes.

In the cerebral rudiment two parts may be distinguished, viz. the floor and the roof. The former gives rise to the ganglia at the base of the hemispheres, the corpora striata, the latter to the hemispheres proper.

The first change which takes place consists in the roof growing out into two lobes, between which a shallow median constriction makes its appearance (Fig. 121).

Fig. 121.

Diagrammatic Longitudinal Horizontal Section through the Fore-brain.

3. v. third ventricle; lv. lateral ventricle; lt. lamina terminalis; ce. cerebral hemisphere; op.th. optic thalamus.
The two lobes thus formed are the rudiments of the two hemispheres. The cavity of each of them opens by a widening aperture into a cavity at the base of the cerebral rudiment, which again opens directly into the cavity of the third ventricle (3 c). The Y-shaped aperture thus formed, which leads from the cerebral hemispheres into the third ventricle, is the foramen of Monro. The cavity (c) in each of the rudimentary hemispheres is a lateral ventricle. The part of the cerebrum which lies between the two hemispheres and passes forwards from the roof of the third ventricle round the end of the brain to the optic chiasma below, is the rudiment of the lamina terminalis (Figs. 121 & and 123 trm). Up to this point the development of the cerebrum is similar in all Vertebrata, and in some forms it practically does not proceed much further.

The cerebral hemispheres undergo in Mammalia the most complicated development. The primitive unpaired cerebral rudiment becomes, as in lower Vertebrata, bilobed, and at the same time divided by the ingrowth of a septum of connective tissue into two distinct hemispheres (Figs. 125 and 124 f. and 122 r. From this septum is formed the foramen internum and other parts.

The hemispheres contain at first very large cavities communicating by a wide foramen of Monro with the third ventricle (Fig 124). They grow rapidly in size and extend, especially backwards and gradually across the thalamencephalon and the mesencephalon (Fig. 122 c.). The foramen of Monro becomes very much narrower and reduced to a mere slit.

The walls are at first nearly uniformly thick, but
to the nature of the pineal gland. It appears to possess in all forms an epithelial structure, but, except at the base of the stalk (infra-pineal process) in Mammalia, in the wall of which there are nerve-fibres, no nervous structures are present in it in the adult state.

The cerebral hemispheres. It will be convenient to treat separately the development of the cerebral hemispheres proper and that of the olfactory lobes.

In the cerebral rudiment two parts may be distinguished, viz. the floor and the roof. The former gives rise to the gyriums at the base of the hemispheres; the corpus striatum; the latter to the hemispheres proper.

The first change which takes place consists in the roof growing out into two lobes, between which a shallow median constriction makes its appearance (Fig. 121).

\[\text{Diagramatic Longitudinal Horizontal Section through the brain.}\]

- 2. third ventricle; 5. lateral ventricle; 7. mammal terminale de cerebral hemisphere; 9. optic thalamus.
The two lobes thus formed are the rudiments of the two hemispheres. The cavity of each of them opens by a widish aperture into a cavity at the base of the cerebral rudiment, which again opens directly into the cavity of the third ventricle (3 v). The Y-shaped aperture thus formed, which leads from the cerebral hemispheres into the third ventricle, is the foramen of Monro. The cavity (lv) in each of the rudimentary hemispheres is a lateral ventricle. The part of the cerebrum which lies between the two hemispheres, and passes forwards from the roof of the third ventricle round the end of the brain to the optic chiasma below, is the rudiment of the lamina terminalis (Figs. 121 lt and 123 trm). Up to this point the development of the cerebrum is similar in all Vertebrata, and in some forms it practically does not proceed much further.

The cerebral hemispheres undergo in Mammalia the most complicated development. The primitive unpaired cerebral rudiment becomes, as in lower Vertebrates, bilobed, and at the same time divided by the ingrowth of a septum of connective tissue into two distinct hemispheres (Figs. 125 and 124 f and 122 r). From this septum is formed the falx cerebri and other parts.

The hemispheres contain at first very large cavities, communicating by a wide foramen of Monro with the third ventricle (Fig. 124). They grow rapidly in size, and extend, especially backwards, and gradually cover the thalamencephalon and the mid-brain (Fig. 122 r, f). The foramen of Monro becomes very much narrowed and reduced to a mere slit.

The walls are at first nearly uniformly thick, but
Brain of a Three Months' Human Embryo: Natural Size.

(From Kölliker.)

1. From above with the dorsal part of hemispheres and mid-brain removed; 2. From below. *f.* anterior part of cut wall of the hemisphere; *f'*. cornu ammonis; *tho.* optic thalamus; *cst.* corpus striatum; *to.* optic tract; *cm.* corpora mammillaria; *p.* pons Varolii.

The floor becomes thickened on each side, and gives rise to the corpus striatum (Figs. 124 and 125 *st*). The corpus striatum projects upwards into each lateral ventricle, and gives to this a somewhat semilunar form, the two horns of which constitute the permanent anterior and descending cornua of the lateral ventricles (Fig. 126 *st*).

With the further growth of the hemisphere the corpus striatum loses its primitive relations to the descending cornu. The reduction in size of the foramen of Monro above mentioned is, to a large extent, caused by the growth of the corpora striata.

The corpora striata are united at their posterior border with the optic thalami. In the later stages of development the area of contact between these two pairs of ganglia increases to a large extent (Fig. 125),
and the boundary between them becomes confused obscure, so that the sharp distinction which exists in the embryo between the thalamencephalon and cerebral hemispheres becomes lost.

**Fig. 123.**

**Transverse Section through the Brain of a Rabbit of Five Centimetres. (After Milikovsky.)**

The section passes through nearly the posterior border of the septum lucidum, immediately in front of the foramen of Monro.

*Ant. cerebral hemispheres; ca. corpus callosum; ant. cornu ammonis (hippocampus major); ant. superior commissure of the cornu ammonis; ant. septum lucidum; ex. anterior pillar of the fornix; ca. anterior commissure; trv. lamina terminalis; trv. corpus striatum; 6. nucleus lentiformis of corpus striatum; 1. lateral ventricle; 2. third ventricle; 3. slit between cerebral hemispheres.*
Brain of a Three-month Human Embryo: Natural Size. (From Kölliker.)

1. From above with the dorsal part of hemispheres and mid-brain parts. 2, from below. 3, anterior part of one wall of the hemispheres; 4, ventricle ammoniæ; 5, optic thalamus; 6, corpus striatum; 7, optic tract; 8, corpora mamillaria; 9, optic nerve.

The double nucleii mammillariæ are each side, and gives rise to the corpus striatum (Figs. 124 and 125 a). The corpus striatum projects outward into each lateral ventricle, and gives in this a somewhat semilunar form, the two horns of which constitute the permanent anterior and descending horns of the lateral ventricles (Fig. 126 c).

With the further growth of the hemisphere the corpus striatum loses the primitive relations to the descending cornu. The reduction in size of the foramen of Monro above mentioned is, to a large extent, caused by the growth of the corpus striatum.

The corpora striata are united at their posterior border with the optic thalamus. In the later stages of development the area of contact between these two pairs of ganglia increases to a large extent (Fig. 125).
and the boundary between them becomes somewhat obscure, so that the sharp distinction which exists in the embryo between the thalamencephalon and cerebral hemispheres becomes lost.

**Fig. 123.**

**Transverse Section through the Brain of a Rabbit of Five Centimetres.** (After Mihalkovics.)

The section passes through nearly the posterior border of the septum lucidum, immediately in front of the foramen of Monro.

*hms.* cerebral hemispheres; *cal.* corpus callosum; *amm.* cornu ammonis (hippocampus major); *cms.* superior commissure of the cornua ammonis; *spt.* septum lucidum; *frz 2.* anterior pillars of the fornix; *ema.* anterior commissure; *trm.* lamina terminalis; *str.* corpus striatum; *lif.* nucleus lenticularis of corpus striatum; *vtr 1.* lateral ventricle; *vtr 3.* third ventricle; *ipl.* slit between cerebral hemispheres.
The outer wall of the hemispheres gradually thickens, while the inner wall becomes thinner. In the latter, two curved folds, projecting towards the interior of the lateral ventricle, become formed. These folds extend from the foramen of Monro along nearly the whole of what afterwards becomes the descending cornu of the lateral ventricle. The upper fold becomes the hippocampus major (cornu ammonis) (Figs. 123 amm, 124 and 125 h, and 126 am).

The wall of the lower fold becomes very thin, and a vascular plexus, derived from the connective-tissue septum between the hemispheres, and similar to that of the roof of the third ventricle, is formed outside it. It constitutes a fold projecting into the cavity of the lateral ventricle, and together with the vascular connective tissue in it gives rise to the choroid plexus of the lateral ventricle (Figs. 124 and 125 pl).

It is clear from the above description that a marginal fissure leading into the cavity of the lateral ventricle does not exist in the sense often implied in works on human anatomy, since the epithelium covering the choroid plexus, and forming the true wall of the brain, is a continuous membrane. The epithelium of the choroid plexus of the lateral ventricle is quite independent of that of the choroid plexus of the third ventricle, though at the foramen of Monro the roof of the third ventricle is of course continuous with the inner wall of the lateral ventricle (Fig. 124 s). The vascular elements of the two plexuses form however a continuous structure.

The most characteristic parts of the Mammalian cerebrum are the commissures connecting the two
hemispheres. These commissures are (1) the corpus callosum, (2) the fornix, and (3) the corpus semicircularis, the two latter being peculiar to Mammalia.

Fig. 184.

TRANVERSE SECTION THROUGH THE BRAIN OF A SHEEP'S EMBRYO OF 27 CM. IN LENGTH. (From Kölîker.)

The section passes through the level of the foramen of Monro.

ā, corpus striatum; s, foramen of Monro; t, third ventricle; cl, choroid plexus of lateral ventricle; f, falk cerebri; ah, anterior part of optic thalamus; al, optic chiasma; a, optic nerve; o, fibres of the cerebral peduncles; c, cornu ammonis; ρ, pharynx; sa, pre-sphenoid bone; a, orbito-sphenoid bone; p, pons to part of the roof of the brain at the junction between the roof of the third ventricle and the foramen terminalis; l, lateral ventricle.
The outer wall of the hemispheres gradually thickens, while the inner wall becomes thinner. In the latter, two curved folds, projecting towards the interior of the lateral ventricle, become formed. These folds extend from the fornix of Monro along nearly the whole of what afterwards becomes the descending cornu of the lateral ventricle. The upper fold becomes the hippocampus major (cornu ammonis) (Figs. 129 and 125 a, and 126 a). The wall of the lower fold becomes very thin, and a vascular plexus derived from the connective tissue septum between the hemispheres, and similar to that of the roof of the third ventricle, is formed outside it. It constitutes a fold projecting into the cavity of the lateral ventricle, and together with the vascular connective above in it gives rise to the choroid plexus of the lateral ventricle (Figs. 124 and 125 b).

It is clear from the above description that a marginal fissure leading into the cavity of the lateral ventricle does not exist in the sense often implied in works on human anatomy, since the epithelium covering the choroid plexus, and forming the true wall of the brain, is a continuous membrane. The epithelium of the choroid plexus of the lateral ventricle is quite independent of that of the choroid plexus of the third ventricle, though at the fornix of Monro the roof of the third ventricle is of course continuous with the inner wall of the lateral ventricle (Fig. 134 a). The vascular elements of the two plexuses form however a continuous structure.

The most characteristic parts of the Mammalian cerebrum are the commissures connecting the two
hemispheres. These commissures are (1) the anterior commissure, (2) the fornix, and (3) the corpus callosum, the two latter being peculiar to Mammalia.

Fig. 124.

Transverse section through the brain of a sheep's embryo of 2.7 cm. in length. (From Kölliker.)

The section passes through the level of the foramen of Monro.

st. corpus striatum; m. foramen of Monro; t. third ventricle; pl. choroid plexus of lateral ventricle; f. falx cerebri; th. anterior part of optic thalamus; ch. optic chiasma; o. optic nerve; c. fibres of the cerebral peduncles; h. cornu ammonis; p. pharynx; sa. pre-sphenoid bone; a. orbito-sphenoid bone; s. points to part of the roof of the brain at the junction between the roof of the third ventricle and the lamina terminalis; l. lateral ventricle.
By the fusion of the inner walls of the hemispheres in front of the lamina terminalis a solid septum is formed, continuous behind with the lamina terminalis,

Fig. 125.

The section is taken a short distance behind the section represented in Fig. 124, and passes through the posterior part of the hemispheres and the third ventricle.

**Transverse Section through the Brain of a Sheep's Embryo of 2.7 cm. in Length.** (From Kölliker.)

st. corpus striatum; th. optic thalamus; to. optic tract; t. third ventricle; d. roof of third ventricle; c. fibres of cerebral peduncles; c'. divergence of these fibres into the walls of the hemispheres; e. lateral ventricle with choroid plexus pl; h. cornu ammonis; f. primitive falx; am. alisphenoid; a. orbito-sphenoid; sa. presphenoid; p. pharynx; mk. Meckel's cartilage.
and below with the corpora striata (Figs. 120 and 123 apt). It is by a series of differentiations within this septum, the greater part of which gives rise to the septum lucidum, that the above commissures originate. In Man there is a closed cavity left in the septum known as the fifth ventricle, which has however no communication with the true ventricles of the brain.

In this septum there become first formed, below and behind, the transverse fibres of the anterior commissure (Fig. 120 and Fig. 123 cao), while above and behind these the vertical fibres of the fornix are developed (Fig. 120 and Fig. 123 ocm). The vertical fibres meet above the foramen of Monro, and thence diverge backwards, as the posterior pillars, to lose themselves in the cornu ammonis (Fig. 120 oem). Ventrally they are continued, as the descending or anterior pillars of the fornix, into the corpus Albicans; and thence into the optic thalamus.

The corpus callosum is not formed till after the anterior commissure and fornix. It arises in the upper part of the septum formed by the fusion of the lateral walls of the hemispheres (Figs. 120 and 123 cao), and at first only its curved anterior portion—the genu or rostrum—is developed. This portion is alone found in Monotremes and Marsupials. The posterior portion, which is present in all the Monodelphs, is gradually formed as the hemispheres are prolonged further backwards.

1 Recent observations tend to show that the anterior pillars of the fornix end in the corpus Albicans; and that the fibres running from the latter into the optic thalamus are independent of the anterior pillars.
By the fusion of the inner walls of the hemispheres in front of the corpus striatum: a solid septum is formed, continuous behind with the lamina terminalis.

Transverse Section through the Brain of a Sheep. (From Kölliker.)

The section is taken a short distance behind the section represented in Fig. 134, and passes through the posterior part of the hemispheres and the third ventricle.

1. corpus striatum; 2. white substance; 3. optic tract; 4. fourth ventricle; 5. root of third ventricle; 6. fibres of cardiac plexus; 7. divergence of these fibres into the walls of the hemispheres; 8. lateral ventricle with choroid plexus at

and below with the corpora striata (Figs. 120 and 123 spt). It is by a series of differentiations within this septum, the greater part of which gives rise to the septum lucidum, that the above commissures originate. In Man there is a closed cavity left in the septum known as the fifth ventricle, which has however no communication with the true ventricles of the brain.

In this septum there become first formed, below and behind, the transverse fibres of the anterior commissure (Fig. 120 and Fig. 123 cma), while above and behind these the vertical fibres of the fornix are developed (Fig. 120 and Fig. 123 frx 2). The vertical fibres meet above the foramen of Monro, and thence diverge backwards, as the posterior pillars, to lose themselves in the cornu ammonis (Fig. 123 amm). Ventrally they are continued, as the descending or anterior pillars of the fornix, into the corpus albicans, and thence into the optic thalami.

The corpus callosum is not formed till after the anterior commissure and fornix. It arises in the upper part of the septum formed by the fusion of the lateral walls of the hemispheres (Figs. 120 and 123 cal), and at first only its curved anterior portion—the genu or rostrum—is developed. This portion is alone found in Monotremes and Marsupials. The posterior portion, which is present in all the Monodelphia, is gradually formed as the hemispheres are prolonged further backwards.

1 Recent observations tend to show that the anterior pillars of the fornix end in the corpus albicans; and that the fibres running from the latter into the optic thalami are independent of the anterior pillars.
Primitively the Mammalian cerebrum, like that of the lower Vertebrata, is quite smooth. In some of the Mammalia, Monotremata, Insectivora, etc., this condition is retained nearly throughout life, while in the majority of Mammalia a more or less complicated system of fissures is developed on the surface. The most important, and first formed, of these is the Sylvian fissure. It arises at the time when the hemispheres, owing to their growth in front of and behind the corpora striata have assumed somewhat the form of a bean. At the root of the hemispheres—the hilus of the bean—there is formed a

LATERAL VIEW OF THE BRAIN OF A CALF EMBRYO OF 5 CM. (After Mihalkovics.)

The outer wall of the hemisphere is removed, so as to give a view of the interior of the left lateral ventricle.

hs. cut wall of hemisphere; st. corpus striatum; am. hippocampus major (cornu ammonis); d. choroid plexus of lateral ventricle; fm. foramen of Monro; op. optic tract; in. infundibulum; mb. mid-brain; cb. cerebellum; IV.V. roof of fourth ventricle; ps. pons Varolii, close to which is the fifth nerve with Gasserian ganglion.
The depression which constitutes the first part of the Sylvian fissure. The part of the brain lying in this fissure is known as the island of Reil.

The fissures of the cerebrum may be divided into two classes: (1) the primitive, (2) the secondary fissures. The primitive fissures are the first to appear; they owe their origin to the splitting of the inner wall of the cerebral vesicles. Many of them are transient structures and early disappear. The most important of these which persist are the hippocampal, the parieto-occipital, the temporal (in Man and Ape) sulci and the Sylvian fissures. The secondary fissures appear later, and are due to folds which replicate the cortex of the hemisphere only.

The olfactory lobes. The olfactory lobes, or rhinencephalons, are secondary outgrowths of the cerebral hemispheres, and contain prolongations of the lateral ventricles, which may however be closed in the adult state; they arise at a fairly early stage of development from the under and anterior part of the hemispheres (Fig. 17).

Histogenetic changes. The walls of the brain are at first very thin and, like those of the spinal cord, are composed of a number of masses of spindle-shaped cells. The floor of the hind- and mid-brain, a superficial layer of delicate nerve-fibres is formed at an early stage. This layer appears at first on the floor and roof of the hind-brain, and almost immediately afterwards on the floor and the sides of the mid-brain. The cells internal to the above fibres become differentiated into an innermost epithelial layer lining the roofs of the ventricles, and an outer layer of gray.

The similarity of the primitive arrangement and
Primitively the Mammalian cerebrum, like that of the lower Vertebrata, is quite smooth. In some of the Mammalia, Monotremata, Insectivora, etc., this condition is retained nearly throughout life, while in the majority of Mammalia a more or less complicated system of fissures is developed on the surface. The most important, and first formed, of these is the Sylvian fissure. It arises at the time when the hemispheres, owing to their growth in front of and behind the corpora striata have assumed somewhat the form of a bean. At the root of the hemispheres—the hilus of the bean—there is formed a
shallow depression which constitutes the first trace of the Sylvian fissure. The part of the brain lying in this fissure is known as the island of Reil.

The fissures of the cerebrum may be divided into two classes; (1) the *primitive*, (2) the *secondary* fissures. The primitive fissures are the first to appear; they owe their origin to a folding of the entire wall of the cerebral vesicles. Many of them are transient structures and early disappear. The most important of those which persist are the hippocampal, the parieto-occipital, the calcarine (in Man and Apes) sulci and the Sylvian fissures. The secondary fissures appear later, and are due to folds which implicate the cortex of the hemispheres only.

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Histogenetic changes. The walls of the brain are at first very thin and, like those of the spinal cord, are formed of a number of ranges of spindle-shaped cells. In the floor of the hind- and mid-brain a superficial layer of delicate nerve-fibres is formed at an early period. This layer appears at first on the floor and sides of the hind-brain, and almost immediately afterwards on the floor and the sides of the mid-brain. The cells internal to the nerve-fibres become differentiated into an innermost epithelial layer lining the cavities of the ventricles, and an outer layer of grey matter.

The similarity of the primitive arrangement and
Section through the Brain and Olfactory Organ of an Embryo of Scyllium.

ch. cerebral hemispheres; ol.v. olfactory vesicle; olf. olfactory pit; Sch. Schneiderian folds; I. olfactory nerve (the reference line has been accidentally carried through the nerve so as to appear to indicate the brain); pn. anterior prolongation of pineal gland.

histological characters of the parts of the brain behind the cerebral hemispheres to those of the spinal cord is very conclusively shewn by the examination of any good series of sections. In both brain and spinal cord the white matter forms a cap on the ventral and lateral parts some considerable time before it extends to the dorsal surface. In the medulla oblongata the white matter does not eventually extend to the roof owing to the peculiar degeneration which that part undergoes.

In the case of the fore-brain the walls of the hemispheres become first divided (Kölliker) into a superficial thinner layer of rounded elements, and a deeper and thicker epithelial layer, and between these the fibres of
the crus cerebri soon interpose themselves. At a slightly later period a thin superficial layer of white matter, homologous with that of the remainder of the brain, becomes established.

The inner layer, together with the fibres from the crus cerebri, gives rise to the major part of the white matter of the hemispheres and to the epithelium lining the lateral ventricles.

The outer layer of rounded cells becomes divided into (1) a superficial part with comparatively few cells, which, together with its coating of white matter, forms the outer part of the grey matter, and (2) a deeper layer with numerous cells, which forms the main mass of the grey matter of the cortex.

The eye. The development of the Mammalian eye is essentially similar to that of the chick (ch. vi.). There are, however, two features in its development which deserve mention. These are (1) the immense fetal development of the blood-vessels of the vitreous humour and the presence in the embryo of a vascular membrane surrounding the lens, known as the membra capulosa-papillaris, (2) the absence of any structure comparable to the pecten, and the presence of the arteria centralis retinae.

In the invagination of the lens (rabbit), a thin layer of mesenchyme is carried before it, and is thus transported into the cavity of the vitreous humour. In the folding in of the optic vesicle, which accompanies the formation of the lens the optic nerve is included, and on the development of the cavity of the vitreous humour an artery, running in the fold of the optic nerve, passes through the choroid slit into the
HISTOLOGICAL CHARACTERS OF THE PARTS OF THE BRAIN BEHIND THE CEREBRAL HEMISPHERE TO THOSE OF THE SPINAL CORD IS VERY CONCLUSIVELY SHOWN BY THE EXAMINATION OF ANY GOOD SERIES OF SECTIONS. IN BOTH BRAIN AND SPINAL CORD THE WHITE MATTER FORMS A CAP ON THE VENTRAL AND LATERAL PARTS SOME CONSIDERABLE TIME BEFORE IT EXTENDS TO THE DORSAL SURFACE. IN THE MEDULLA OBLONGATA THE WHITE MATTER DOES NOT EVENTUALLY EXTEND TO THE ROOF EQUALLY TO THE PECULIAR DEGENERATION WHICH THAT PART UNDERGOES.

In the case of the fore-brain the walls of the hemispheres become first divided (Kölliker) into a superficial thinner layer of rounded elements, and a deeper and thicker epithelial layer, and between these the fibres of
the crura cerebri soon interpose themselves. At a slightly later period a thin superficial layer of white matter, homologous with that of the remainder of the brain, becomes established.

The inner layer, together with the fibres from the crura cerebri, gives rise to the major part of the white matter of the hemispheres and to the epithelium lining the lateral ventricles.

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In the invagination of the lens (rabbit) a thin layer of mesoblast is carried before it, and is thus transported into the cavity of the vitreous humour. In the folding in of the optic vesicle which accompanies the formation of the lens the optic nerve is included, and on the development of the cavity of the vitreous humour an artery, running in the fold of the optic nerve, passes through the choroid slit into the
DEVELOPMENT OF ORGANS IN MAMMALIA. [CHAP.
cavity of the vitreous humour (Fig. 128 acr). The sides
of the optic nerve subsequently bend over, and com-
pletely envelope this artery, which then gives off

Fig. 128.

SECTION THROUGH THE EYE OF A RABBIT EMBRYO OF ABOUT
TWELVE DAYS.

c. epithelium of cornea; l. lens; mec. mesoblast growing in from
the side to form the cornea; rt. retina; a.c.r. arteria cen-
tralis retinae; of.n. optic nerve.

The figure shews (1) the absence at this stage of mesoblast
between the lens and the epiblast; the interval between the
two has however been made too great; (2) the arteria centralis
retinae forming the vascular capsule of the lens and continuous
with vascular structures round the edges of the optic cup.
branches to the retina, and becomes known as the arteria centrales retinae. It is homologous with the arterial limb of the vascular loop projecting into the vitreous humour in Birds.

Before becoming enveloped in the optic nerve this artery is continued through the vitreous humour (Fig. 128), and when it comes in close proximity to the lens it divides into a number of radiating branches, which pass round the edge of the lens and form a vascular sheath which is prolonged so as to cover the anterior wall of the lens. In front of the lens they anastomose with vessels, coming from the iris, many of which are venous, and the whole of the blood from the arteria centralis is carried away by these veins. The vascular sheath surrounding the lens is the membrana capsulo-papillaris. The posterior part of it is either formed simply by branches of the arteria centrales, or out of the mesoblast cells invaginated with the lens. The anterior part of the vascular sheath is however enclosed in a very delicate membrane, the membrana papillaris, continuous at the sides with the membrane of Descemet.

The membrana capsulo-papillaris is simply a provisional embryonic structure, subserving the nutrition of the lens.

In many forms, in addition to the vessels of the vascular capsule round the lens, there arise from the arteria centrales retinae, just after its exit from the optic nerve, provisional vascular branches which extend themselves to the posterior part of the vitreous humour. Near the ciliary end of the vitreous humour they anastomose with the vessels of the membrana capsulo-papillaris.
The figure shows (1) the interval between the lens and the optic cup. The interval between the two has however been made the plate; in the arteria centralis retinae forming the vascular capsule of the lens and continuous with vascular structure round the edge of the optic cup.
branches to the retina, and becomes known as the *arteria centralis retinae*. It is homologous with the arterial limb of the vascular loop projecting into the vitreous humour in Birds.

Before becoming enveloped in the optic nerve this artery is continued through the vitreous humour (Fig. 128), and when it comes in close proximity to the lens it divides into a number of radiating branches, which pass round the edge of the lens, and form a vascular sheath which is prolonged so as to cover the anterior wall of the lens. In front of the lens they anastomose with vessels, coming from the iris, many of which are venous, and the whole of the blood from the *arteria centralis* is carried away by these veins. The vascular sheath surrounding the lens is the *membrana capsulo-pupillaris*. The posterior part of it is either formed simply by branches of the *arteria centralis*, or out of the mesoblast cells involuted with the lens. The anterior part of the vascular sheath is however enclosed in a very delicate membrane, the *membrana pupillaris*, continuous at the sides with the membrane of Descemet.

The *membrana capsulo-pupillaris* is simply a provisional embryonic structure, subserving the nutrition of the lens.

In many forms, in addition to the vessels of the vascular capsule round the lens, there arise from the *arteria centralis retinae*, just after its exit from the optic nerve, provisional vascular branches which extend themselves in the posterior part of the vitreous humour. Near the ciliary end of the vitreous humour they anastomose with the vessels of the *membrana capsulo-pupillaris*. 

The choroid slit closes very early, and is not perforated by any structure homologous with the pecten. The only part of the slit which can be said to remain open is that in which the optic nerve is involved; in the centre of the latter is situated the arteria centralis retinae as explained above. From this artery there grow out the vessels to supply the retina, which however are distinct from the provisional vessels of the vitreous humour just described, the blood being returned from them by veins accompanying the arteries. On the atrophy of the provisional vessels the whole of the blood of the arteria centralis passes into the retina.

Of the cornea, aqueous humour, eyelids and lacrimal duct no mention need here be made, the account given in Part I. being applicable equally to mammalian embryos.

The auditory organ. In Mammals, as we have seen to be the case in the chick (chap. vi.), the auditory vesicle is at first nearly spherical, and is imbedded in the mesoblast at the side of the hind-brain. It soon becomes triangular in section, with the apex of the triangle pointing inwards and downwards. This apex gradually elongates to form the rudiment of the cochlear canal and sacculus hemisphericus (Fig. 129, CC). At the same time the recessus labyrinthi (R.L) becomes distinctly marked, and the outer wall of the main body of the vesicle grows out into two protuberances, which form the rudiments of the vertical semicircular canals (V.B). In the lower forms (Fig. 132) the cochlear process hardly reaches a higher stage of development than that found at this stage in Mammalia.

The parts of the auditory labyrinth thus established soon increase in distinctness (Fig. 130); the cochlear
Transverse Section of the Head of a Fetal Sheep (10 cm. in Length) in the Region of the Hind-Brain.

(After Bütcher.)

H.D., the hind-brain. The section is somewhat oblique, hence while on the right side the connections of the recessus vestibuli $H.D.$, and of the commencing vertical semicircular canal $P.B.$, and of the ductus cochleare $G.G.$, with the cavity of the primary otic vesicle are seen; on the left side, only the extremity of the ductus cochleare $G.G.$, and of the semicircular canal $P.B.$ are observable.

Lying close to the inner side of the otic vesicle is seen the cochlear ganglion $G.G.$, on the left side the auditory nerve $N$, and its connection $A$ with the hind-brain are also shown.

Below the otic vesicle on either side lie the tegumentaria.
The choroid slit closes very early, and is not perforated by any structure homologous with the pecten. The only part of the slit which can be said to remain open is that in which the optic nerve is involved; in the centre of the latter is situated the arteria centralis retinae as explained above. From this artery there grow out the vessels to supply the retina, which however are distinct from the provisional vessels of the vitreous humour just described, the blood being returned from them by venules accompanying the arteries. On the atrophy of the provisional vessels the whole of the blood of the arteria centralis passes into the retina.

Of the sclera, aqueous humour, eyelids and lacrimal duct no mention need here be made, the account given in Part I. being applicable equally to mammalian embryos.

The auditory organ. In Mammals, as we have seen to be the case in the chick (chap. vi.), the auditory vesicle is at first nearly spherical, and is imbedded in the mesoblast at the side of the hind-brain. It soon becomes triangular in section, with the apex of the triangle pointing backwards and downwards. This apex gradually elongates to form the rudiment of the cochlear canal and vesicula acustica inferioris (Fig. 129, CC). At the same time the recessus labirinti (K.L) becomes distinctly marked, and the outer wall of the main body of the vesicle grows out into two protuberances, which form the rudiments of the vertical semicircular canals (V.B). In the lower forms (Fig. 132) the cochlear process hardly reaches a later stage of development than that found at this stage in Mammals.

The parts of the auditory labyrinth thus established soon increase in distinctness (Fig. 130); the cochlear
Transverse Section of the Head of a Foetal Sheep (16 mm. in Length) in the Region of the Hind-Brain. (After Böttcher.)

HB. the hind-brain. The section is somewhat oblique, hence while on the right side the connections of the recessus vestibuli R.L., and of the commencing vertical semicircular canal V.B., and of the ductus cochlearis CC., with the cavity of the primary otic vesicle are seen: on the left side, only the extreme end of the ductus cochlearis CC, and of the semicircular canal V.B. are shewn.

Lying close to the inner side of the otic vesicle is seen the cochlear ganglion GC; on the left side the auditory nerve G' and its connection N with the hind-brain are also shewn.

Below the otic vesicle on either side lies the jugular vein.
canal (CC) becomes longer and curved; its inner and concave surface being lined by a thick layer of columnar epiblast. The recessus labyrinthi also increases in length, and just below the point where the bulgings to form the vertical semicircular canals are situated, there is formed a fresh protuberance for the horizontal semi-

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**Fig. 130.**

**SECTION OF THE HEAD OF A FETAL SHEEP 20 MM. IN LENGTH. (After Böttcher.)**

*R.V.* recessus labyrinthi; *V.B.* vertical semicircular canal; *H.B.* horizontal semicircular canal; *C.C.* cochlear canal; *G.* cochlear ganglion.
ocular canal. At the same time the central core of the walls of the flat bulgings of the vertical is brought together, obliterated this part of the lumen, not leaving a canal round the periphery; and, on the separation of their central parts, each of the original simple afferent of the wall of the vesicle becomes converted into a semi-circular canal, opening at its two extremities into the auditory vesicle. The vertical canals are first established and then the horizontal canal.

Shortly after the formation of the rudiment of the horizontal semicircular canal a slight protuberance becomes apparent on the inner commencement of the cochlear canal. A constriction arises on each side of the protuberance, converting it into a prominent hemispherical projection, the saccular hemisphaericus (Fig. 131 b).

The constrictions are so deep that the saccular is only connected with the cochlear canal on the one hand, and with the general cavity of the auditory vesicle on the other, by, in each case, a narrow short canal. The former of these canals (Fig. 131 b) is known as the canalis reunens.

At this stage we may call the remaining cavity of the original otic vesicle into which all the above parts open, the vesicula.

Soon after the formation of the saccular hemisphaericus, the cochlear canal and the semicircular canals become invested with cartilage. The mesenchyma remains however still enclosed in undifferentiated membrane.

Before the cartilage and the parts which it surrounds there remains a certain amount of indifferent
canal (CC) becomes longer and curved; its inner and concave surface being lined by a thick layer of olfactory epiblast. The recessus labyrinthi also increases in length, and just below the point where the bulgings to form the vertical semicircular canals are situated, there is formed a fresh vestibulocerebral for the horizontal semi-

**Fig. 126.**

**SECTION OF THE HEAD OF A FETAL SHEEP 15 MM. IN LENGTH (After Pützcher.)**

A.V. recessus labyrinthi; V.B. vertical semicircular canal; H.B. horizontal semicircular canal; C.C. cochlear canal; G. cerebellar ganglion.
circular canal. At the same time the central parts of the walls of the flat bulgings of the vertical canals grow together, obliterating this part of the lumen, but leaving a canal round the periphery; and, on the absorption of their central parts, each of the original simple bulgings of the wall of the vesicle becomes converted into a true semicircular canal, opening at its two extremities into the auditory vesicle. The vertical canals are first established and then the horizontal canal.

Shortly after the formation of the rudiment of the horizontal semicircular canal a slight protuberance becomes apparent on the inner commencement of the cochlear canal. A constriction arises on each side of the protuberance, converting it into a prominent hemispherical projection, the sacculus hemisphericus (Fig. 131 SR).

The constrictions are so deep that the sacculus is only connected with the cochlear canal on the one hand, and with the general cavity of the auditory vesicle on the other, by, in each case, a narrow short canal. The former of these canals (Fig. 131 b) is known as the canalis reuniens.

At this stage we may call the remaining cavity of the original otic vesicle, into which all the above parts open, the utriculus.

Soon after the formation of the sacculus hemisphericus, the cochlear canal and the semicircular canals become invested with cartilage. The recessus labyrinthi remains however still enclosed in undifferentiated mesoblast.

Between the cartilage and the parts which it surrounds there remains a certain amount of indifferent
Fig. 131.

**Section through the Internal Ear of an Embryonic Sheep 28 mm. in Length.** (After Böttcher.)

*D.M.* dura mater; *R.V.* recessus labyrinthi; *H.V.B.* posterior vertical semicircular canal; *U.* utriculus; *H.B.* horizontal...
semicircular anil f. canal of remnant f. constriction by means of which the sacculus hemisphericus A.B. is formed  f. narrowed opening between sacculus hemisphericus and utriculus c.c. cochlea  c.c. lamens of cochlea n.k. cartilaginous capsule of cochlea a.h. basilar plate c. notochord

connective tissue which is more abundant around the cochlear canal than around the semicircular canals.

As soon as they have acquired a distinct connective-tissue coat, the semicircular canals begin to be dilated at one of their terminations to form the ampullae. At about the same time a constriction appears opposite the mouth of the recessus labyrinthi, which causes its opening to be divided into two branches—one towards the utriculus and the other towards the sacculus hemisphericus; and the relations of the parts become so altered that communication between the sacculus and utriculus can only take place through the mouth of the recessus labyrinthi (Fig. 132).

When the cochlear canal has come to consist of two and a half coils, the thickened epithelium which lines the lower surface of the canal forms a double ridge from which the organ of Corti is subsequently developed. Above the ridge there appears a delicate cuticular membrane, the membrane of Corti or mem-
brane tectoria.

The epithelial walls of the utricle, the sacculus, the recessus labyrinthi, the semicircular canals, and the cochlear canal constitute together the highly complicated product of the original auditory vesicle. The whole structure forms a closed cavity, the various parts of which are in free communication. In the adult the
SECTION THROUGH THE INTERNAL EAR OF AN EMBRYONIC EMBRYO 20 MM. IN LENGTH. (After Hottiger.)

D.M. dura mater; h.v. vestibular labyrinth; h.v.b. posterior vertical semicircular canal; U. utriculus; H.H. horizontal.
semicircular canal; b. canalis reuniens; a. constriction by means of which the sacculus hemisphericus S.H. is formed; f. narrowed opening between sacculus hemisphericus and utriculus; C.C. cochlea; C.C\(^1\). lumen of cochlea; K.K. cartilaginous capsule of cochlea; K.B. basilar plate; Ch. notochord.

connective tissue, which is more abundant around the cochlear canal than around the semicircular canals.

As soon as they have acquired a distinct connective-tissue coat, the semicircular canals begin to be dilated at one of their terminations to form the ampullae. At about the same time a constriction appears opposite the mouth of the recessus labyrinthi, which causes its opening to be divided into two branches—one towards the utriculus and the other towards the sacculus hemisphericus; and the relations of the parts become so altered that communication between the sacculus and utriculus can only take place through the mouth of the recessus labyrinthi (Fig. 132).

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The epithelial walls of the utricle, the saccule, the recessus labyrinthi, the semicircular canals, and the cochlear canal constitute together the highly complicated product of the original auditory vesicle. The whole structure forms a closed cavity, the various parts of which are in free communication. In the adult the
fluid present in this cavity is known as the **endolymph**.

In the mesoblast lying between these parts and the cartilage, which at this period envelopes them, lymphatic spaces become established, which are partially developed in the Sauropsida, but become in Mammals very important structures.

They consist in Mammals partly of a space surrounding the utricle and saccule and called the vestibule, into which open spaces surrounding the semicircular canals, and partly of two very definite channels, which largely embrace between them the cochlear canal. The latter channels form the *scala vestibuli* on the upper side of the cochlear canal and the *scala tympani* on the lower. The scala vestibuli is in free communication with the lymphatic cavity surrounding the utricle and saccule, and opens at the apex of the cochlea into the scala tympani. The latter ends blindly at the fenestra rotunda.

The fluid contained in the two scalæ, and in the remaining lymphatic cavities of the auditory labyrinth, is known as **perilymph**.

The cavities just spoken of are formed by an absorption of parts of the embryonic mucous tissue between the perichondrium and the walls of the membranous labyrinth.

The scala vestibuli is formed before the scala tympani, and both scalæ begin to be developed at the basal end of the cochlea: the cavity of each is continually being carried forwards towards the apex of the cochlear canal by a progressive absorption of the mesoblast. At first both scalæ are somewhat narrow, but they soon increase in size and distinctness.
The cochlear canal, which is often known as the scala media of the cochlea, becomes compressed in the formation of the scala so as to be triangular in section, with the base of the triangle outwards. This tube is only separated from the surrounding cartilage by a narrow strip of firm mesoblast, which becomes the stria vascularis, etc. At the angle opposite the base the cochlear canal is joined to the cartilage by a narrow isthmus of firm material, which contains nerves and vessels. This isthmus subsequently forms the laguna spiralis, separating the scala vestibuli from the scala tympani.

The scala vestibuli lies on the upper border of the cochlear canal, and is separated from it by a very thin layer of mesoblast, bordered on the cochlear aspect by a flight of epiblast cells. This membrane is called the mem- brana of Reissner. The scala tympani is separated from the cochlear canal by a thicker sheet of mesoblast, called the basilar membrane, which supports the organ of Corti and the epithelium adjoining it. The upper extremity of the cochlear canal ends in a blind extremity called the cupola, to which the two scales do not for some time extend. This condition is permanent in Birds, where the cupola is represented by a structure known as the lagena (Fig. 132, II, L). Subsequently the two scales join at the extremity of the cochlear canal; the point of the cupola still however remains in contact with the base, which has now replaced the cartilage, but at a still later period the scala vestibuli, growing further inward, separates the cupola from the adjoining osteous tissue.

Accessory auditory structures. The development of the Eustachian tube, tympanum cavity, tympanic
The fluid present in this cavity is known as the **lymph**.

In the mesoblast lying between these parts and the cartilages, which at this period envelops them, lymphatic spaces become established, which are partially developed in the Sauropsida, but become in Mammals very important structures.

They consist in Mammals partly of a space surrounding the utricle and saccule and called the **vestibule**, into which open spaces surrounding the semicircular canals, and partly of two very definite channels, which largely replace between them the cochlear canal. The latter channels form the **scala vestibuli** on the upper side of the cochlear case, and the **scala tympani** on the lower.

The **scala vestibuli** is in free communication with the lymphatic cavity surrounding the utricle and saccule, and opens at the apex of the cochlea into the **scala tympani**. The latter ends blindly at the fenestra rotunda.

The fluid contained in the two scalae, and in the remaining lymphatic cavities of the auditory labyrinths, is known as *perilymph*.

The semicircular canals and of are formed by an absorption of part of the mesoblastic connective tissue between the pericentrocysteae and the walls of the membranous labyrinth.

The **scala vestibuli** is formed before the **scala tympani**, and both scalae begin to be developed at the basal end of the cochlea. The area of each is continually being carried forwards towards the apex of the cochlear case, by a progressive absorption of the mesoblast. As first both scalae are somewhat narrow, but they soon increase in size and distinctness.
The cochlear canal, which is often known as the scala media of the cochlea, becomes compressed on the formation of the scalæ so as to be triangular in section, with the base of the triangle outwards. This base is only separated from the surrounding cartilage by a narrow strip of firm mesoblast, which becomes the stria vascularis, etc. At the angle opposite the base the cochlear canal is joined to the cartilage by a narrow isthmus of firm material, which contains nerves and vessels. This isthmus subsequently forms the lamina spiralis, separating the scala vestibuli from the scala tympani.

The scala vestibuli lies on the upper border of the cochlear canal, and is separated from it by a very thin layer of mesoblast, bordered on the cochlear aspect by flat epiblast cells. This membrane is called the membrane of Reissner. The scala tympani is separated from the cochlear canal by a thicker sheet of mesoblast, called the basilar membrane, which supports the organ of Corti and the epithelium adjoining it. The upper extremity of the cochlear canal ends in a blind extremity called the cupola, to which the two scalæ do not for some time extend. This condition is permanent in Birds, where the cupola is represented by a structure known as the lagena (Fig. 132, II. L). Subsequently the two scalæ join at the extremity of the cochlear canal; the point of the cupola still however remains in contact with the bone, which has now replaced the cartilage, but at a still later period the scala vestibuli, growing further round, separates the cupola from the adjoining osseous tissue.

Accessory auditory structures. The development of the Eustachian tube, tympanic cavity, tympanic
Diagram of the Membranous Labyrinth. (From Gegenbaur.)

I. Fish. II. Bird. III. Mammal.

U. utriculus; S. sacculus; US. utriculus and sacculus; Cr. canalis reuniens; R. recessus labyrinthi; UC. commencement of cochlea; C. cochlear canal; L. lagena; K. cupola at apex of cochlear canal; V. cæcal sac of the vestibulum of the cochlear canal.

membrane and external auditory meatus resembles that in Birds (p. 166). As in Birds two membranous fenestrae, the fenestra ovalis and rotunda, in the bony inner wall of the tympanic cavity are formed. The fenestra ovalis opens into the vestibule, and is in immediate contiguity with the walls of the utricle, while the fenestra rotunda adjoins the scala tympani. In place of the columella of Birds, three ossicles, the malleus, incus and stapes reach across the tympanic cavity from the tympanic membrane.
to the nascent cavities. These ossicles, which arise mainly from the mandibular and hyoid arches (see p. 403), are at first embedded in the connective tissue of the neighborhood of the tympanic cavity. Later on the full development of this cavity, become apparently placed within it, though really enveloped in the mucous membrane lining it.

Nasal organ. In Mammals the general formation of the anterior and posterior nares is the same as in Birds; but an outgrowth from the inner side of the nasal between the two openings arises at an early period; and becoming separate from the posterior nares and provided with a special opening into the mouth, forms the organ of Jacobson. The general relations of this organ when fully formed are shown in Fig. 138.

**Fig. 138.**

 секция через носовую полость и орган Джакобсона (головной мозг).

1. septum nasi; 2. narial cavity; 3. Jacobson’s organ; 4. edge of upper jaw.
membrane and external auditory meatus resembles that in Birds (p. 108). As in Birds two membranous fenestrae, the fenestra ovina and retrotympani, in the bony inner wall of the tympanic cavity are formed. The fenestra ovina opens into the vestibule, and is in immediate contiguity with the walls of the utricle, while the fenestra rotundata adjoins the scala tympani. In place of the columella of Birds, three osicles, the malleus, incus and stapes, reach across the tympanic cavity from the tympanic membrane.
to the fenestra ovalis. These ossicles, which arise mainly from the mandibular and hyoid arches (*vide* p. 403), are at first imbedded in the connective tissue in the neighbourhood of the tympanic cavity, but on the full development of this cavity, become apparently placed within it, though really enveloped in the mucous membrane lining it.

**Nasal organ.** In Mammalia the general formation of the anterior and posterior nares is the same as in Birds; but an outgrowth from the inner side of the canal between the two openings arises at an early period; and becoming separate from the posterior nares and provided with a special opening into the mouth, forms the *organ of Jacobson*. The general relations of this organ when fully formed are shewn in Fig. 133.

---

**Fig. 133.**

*SECTION THROUGH THE NASAL CAVITY AND JACOBSON'S ORGAN.*

(From Gegenbaur.)

*sn.* septum nasi; *cn.* nasal cavity; *J.* Jacobson's organ; *d.* edge of upper jaw.
The development of the cranial and spinal nerves in Mammals is as far as is known essentially the same as in the chick, for an account of which see p. 123 et seq.

Sympathetic nervous system. The development of the sympathetic system of both Aves and Mammalia has not been thoroughly worked out. There is however but little doubt that in Mammalia the main portion arises in continuity with the posterior spinal ganglia.

The later history of the sympathetic system is intimately bound up with that of the so-called supra-renal bodies, the medullary part of which is, as we shall see below, derived from the peripheral part of the sympathetic system.

THE ORGANS DERIVED FROM MESOBLAST.

The vertebral column. The early development of the perichordal cartilaginous tube and rudimentary neural arches is almost the same in Mammals as in Birds. The differentiation into vertebral and intervertebral regions is the same in both groups; but instead of becoming divided as in Birds into two segments attached to two adjoining vertebrae, the intervertebral regions become in Mammals wholly converted into the intervertebral ligaments (Fig. 135 li). There are three centres of ossification for each vertebra, two in the arch and one in the centrum.

The fate of the notochord is in important respects different from that in Birds. It is first constricted in the centres of the vertebrae (Fig. 134) and disappears there shortly after the beginning of ossification; while in
the intervertebral regions it remains relatively unconsstricted (Figs. 134 and 135 e) and after undergoing certain histological changes remains through life as part of the nucleus pulposus in the axis of the intervertebral segments. There is also a slight swelling of the notochord near the two extremities of each vertebra (Fig. 135 a' and c').

In the persistent vertebral constriction of the notochord Mammals retain a more primitive and piscine mode of formation of the vertebral column than the majority either of the Reptilia or Amphibia.

**Fig. 134.**

**LONGITUDINAL SECTION THROUGH THE VERTEBRAL COLUMN OF AN EIGHT WEEKS' HUMAN EMBRYO IN THE THORACIC REGION.** (From Kolliker)

* a, cartilaginous vertebral body; b, intervertebral ligament; c, notochord.

The skull. Excepting in the absence of the interorbital plate, the early development of the Mammalian cranium resembles in all essential points that of Aves, to our account of which on p. 235 et seq. we refer the reader.
The development of the cranial and spinal nerves in Mammals is as far as is known essentially the same as in the chick, for an account of which see p. 123 of sep.

Sympathetic nervous system. The development of the sympathetic system of both Aves and Mammalia has not been thoroughly worked out. There is however little doubt that in Mammalia the main portion arises in continuity with the posterior spinal ganglia.

The later history of the sympathetic system is intimately bound up with that of the so-called super-renal bodies, the medullary part of which is, as we shall see below, derived from the peripheral part of the sympathetic system.

THE ORIGINS DERIVED FROM MESOBLAST.

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The fate of the notochord is in important respects different from that in Birds. It is first constructed as the centrum of the vertebrae (Fig. 134) and disappears there shortly after the beginning of ossification; while
the intervertebral regions it remains relatively unconstricted (Figs. 134 and 135 c) and after undergoing certain histological changes remains through life as part of the nucleus pulposus in the axis of the intervertebral ligaments. There is also a slight swelling of the notochord near the two extremities of each vertebra (Fig. 135 c' and c'').

In the persistent vertebral constriction of the notochord Mammals retain a more primitive and piscine mode of formation of the vertebral column than the majority either of the Reptilia or Amphibia.

**Fig. 134.**

**Longitudinal Section through the Vertebral Column of an Eight Weeks' Human Embryo in the Thoracic Region.** (From Kölliker.)

v. cartilaginous vertebral body; li. intervertebral ligament; ch. notochord.

**The skull.** Excepting in the absence of the interorbital plate, the early development of the Mammalian cranium resembles in all essential points that of Aves, to our account of which on p. 235 et seq. we refer the reader.
LONGITUDINAL SECTION THROUGH THE INTERVERTEBRAL LIGAMENT AND ADJACENT PARTS OF TWO VERTEBRAE FROM THE THORACIC REGION OF AN ADVANCED EMBRYO OF A SHEEP. (From Kölliker.)

\[l_a.\] ligamentum longitudinale anterius; \[lp.\] ligamentum long. posterius; \[li.\] ligamentum intervertebrale; \[k, k'.\] epiphysis of vertebra; \[w.\] and \[w'.\] anterior and posterior vertebrae; \[c.\] intervertebral dilatation of notochord; \[c'.\] and \[c''.\] vertebral dilatation of notochord.

The early changes in the development of the visceral arches and clefts have already been described, but the later changes undergone by the skeletal elements of the first two visceral arches are sufficiently striking to need a special description.
The skeletal bars of both the hyoid and mandibular arches develop at first more completely than in any of the other types above Fishes; they are articulated to each other above, while the pterygo-palatine bar is quite distinct.

The main features of the subsequent development are undisputed, with the exception of that of the upper end of the hyoid, which is still controverted. The following is Parker's account for the Pig.

The mandibular and hyoid arches are at first very similar, their dorsal ends being somewhat incurved, and articulating together.

In a somewhat later stage (Fig. 136) the upper end of the mandibular bar (mô), without becoming segmented...
LONGITUDINAL SECTION THROUGH THE INTERVERTEBRAL LIGA-
MENTS AND ADJACENT PARTS OF TWO VERTEBRES FROM THE
THORACIC REGION OF AN ADULT SHEEP OF A SHEEP.

(From Hollier.)

l. ligamentum longitudinale anterior; l.p. ligamentum long. pos-
terius; a. ligamentum intervertebrale; e, $e$. epiphysis of
vertebra; a. and $a$. anterior and posterior vertebrae; $e$. inter-
vertebral discation of notochord; $e.$ and $e.$ vertebral dis-
placement of notochord.

The early changes in the development of the visceral
arches and ribs have already been described, but the
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The main features of the subsequent development are undisputed, with the exception of that of the upper end of the hyoid, which is still controverted. The following is Parker's account for the Pig.

The mandibular and hyoid arches are at first very similar, their dorsal ends being somewhat incurved, and articulating together.

In a somewhat later stage (Fig. 136) the upper end of the mandibular bar (mb), without becoming segmented

**Fig. 136.**

Embryo Pig, an inch and a third long; Side View of Mandibular and Hyoid Arches. The Main Hyoid Arch is seen as displaced backwards after Segmentation from the Incus. (From Parker.)

*ty. tongue; mk. Meckelian cartilage; ml. body of malleus; mb. manubrium or handle of the malleus; t.ty. tegmen tympani; i. incus; st. stapes; i.hy. interhyal ligament; st.h. stylohyal cartilage; h.h. hypohyal; b.h. basibranchial; th.h. rudiment of first branchial arch; 7a. facial nerve.
from the ventral part, becomes distinctly swollen, and clearly corresponds to the quadrate region of other types. The ventral part of the bar constitutes Meckel’s cartilage \((mk)\).

The hyoid arch has in the meantime become segmented into two parts, an upper part \((i)\), which eventually becomes one of the small bones of the ear—the \textit{incus}—and a lower part which remains as the \textit{anterior cornu} of the \textit{hyoid} \((st.h)\). The two parts continue to be connected by a ligament.

The incus is articulated with the quadrate end of the mandibular arch, and its rounded head comes in contact with the stapes (Fig. 136, \(st\)) which is segmented from the \textit{fenestra ovalis}.

According to some authors the stapes is independently formed from mesoblast cells surrounding a branch of the \textit{internal carotid artery}.

The main arch of the hyoid becomes divided into a hypohyal \((h.h)\) below and a stylohyal \((st.h)\) above, and also becomes articulated with the basal element of the arch behind \((bh)\).

In the course of further development the Meckelian part of the mandibular arch becomes enveloped in a superficial ossification forming the dentary. Its upper end, adjoining the quadrate region, becomes calcified and then absorbed, and its lower, with the exception of the extreme point, is ossified and subsequently incorporated in the dentary.

The quadrate region remains relatively stationary in growth as compared with the adjacent parts of the skull, and finally ossifies to form the \textit{malleus}. The processus
The gracilla of the malleus is the primitive continuation into Meckel's cartilage.

The malleus and incus are at first embedded in the connective tissue adjoining the tympanic cavity, which with the Eustachian tube is the persistent remains of the hyocondibular cleft, and externally to them a bone known as the tympanic bone becomes developed so that they become placed between the tympanic bone and the periosteal capsule. In late fetal life they become transported completely within the tympanic cavity, though covered by a reflection of the tympanic mucous membrane.

The dorsal end of the part of the hyoid separated from the malleus becomes ossified as the tympano-hyal and is ankylosed with the adjacent parts of the periosteal capsule. The middle part of the bar just outside the skull forms the stylo-hyal (stylloid process in man) which is attacked by ligament to the anterior cornu of the hyoid (cerato-hyal). The tympanic membrane and external auditory meatus develop as in the chick (p. 166).

The ribs and sternum appear to develop in Mammalia as in Birds (p. 234).

The pectoral girdle, as in Birds (p. 234), arises as a continuous plate of cartilage, the coracoid element of which is however much reduced.

The clavicle in Man is provided with a central axis of cartilage, and the mode of ossification is intermediate between that of a true cartilage bone and a membrane bone.

The pelvic girdle is formed in cartilage as in Birds, but in Man at an early rate the pubic part of the cartilage is formed independently of the remainder. There are the usual three centres of ossification, which unite eventually into a single bone—the innominate bone. The pubis and ischium of each side unite ventrally, so as completely to outline the obturator foramen.
from the ventral part, becomes distinctly splayed, and clearly corresponds to the quadrate region of other types.

The ventral part of the bar constitutes Meckel's cartilage (mk).

The hyoid arch has in the meantime become segmented into two parts, an upper part (v), which eventually becomes one of the small bones of the ear—the incus—and a lower part which remains as the anterior cornu of the hyoid (stA). The two parts continue to be connected by a ligament.

The incus is articulated with the quadrate end of the mandibular arch, and its rounded head comes in contact with the stylopharyngeus (Fig. 186, st) which is segmented from the basihyal oticum.

According to some authors the stapes is independently formed from mesoblastic cells surrounding a branch of the internal carotid artery.

The main arch of the hyoid becomes divided into a hypohyal (kA) below and a stylohyal (stA) above, and also becomes articulated with the basal element of the arch behind (tA).

In the course of further development the Meckelian part of the mandibular arch becomes enveloped in a superficial ossification forming the dentary. Its upper end, adjoining the quadrate region, becomes calcified and then absorbed, and its lower, with the exception of the extreme point, is ossified and subsequently incorporated in the dentary.

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The clavicle in Man is provided with a central axis of cartilage, and its mode of ossification is intermediate between that of a true cartilage bone and a membrane bone.

**The pelvic girdle** is formed in cartilage as in Birds, but in Man at any rate the pubic part of the cartilage is formed independently of the remainder. There are the usual three centres of ossification, which unite eventually into a single bone—the innominate bone. The pubis and ischium of each side unite ventrally, so as completely to enclose the obturator foramen.
The skeleton of the limbs develops so far as is known as in Birds, from a continuous mesoblastic blastema, within which the corresponding cartilaginous elements of the limbs become differentiated.

The body cavity. The development of the body cavity and its subsequent division into pericardial pleural and peritoneal cavities is precisely the same in Mammalia as in Aves (p. 264 et seq.). But in Mammalia a further change takes place, in that by the formation of a vertical partition across the body cavity, known as the diaphragm, the pleural cavities, containing the lungs, become isolated from the remainder of the body or peritoneal cavity. As shewn by their development the so-called pleuræ or pleural sacs are simply the peritoneal linings of the anterior divisions of the body cavity, shut off from the remainder of the body cavity by the diaphragm.

The vascular system.

The heart. The two tubes out of which the heart is formed appear at the sides of the cephalic plates, opposite the region of the mid- and hind-brain (Fig. 107). They arise at a time when the lateral folds which form the ventral wall of the throat are only just becoming visible. Each half of the heart originates in the same way as in the chick; and the layer of the splanchnic mesoblast, which forms the muscular wall for each part (ahh), has at first the form of a half tube open below to the hypoblast.

On the formation of the lateral folds of the splanchnic walls, the two halves of the heart become carried inwards
and downwards, and eventually meet on the ventral side of the throat. For a short time they here remain distinct, but soon coalesce into a single tube.

In Birds, it will be remembered, the heart at first has the form of two tubes, which however are in contact in front. It arises at a time when the formation of the throat is very much more advanced than in Mammalia; while in fact, the ventral wall of the thorax is established as far back as the front end of the heart.

In the lower types the heart does not appear till the ventral wall of the throat is completely established, and it has from the first the form of a single tube.

It is therefore probable that the formation of the heart as two cavities is a secondary mode of development, which has been brought about by variations in the period of the closing in of the wall of the thorax.

The later development of the heart is in the main similar to that of the chick (p. 290 et seq.).

The arterial system. The early stages of the arterial system of Mammalia are similar to those in Birds. Five arterial arches are formed, the three posterior of which wholly or in part persist in the adult.

The bulbus arteriosus is divided into two (fig. 137 B), but the left fourth arch (x) instead of, as in Birds, the right, is that continuous with the dorsal aorta, and the right fourth arch (x) is only continued into the right vertebral and right subclavian arteries.

The fifth pair of arches, which is continuous with one of the divisions of the bulbus arteriosus gives origin to the two pulmonary arteries. Both these however are derived from the arch on one side, viz. the left (fig. 137 B); whereas in Birds, one pulmonary artery comes from the left and the other from the right fifth arch (fig. 137 A).
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The bulbus arteriosus is divided into two (fig. 137 B), but the left fourth arch (e), instead of, as in Birds, the right, is that continuous with the dorsal aorta, and the right fourth arch (i) is only continued into the right vertebral and right subclavian arteries.

The fifth pair of arches which is continuous with one of the divisions of the bulbus arteriosus gives origin to the two pulmonary arteries. Both these however are derived from the arch on one side, viz. the left (fig. 137 B); whereas in Birds, one pulmonary artery comes from the left and the other from the right fifth arch (fig. 137 A).
The ductus Botalli of the fifth arch (known in Man as the ductus arteriosus) of the side on which the pulmonary arteries are formed, may remain (e.g. in Man) as a solid cord connecting the common stem of the pulmonary aorta with the systemic aorta.

The diagram, Fig. 137, copied from Rathke, shews at a glance the character of the metamorphosis the arterial arches undergo in Birds and Mammals.

**Fig. 137.**

Diagrams illustrating the Metamorphosis of the Arterial Arches in a Bird A. and a Mammal B.

(From Mivart after Rathke.)

**A.** a. internal carotid; b. external carotid; c. common carotid; d. systemic aorta; e. fourth arch of right side (root of dorsal aorta); f. right subclavian; g. dorsal aorta; h. left subclavian (fourth arch of left side); i. pulmonary artery; k. and l. right and left ductus Botalli of pulmonary arteries.

**B.** a. internal carotid; b. external carotid; c. common carotid; d. systemic aorta; e. fourth arch of left side (root of dorsal aorta); f. dorsal aorta; g. left vertebral artery; h. left subclavian artery; i. right subclavian (fourth arch of right side); k. right vertebral; l. continuation of right subclavian; m. pulmonary artery; n. ductus Botalli of pulmonary artery.
In some Mammals both subclavian arteries spring from a trunk common to them and the carotides (arteria anonyma); or as in Man and some other Mammals the left one arises from the systemic aorta just beyond the carotides. Various further modifications in the origin of the subclavian arteries are found in Mammals, but they need not be specified in detail. The vertebral arteries arise in close connection with the subclavians, whereas in Birds they arise from the common carotids.

**The venous system.** In Mammals the same venous trunks are developed in the embryo as in Birds (Fig. 138 A). The anterior cardinals or external jugulars form the primitive venae of the anterior part of the body, and the internal jugulars and anterior vertebrais are subsequently formed. The subclavians (Fig. 138 A, 8), developed on the formation of the anterior limbs, also pour their blood into these primitive trunks. In the lower Mammalia (Mammalia, Monotrema, Marsupialia, Insectivora, some Rodentia, etc.) the two ductus Cuvieri remain as the two superior vena cavae, but more usually an anastomosis arises between the right and left in nominate veins, and eventually the whole of the blood of the left superior cava is carried to the right side, and there is left only a single superior cava (Fig. 138 B and C). A small rudiment of the left superior cava remains however as the stegos connecting and regulating the coronary veins from the heart (Figs. 138 A, so as 1; 138 C).

The posterior cardinals, unlike those of the vertebral veins returning the blood from the posterior part of the trunk and kidneys; and on the development of the hind limbs receive the blood from them also.

An unpaired vena cava inferior becomes eventually
The ductus Botalli of the fifth arch (known in Man as the ductus arteriosum) of the side on which the pulmonary arteries are formed may remain (as in Man) as a solid cord connecting the common stem of the pulmonary aorta with the systemic aorta.

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(The Mammal after Rathke.)

**A.**
- a. internal carotid
- b. external carotid
- c. common carotid
- d. systemic aorta
- a. fourth arch of right side (root of dorsal aorta)
- b. right subclavian
- c. dorsal aorta
- d. left subclavian (fourth arch of left side)
- e. pulmonary artery
- f. right and left ductus Botalli of pulmonary arterios

**B.**
- a. internal carotid
- b. external carotid
- c. common carotid
- d. systemic aorta
- a. fourth arch of left side (root of dorsal aorta)
- b. dorsal aorta
- c. left vertebral artery
- d. left subclavian artery
- e. right subclavian (fourth arch of right side)
- f. right vertebral
- g. continuation of right subclavian
- h. pulmonary artery
- i. ductus Botalli of pulmonary artery
In some Mammals both subclavians spring from a trunk common to them and the carotids (arteria anonyma); or as in Man and some other Mammals, the left one arises from the systemic aorta just beyond the carotids. Various further modifications in the origin of the subclavians are found in Mammalia, but they need not be specified in detail. The vertebral arteries arise in close connection with the subclavians, whereas in Birds they arise from the common carotids.

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The posterior cardinal veins form at first the only veins receiving the blood from the posterior part of the trunk and kidneys; and on the development of the hind limbs receive the blood from them also.

An unpaired vena cava inferior becomes eventually
Diagram of the Development of the Paired Venous System of Mammals (Man). (From Gegenbaur.)

j. jugular vein; cs. vena cava superior; s. subclavian veins; c. posterior cardinal vein; v. vertebral vein; az. azygos vein; cor. coronary vein.

A. Stage in which the cardinal veins have already disappeared. Their position is indicated by dotted lines.

B. Later stage when the blood from the left jugular vein is carried into the right to form the single vena cava superior; a remnant of the left superior cava being however still left.

C. Stage after the left vertebral vein has disappeared; the right vertebral remaining as the azygos vein. The coronary vein remains as the last remnant of the left superior vena cava.

developed, and gradually carries off a larger and larger portion of the blood originally returned by the posterior cardinals. It unites with the common stem of the allantoic and vitelline veins in front of the liver.

At a later period a pair of trunks is established bringing the blood from the posterior part of the cardinal veins and the crural veins directly into the vena cava.
inferior (Fig. 130, ii). These vessels, whose development has not been adequately investigated, form the common

![Diagram](image)

**Diagram of the Chief Vascular Trunks of Man.**

- **v. coronary sinus**: v. subclavian vein; **v. internal jugular**: v. external jugular; **v. aygii vein**: v. hemiazygos vein; a dotted line showing previous position of cardinal veins; **v. vena cava inferior**: v. renal vein; **v. iliac**: **v. hypogastric vein**: **v. biceps vein**.

The dotted lines show the position of embryonic vessels aborted in the adult.

The veins, while the posterior ends of the cardinal veins which join them become the hypogastric veins (Fig. 130, hy).

Posterior vertebral veins, similar to those of Birds, are established in connection with the intercostal and
Diagram of the Development of the Paired Vascular System in Mammals (Man). (From Gegenbaur.)

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cs. coronary sinus; s. subclavian vein; ji. internal jugular;
je. external jugular; az. azygos vein; ha. hemiazygos vein;
c. dotted line shewing previous position of cardinal veins;
ci. vena cava inferior; r. renal veins; il. iliac; hy. hypogastric veins; h. hepatic veins.

The dotted lines shew the position of embryonic vessels aborted in the adult.

iliac veins, while the posterior ends of the cardinal veins which join them become the hypogastric veins (Fig. 139 hy).

Posterior vertebral veins, similar to those of Birds, are established in connection with the intercostal and
lumbar veins, and unite anteriorly with the front part of the posterior cardinal veins (Fig. 138 A).

Upon the formation of the posterior vertebral veins, and upon the inferior vena cava becoming more important, the middle part of the posterior cardinals becomes completely aborted (Fig. 139 c), the anterior and posterior parts still persisting, the former as the continuations of the posterior vertebrales into the anterior vena cava (az), the latter as the hypogastric veins (hy).

Though in a few Mammalia both the posterior vertebrales persist, a transverse connection is usually established between them, and the one (the right), becoming the more important, constitutes the azygos vein (Fig. 139 az), the persisting part of the left forming the hemi-azygos vein (ha).

The remainder of the venous system is formed in the embryo by the vitelline and allantoic veins, the former being eventually joined by the mesenteric vein so as to constitute the portal vein.

The vitelline vein is the first part of this system established, and divides near the heart into two veins bringing back the blood from the yolk-sac (umbilical vesicle). The right vein soon however aborts.

The allantoic (anterior abdominal) veins are originally paired. They are developed very early, and at first course along the still widely open somatic walls of the body, and fall into the single vitelline trunk in front. The right allantoic vein disappears before long, and the common trunk formed by the junction of the vitelline and allantoic veins becomes considerably elongated. This trunk is soon enveloped by the liver, and later in its passage through, gives off branches to, and also
receives branches from this organ near its anterior exit. The main trunk is however never completely arrested, as in the embryos of other types, but remains as the ductus venosus Ascendens.

With the development of the placenta the allantoic vein becomes the main source of the ductus venosus, and the vitelline or portal vein, as it may perhaps be now conveniently called, ceases to join it directly, but falls into one of its branches in the liver.

The vena cava inferior joins the continuation of the ductus venosus in front of the liver, and, as it becomes more important, it receives directly the hepatic veins which originally brought back blood into the ductus venosus. The ductus venosus becomes moreover merely a small branch of the vena cava.

At the close of fetal life the allantoic vein becomes obliterated up to its place of entrance into the liver; the ductus venosus becomes a solid cord—the so-called round ligament—and the whole of the venous blood is brought to the liver by the portal vein.

Owing to the allantoic (anterior abdominal) vein having merely a fetal existence an anastomosis between the iliac veins and the portal system by means of the anterior abdominal vein is not established.

The supra-renal bodies. These are paired bodies lying anterior to the kidneys and are formed of two parts, (1) a cortical and (2) a medullary portion. They first appear in the Rabbit on the 12th or 13th day of gestation, and arise as masses of mesoblast cells lying between the aorta and the mesentery and to one side of the former. On the 14th day they are well marked, and lying dorsal to them is another mass of cells which
lumbar veins, and unite anteriorly with the front part of the posterior cardinal veins (Fig. 138 A).

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is found to be continuous with the sympathetic nervous system.

On the 16th day processes from the sympathetic mass enter the mesoblastic tissue and become transformed into the medullary portion of the adult suprarenal; while the mesoblastic tissue gives rise to the cortical layer.

The urinogenital organs.

The history of these organs in Mammalia, excepting so far as concerns the lower parts of the urinogenital ducts, is the same as in the Chick.

The Wolffian body and duct first appear, and are followed by the Müllerian duct and the kidney. The exact method of development of the latter structures has not been followed so completely as in the Chick; and it is not known whether the peculiar structures found at the anterior end of the commencing Müllerian duct in Aves occur in Mammalia.

The history of the generative glands is essentially the same as in the Chick.

Outgrowths from a certain number of Malpighian bodies in the Wolffian body are developed along the base of the testis, and enter into connection with the seminiferous stroma. It is not certain to what parts of the testicular tubuli they give rise, but they probably form at any rate the vasa recta and rete vasculosum. Similarly intrusions from the Malpighian bodies make their way into the ovary of the female, and give rise to cords of tissue which may persist throughout life.

The vasa efferentia (coni vasculosi) appear to be derived from the glandular tubes of part of the Wolffian
Secy. The Wolffian duct itself becomes in the male the vasa deferens and the convoluted canal of the epididymis; the latter structure except the head being entirely derived from the Wolffian duct.

The functional remnants of the urogenital organs described for the chick (p. 224) are found also in mammals.

The Müllerian ducts persist in the female as the Fallopian tubes and uterus.

The lower parts of the urogenital ducts are somewhat further modified in the Mammalia than the Chick.

The genital cord. The lower part of the Wolffian ducts becomes enveloped in both sexes in a special cord of tissue, known as the genital cord (Fig. 146 gc), within the lower part of which the Müllerian ducts are also enclosed. In the male the Müllerian ducts in this cord atrophy, except at their distal end where they unite to form the uterus masculinus. The Wolffian ducts, after becoming the vasa deferentia, remain for some time enclosed in the common cord but afterwards separate from each other. The seminal vesicles are outgrowths of the vasa deferentia.

In the female the Wolffian ducts within the genital cord atrophy, though rudiments of them are for a long time visible or even permanently persistent. The lower part of the Müllerian ducts unite to form the vagina and body of the uterus, while the upper become the horns of the uterus and the Fallopian tubes. The junction commences in the middle and extends forwards and backwards; the stage with a median junction being obtained permanently in Marsupials.

The urogenital sinuses and external generative organs. The dorsal part of the cloaca with the visceral.
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**The genital cord.** The lower part of the Wolffian ducts becomes enveloped in both sexes in a special cord of tissue, known as the genital cord (Fig. 140 gc), within the lower part of which the Müllerian ducts are also enclosed. In the male the Müllerian ducts in this cord atrophy, except at their distal end where they unite to form the uterus masculinus. The Wolffian ducts, after becoming the vasa deferentia, remain for some time enclosed in the common cord but afterwards separate from each other. The seminal vesicles are outgrowths of the vasa deferentia.

In the female the Wolffian ducts within the genital cord atrophy, though rudiments of them are for a long time visible or even permanently persistent. The lower parts of the Müllerian ducts unite to form the vagina and body of the uterus while the upper become the horns of the uterus and the Fallopian tubes. The junction commences in the middle and extends forwards and backwards; the stage with a median junction being retained permanently in Marsupials.

**The urinogenital sinus and external generative organs.** The dorsal part of the cloaca with the alimen-
416 DEVELOPMENT OF ORGANS IN MAMMALIA. [CHAP.

tary tract becomes partially constricted off from the ventral, which then forms a urinogenital sinus (Fig. 140 ug). In the course of development the urinogenital

Diagram of the Urinogenital Organs of a Mammal at an Early Stage. (After Allen Thomson; from Quain's Anatomy.)

The parts are seen chiefly in profile, but the Müllerian and Wolffian ducts are seen from the front.

3. ureter; 4. urinary bladder; 5. urachus; ot. genital ridge (ovary or testis); W. left Wolffian body; x. part at apex from which coni vasculosi are afterwards developed; w. Wolffian duct; m. Müllerian duct; gc. genital cord consisting of Wolffian and Müllerian ducts bound up in a common sheath; i. rectum; ug. urinogenital sinus; cp. elevation which becomes the clitoris or penis; ls. ridge from which the labia majora or scrotum are developed.
organ becomes in all Semenmala, but the Orithelisolem, completely separated from the intestinal canal, and the two parts close upon external openings. The ureters (Fig. 180) are higher up than the other ducts into the stapes of the alveolus which here divides to form the bladder. The part of the stalk which connects the bladder with the ventral wall of the body substitutes the bladder, and here the human before the close of embonpoint. The part of the stalk of the allantias below the entrance of the ureters narrows to form the urether, which opens together with the Welling and Müllerian ducts into the inter genital canal.

In front of the inguinal canal there is formed a genital prominence (Fig. 181 fig.) with a groove continued from the urinogenital region, and on each side a genital fold (la). In the midline the sides of the groove or the prominence coalesce together, embracing between them the opening of the urinogenital canal, and the prominence itself gives rise in the penis along which the common urinogenital passage is continued. The two genital folds unite from behind towards to form the scrotum.

In the female the groove on the genital prominence gradually disappears, and the prominence becomes at the clitoris, which is therefore the homologue of the glans. The two genital folds form the labia majora. The urethra and vagina open independently into the common urinogenital sinus.

THE ALIMENTARY CANAL AND ITS ADVANTAGES.

It is convenient to introduce also an account of the organs derived from the hypophysis, in order of occurrence of
tory tract becomes partially constricted off from the ventral, which then forms a urinogenital sinus (Fig. 130 sq.). In the course of development the urinogenital

**Diagram of the Urinogenital Organs of a Mammal at an Early Stage.** (After Allen Thomson, from Quain’s Anatomy.)

The parts are seen chiefly in profile, but the Mullerian and Wolffian ducts are seen from the front.

1. uterus; 2. bladder; 3. urachus; 4. genital ridge (ovary or testis); 5. left Wolffian body; 6. part at apex from which coital vesiculae are afterwards developed; 7. Wolffian duct; 8. Mullerian duct; 9. genital cord consisting of Wolffian and Mullerian ducts bound up in a common sheath; 10. rectum; 11. urinogenital sinus; 12. elevation which becomes preputium or penis; 13. ridge from which the labia majora or scrotum are developed.
sinus becomes, in all Mammalia but the Ornithodelphia, completely separated from the intestinal cloaca, and the two parts obtain separate external openings. The ureters (Fig. 140, 3) open higher up than the other ducts into the stalk of the allantois which here dilates to form the bladder. That part of the stalk which connects the bladder with the ventral wall of the body constitutes the urachus, and loses its lumen before the close of embryonic life. The part of the stalk of the allantois below the openings of the ureters narrows to form the urethra, which opens together with the Wolffian and Müllerian ducts into the urogenital cloaca.

In front of the urogenital cloaca there is formed a genital prominence (Fig. 140 cp) with a groove continued from the urinogenital opening, and on each side a genital fold (ls). In the male the sides of the groove on the prominence coalesce together, embracing between them the opening of the urinogenital cloaca, and the prominence itself gives rise to the penis, along which the common urinogenital passage is continued. The two genital folds unite from behind forwards to form the scrotum.

In the female the groove on the genital prominence gradually disappears, and the prominence remains as the clitoris, which is therefore the homologue of the penis: the two genital folds form the labia majora. The urethra and vagina open independently into the common urogenital sinus.

THE ALIMENTARY CANAL AND ITS APPENDAGES.

It is convenient to introduce into our account of the organs derived from the hypoblast, a short account of
certain organs connected with the alimentary canal such as the mesentery, stomodæum, etc., which are not hypoblastic in origin.

The origin of the hypoblast, and the process of folding by which the cavity of the mesenteron is established have already been described. The mesenteron may be considered under three heads.

1. *The anterior or respiratory division of the mesenteron*. The pharynx, thyroid body, Eustachian tube, tympanic cavity, oesophagus, trachea, bronchi, lungs and stomach are developed from this portion, and their development in the Mammal so closely resembles that in the Chick that it is unnecessary for us to add to the account we have already given in the earlier part of this work.

This section of the alimentary canal, as in the Chick, is distinguished in the embryo by the fact that its walls send out a series of paired diverticula which meet the skin, and, after perforation has been effected at the regions of contact, form the visceral clefts.

2. *The middle division of the mesenteron*, from which the liver and pancreas are developed, as in the Chick, forms the intestinal and cloacal region and is at first a straight tube. It remains for some time connected with the yolk sack.

**The Cloaca** appears as a dilatation of the mesenteron which receives, as in Aves, the opening of the allantois almost as soon as the posterior section of the alimentary tract is established. The eventual changes which it undergoes have already been dealt with in connection with the urinogenital organs.

**The intestine.** The posterior part of this becomes
enlarged to form the large intestine, while the anterior portion becoming very much elongated and united forms the small intestine, and moreover gives rise anteriorly to the liver and pancreas.

From the large intestine close to the junction with the small intestine an outgrowth is developed, the proximal part of which enlarges to form the cecum, while the distal portion to this forms the vermiform appendix.

3. The postanal division of the mesenteron atrophies at an early period of embryonic life. In the Chick and lower types it communicates by a short tube with the hind end of the neural canal.

**Splanchnie mesoblast and mesentery.** The mesenteron consists at first of a simple hypoblastic tube, which however becomes enveloped by a layer of splanchnic mesoblast. This layer, which is at first continued over the dorsal side of the mesenteron, gradually grows in, and interposes itself between the hypoblast of the mesenteron, and the organs above. At the same time it becomes differentiated into two layers, viz. an outer epithelioid layer which gives rise to parts of the peritoneal epithelium, and an inner layer of undifferentiated cells which in time becomes converted into the connective tissue and muscular walls of the mesenteron. The connective tissue layers are thin, fused, while of the muscular layers the circular is the first to make its appearance.

Coincidently with the differentiation of these layers, the connective tissue stroma of the peritoneum becomes established.

*The mesentery is developed as in the Chick (p. 172).* In this thoracic region it is hardly if at all developed.
certain organs connected with the alimentary canal such as the mesentery, stomach, etc., which are not hypoblastic in origin.

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2. The middle division of the mesenteron, from which the liver and pancreas are developed, as in the Chick, forms the intestinal and cloacal region and is at first a straight tube. It remains for some time connected with the yolk sac.

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Coincidently with the differentiation of these layers the connective tissue stratum of the peritoneum becomes established.

*The mesentery* is developed as in the Chick (p. 172). In the thoracic region it is hardly if at all developed.
The primitive simplicity in the arrangement of the mesentery is usually afterwards replaced by a more complicated disposition, owing to the subsequent elongation and consequent convolution of the intestine and stomach.

The layer of peritoneal epithelium on the ventral side of the stomach is continued over the liver, and after embracing the liver, becomes attached to the ventral abdominal wall. Thus in the region of the liver the body-cavity is divided into two halves by a membrane, the two sides of which are covered by the peritoneal epithelium, and which encloses the stomach dorsally and the liver ventrally. The part of the membrane between the stomach and liver is narrow, and constitutes a kind of mesentery suspending the liver from the stomach: it is known to human anatomists as the lesser omentum.

The part of the membrane connecting the liver with the anterior abdominal wall constitutes the falciform or suspensory ligament of the liver. It arises by a secondary fusion, and is not a remnant of a primitive ventral mesentery (vide p. 264).

The mesentery of the stomach, or mesogastrium, enlarges in Mammalia to form a peculiar sack known as the greater omentum.

**The stomodæum.** The anterior section of the permanent alimentary tract is formed, as in the Chick, by an invagination of epiblast, constituting a more or less considerable pit, with its inner wall in contact with the blind anterior extremity of the mesenteron.

From the epiblastic lining of this pit are developed the pituitary body and the salivary as well as the other buccal glands.
Diagram showing the division of the primitive oral cavity into the respiratory portion above and the true mouth below. (From Gegenbaur.)

p. palatine plate of superior maxillary process; m. permanent mouth; n. posterior part of nasal passage; s. intermaxillary septum.

A palate grows inwards from each of the superior maxillary processes (Fig. 141), which, meeting in the middle line, form a horizontal septum dividing the front part of the stomodaeum into a dorsal respiratory section, containing the opening of the posterior nares, and a ventral cavity forming the permanent mouth. These two divisions open into a common cavity behind. This septum on the development within it of an ossaceous plate constitutes the hard palate. A posterior prolongation in which no ossaceous plate is formed constitutes the soft palate. An internasal septum (Fig. 141) may more or less completely divide the cavity into two nasal, continuous respectively with the nasal nasal cavities.

The teeth are special products of the oral mucous membrane. They are formed from the dentine as a center, via an epithelial cup, and a connective tissue wall.
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The part of the membrane connecting the liver with the anterior abdominal wall constitutes the falciform or segmentary ligament of the liver. It arises by a secondary fusion, and is not a remnant of a primitive ventral mesentery (vide p. 261).

The mesentery of the stomach, or mesogastrium, unites in Mammalia to form a peculiar sac known as the greater omentum.

The stomodaeum. The anterior section of the permanent alimentary tract is formed, as in the Chick, by an invagination of epithelium constituting a more or less considerable pit, with its inner wall in contact with the blind anterior extremity of the mesenteron.

From the epithelial lining of this pit are developed the pituitary body and the salivary as well as the other buccal glands.
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The teeth are special products of the oral mucous membrane. They are formed from two distinct organs, viz. an epithelial cap and a connective tissue papilla,
which according to most authors give rise to the enamel and dentine respectively.

The proctodæum. The cloacal section of the alimentary canal is placed in communication with the exterior by means of a shallow epiblastic invagination constituting the proctodæum.
APPENDIX.

PRACTICAL INSTRUCTIONS FOR STUDYING THE DEVELOPMENT OF THE CHICK.

I. A. Incubator.

Of all incubators, the natural one, i.e. the hen, is in some respects the best. The number of eggs which fail to develop is fewer than with an artificial incubator, and the development of measures this is easier. A good sitter will continue to sit for thirty or more days at least, even though the eggs are daily being changed. She should never be allowed to want for water, and should be well supplied according to her appetite with soft food. It is best to place the food at some little distance from the eggs, in order that the hen may leave the eggs when feeding. She will sit most persistently in a warm, quiet, somewhat darkened spot. When an egg is placed under her, the date should be marked on it, in order that the duration of its incubation may be exactly known. When the egg is intended to remain for a few days only, e.g. for seven days or more, the mark should be left and distinct, otherwise it will be rubbed off.
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I. A. Incubators.

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On the whole however we have found it more convenient to use a good artificial incubator. We have ourselves used with success two different incubators. One made by the Cambridge Scientific Instrument Company, and the other by Wiesnegg of 64, Rue Gay-Lussac, Paris (Fig. 65 in his catalogue for 1881). We have had the longest experience with the former, and have found it work exceedingly well: having been able to hatch chicks without more attention than now and then turning over the eggs.

Both these incubators consist essentially of a large water-bath fitted with a gas regulator. They are both perfectly automatic and when once regulated require no further attention.

The temperature within the incubator should be maintained at from 37° to 40° C. A rise above 40° is fatal; but it may be allowed to descend to 35° or in the young stages lower, without doing any further harm than to delay the development.

The products of the combustion of the gas should be kept as much as possible from the eggs, while a supply of fresh air and of moisture is essential.

Tolerably satisfactory results may be obtained with an ordinary chemical double-jacketed drying water-bath, thoroughly covered in with a thick coat of cotton wool and flannel baize, and heated by a very small gas-jet. If the vessel be filled with hot water, and allowed to cool down to 40° or therabouts, before the eggs are introduced, a very small gas flame will be sufficient to maintain the requisite temperature. A small pin-hole-nozzle, giving with ordinary pressure an exceeding narrow jet of flame about two inches high, is the most convenient. By turning the gas off or on, so as to reduce or increase the height
of the jet as required, a very steady more temperature may be maintained.

In the absence of gas, a patent gas light placed at a proper distance below the bath may be made to supply very well. When a body of water, once heated to the necessary temperature, is thoroughly saturated with non-conducting material, a very slight constant current of heat will supply all the loss.

B. On preparing sections of the embryo.

1. Hardening.

a. Picric acid.

We find this reagent the most satisfactory for hardening the chick and in most instances mammalian embryos.

Kleinenberg's solution of picric acid is the best.

With 100 parts of water, make a cold saturated solution of picric acid; add to this two parts of concentrated salicylic acid or nitric acid; filter and add to the filtrate three times its bulk of water.

In this solution of picric acid the embryo must be placed and left for from 2-5 hours. It should then be washed in alcohol of 50 p.c. and placed in alcohol 50 p.c. for one hour. From this it must be removed into alcohol of 70 p.c. in which it should be left until all the picric acid is extracted; to facilitate this the 70 p.c. alcohol should be frequently changed: when free from picric acid reagent

1. It is sometimes advantageous to add to the solution of picric acid as much zinc acetate as it will dissolve in the following.

On the whole however we have found it more convenient to use a good artificial incubator. We have ourselves used with success two different incubators: One made by the Cambridge Scientific Instruments Company, and the other by Wiesner of 64, Rue Gay-Lussac, Paris (Fig. 65 in its catalogue for 1881). We have had the longest experience with the former, and have found it work exceedingly well: having been able to hatch chicken without more attention than now and then turning over the eggs.

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of the jet as required, a very steady mean temperature may be maintained.

In the absence of gas, a patent night-light placed at a proper distance below the bath may be made to answer very well. When a body of water, once raised to the necessary temperature, is thoroughly surrounded with non-conducting material, a very slight constant amount of heat will supply all the loss.

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      We find this reagent the most satisfactory for hardening the chick and in most instances mammalian embryos.

      Kleinenberg's solution of picric acid is the best.

      With 100 parts of water, make a cold saturated solution of picric acid; add to this two parts of concentrated sulphuric acid or nitric acid: filter and add to the filtrate three times its bulk of water.

      In this solution of picric acid\(^1\) the embryo must be placed and left for from 2—5 hours. It should then be washed in alcohol of 30 p.c. and placed in alcohol 50 p.c. for one hour. From this it must be removed into alcohol of 70 p.c. in which it should be left until all the picric acid is extracted; to facilitate this the 70 p.c. alcohol should be frequently changed: when free from picric the embryo

\(^1\) It is sometimes advantageous to add to this solution of picric acid as much pure kreasote as it will dissolve (vide Kleinenberg, "Development of Earthworm," *Quarterly Journal of Mic. Sci.* 1879).
should be placed in 90 p.c. alcohol and kept there until required for further use.

N.B. Hardened embryos should always be kept in 90 p.c. spirit and only placed in absolute before imbedding, or staining with haematoxylin.

Some histologists prefer to keep hardened tissues in alcohol 70 p.c.

b. Corrosive sublimate.

Place the embryo in a large quantity of a saturated aqueous solution of corrosive sublimate to which a few drops of glacial acetic acid have been added, and allow it to remain for half-an-hour\(^1\). It is necessary thoroughly to extract the corrosive sublimate from the cells of the embryo; to accomplish this, wash it thoroughly with water for from 10 minutes to 3 hours according to the size of the object. The washing may be limited to frequent changes of water or the embryo may be placed in a vessel through which a continuous stream of water is kept running. When all the sublimate is removed, place it in 50 p.c. alcohol acidulated with nitric acid (half-a-dozen drops of acid to a 4 oz. bottle of spirit) for five minutes. The preservation of the embryo is completed by treating it with 70 p.c. alcohol for twenty-four hours and then keeping it in 90 p.c. alcohol. We have not found that corrosive sublimate gives such good results as picric acid in the case of chicks and mammalian embryos.

\(^1\) If there is only a small quantity of acetic acid mixed with the sublimate, a prolonged immersion will do the embryo no harm.
Osmeic acid.

Osmeic acid is a difficult reagent to use, but when properly applied it gives most excellent results.

It should be used as a weak solution (1 to 5 p.c.). The object should be left in it until it has acquired a light brown tint. The stronger the solution the less time is required for the production of this tint. It should then be removed and placed in picric-carmine, which arrests the action of the osmic and stains the embryo. The time required for the picric-carmine staining must be determined by practice. From the picric-carmine the object must be washed in 70 p.c. spirit; and then placed in 90, or may be preserved directly in glycerine.

If it is desired to use other staining agents (hemato-carmine is good for some preparations), the object must be removed from osmic into water or weak spirit, thence through 50 into 70 p.c. stained, and passed through 70 to 90 p.c. spirit.

After using osmic it is well in some cases (mammalian segmenting ova) to place the object in Müller's fluid for 2 or 3 days, after which it may be preserved in glycerine or spirit.

Müller's fluid is made by dissolving 25 grms. of tetrachromate of potash and 10 grms. of sodium sulphate in 1000 cc. of water.

With chromic acid.

The embryo must be immersed in a solution of the strength of 1 p.c. for 24 hours. From this it should be removed and placed in a stronger
Practical Directions

should be placed in 30 p.c. alcohol and kept out until required for further use.

1. If. Hardened embryos should always be kept in 30 p.c. spirit and only placed in alcohol before embedding, or staining with haematoxylin.

Some microscopists prefer to keep hardened embryos in spirits. 0 p.c.

2. Corrosive sublimate.

Place the embryo in a large portion of a saturated aqueous solution of corrosive sublimate in which a few drops of glacial acetic acid have been added, and allow it to remain for half an hour. It is necessary thoroughly to extract the corrosive sublimate from the cells of the embryo to accomplish this, wash it thoroughly with water for from 10 minutes to 3 hours according to the size of the object. The washing may be assisted by frequent changes of water or the cell may be placed in a vessel through which a continuous stream of water is kept running. When all the sublimate is removed, place it in 80 p.c. alcohol acidulated with nitric acid (three or four drops of acid to a 1 oz. bottle of spirit) for five minutes. The preservation of the embryo is completed by treating it with 70 p.c. alcohol for twenty-four hours and then keeping it in 20 p.c. alcohol. We have not found that corrosive sublimate gives such good results as phloric acid in the case of chievo and mammalian embryos.

* If there is only a small quantity of acetic acid mixed with the sublimate, a prolonged immersion will do the embryo no harm.
c. **Osmic acid.**

Osmic acid is a difficult reagent to use, but when properly applied it gives most excellent results.

It should be used as a weak solution (·1 to ·5 p.c.). The object should be left in it until it has acquired a *light* brown tint. The stronger the solution the less time is required for the production of this tint. It should then be removed and placed in picro-carmine, which arrests the action of the osmic and stains the embryo. The time required for the picro-carmine staining must be determined by practice. From the picro-carmine the object must be washed in 70 p.c. spirit; and then placed in 90, or may be preserved directly in glycerine.

If it is desired to use other staining agents (borax-carmine is good for some preparations), the object must be removed from osmic into water or weak spirit, thence through 50 into 70 p.c., stained, and passed through 70 to 90 p.c. spirit.

d. After using osmic it is well in some cases (mammalian segmenting ova) to place the object in Müller's fluid for 2 or 3 days, after which it may be preserved in glycerine or spirit.

Müller's fluid is made by dissolving 25 grms. of bichromate of potash and 10 grms. of sodic sulphate in 1000 cc. of water.

e. **With chromic acid.**

The embryo must be immersed in a solution of the strength of ·1 p.c. for 24 hours. From this it should be removed and placed in a stronger
PRACTICAL DIRECTIONS.

solution (3 p.c.) for another 24 hours. If it then appears sufficiently hard, it may be at once placed in alcohol of 70 p.c., in which it should remain for one day, and then be transferred to alcohol of 90 p.c.

Absolute alcohol has also been employed as a hardening reagent, but is by no means so good as the reagents recommended above.

The object of these so-called hardening reagents is to kill the tissues with the greatest possible rapidity without thereby destroying them. The subsequent treatment with alcohol completes the hardening which is only commenced by these reagents.

There is room for the exercise of considerable skill in the use of alcohol, and this skill can only be acquired by experience. A few general rules may however be laid down.

(1) Tissues should not, generally, be changed from water or an aqueous solution of the first hardening reagent into an alcoholic solution of too great strength, nor should the successive solutions of alcohol used differ too much in strength. The distortion produced by the violence and inequality of the diffusion currents is thus diminished. This general rule should be remembered in transferring tissues from alcohol to the staining agents and vice versa.

(2) The tissues should not be left too long (more than one or two hours) in alcoholic solutions containing less than 70 p.c. of alcohol.

(3) They should not be kept in absolute alcohol longer than is necessary to dehydrate them (see B. 1, p. 426). The alcoholic solutions we generally use contain 30, 50, 70, 90 p.c. of alcohol.

2. STAINING.

In most cases it will be found of advantage to stain the embryo. The best method of doing
this is to soak the covers as in the latter, rather than to apply the individual sections when they have been cut.

We have found hematoxyline and eosin, contains the best reagents for accurately delineate each area whole.

With hematoxyline.

The best solution of hematoxyline is that which we are indebted to Kuenenberg, it noted in the following way.

1. Make a saturated solution of crystallized calcium chloride in 70 p.c. alcohol, and add aluminium to saturation.

2. Make also a saturated solution of water in 70 p.c. alcohol, and add 1 to 2 in the proportion of 1 : 8.

3. To the mixture of 1 and 2 add a few drops of a saturated solution of hematoxyline in absolute alcohol.

4. It is often the case that hematoxyline solutions prepared in this way has not the proper purple tint, but a red tint. This is due to acidity of the materials used. The proper colour can be obtained by treating it with some alkaline solution. We have found it convenient to use for this purpose a saturated solution of sodium bicarbonate in 70 p.c. spirit. (The exact amount must be determined by experiment, as it depends upon the amount of acid present.)

The embryo should be placed for one hour, least in absolute alcohol, before staining with the
solution (5% p.c.) for another 24 hours. If it then appears sufficiently hard, it may be at once placed in alcohol of 70 p.c., in which it should remain for one day, and then be transferred to alcohol of 90 p.c.

Absolute alcohol has also been employed as a hardening reagent, but is by no means so good as the reagents recommended above.

The object of these so-called hardening reagents is to kill the tissues with the greatest possible rapidity without thereby destroying them. The subsequent treatment with alcohol completes the hardening which is only commenced by these reagents.

There is room for the exercise of considerable skill in the use of alcohol, and this skill can only be acquired by experience. A few general rules may however be laid down.

(2) Tissues should not, generally, be changed from water or an aqueous solution of the first hardening reagent into an alcoholic solution of too great strength, nor should the successive solutions of alcohol used differ too much in strength. The distortion produced by the violence and inequality of the diffusion currents is thus diminished. This general rule should be remembered in transferring tissues from alcohol to the staining agents and vice versa.

(3) They should not be left too long (more than one or two hours) in alcoholic solutions containing less than 70 p.c. of alcohol.

(4) They should not be kept in absolute alcohol longer than is necessary to dehydrate them (see D. 1, p. 464).

The alcoholic solutions we generally use contain 50, 60, 70, 90 p.c. of alcohol.

2. Staining.

In most cases it will be found of advantage to stain the sections. The best method of doing
this is to stain the embryo as a whole, rather than to stain the individual sections after they have been cut.

We have found hæmatoxylin and borax-carmine the best reagents for staining embryos as a whole.

1. **With hæmatoxylin.**

The best solution of hæmatoxylin, one for which we are indebted to Kleinenberg, is made in the following way.

1. Make a saturated solution of crystallized calcium chloride in 70 p.c. alcohol, and add alum to saturation.

2. Make also a saturated solution of alum in 70 p.c. alcohol, and add 1 to 2 in the proportion of 1 : 8.

3. To the mixture of 1 and 2 add a few drops of a saturated solution of hæmatoxylin in absolute alcohol.

4. It is often the case that hæmatoxylin solution prepared in this way has not the proper purple tint; but a red tint. This is due to acidity of the materials used. The proper colour can be obtained by treating it with some alkaline solution. We have found it convenient to use for this purpose a saturated solution of sodium bi-carbonate in 70 p.c. spirit. (The exact amount must be determined by experiment, as it depends upon the amount of acid present.)

The embryo should be placed for some hours in absolute alcohol, before staining with hæ-
matoxylin, and should be removed directly from absolute into the hæmatoxylin.

The time required for staining varies with the size of the object and the strength of the staining fluid. Hæmatoxylin will not stain if the embryo is not quite free from acid.

If the embryo is stained too dark, it should be treated with a solution of 70 p.c. alcohol acidulated with nitric acid (25 p.c. of acid) until the excess of staining is removed; and in all cases the hæmatoxylin staining is improved by treating the embryo with acidulated 70 p.c. alcohol.

After staining the embryo must be well washed in 70 and placed in 90 p.c. spirit.

b. With borax-carmine.

Make an aqueous solution of 2 to 3 p.c. carmine and 4 p.c. borax, by heating: add an equal volume of 70 p.c. alcohol, and let the mixture stand for thirty-six hours; after which carefully filter.

Stain the object thoroughly by leaving it in this solution for one or even two days; it will attain a dull maroon colour: transfer it then to acidulated alcohol (see a) until it becomes a bright red, and afterwards keep it as before in 90 p.c. alcohol.

This staining solution permeates more thoroughly and uniformly a large object than does hæmatoxylin: therefore when a four or five day chick is to be stained, borax-carmine is the best staining reagent to use. Embryos that have been preserved in corrosive sublimate will be
found to stain more thoroughly in this than in the hematoxylin solution.

With carmine

Beate's carmine or some alcoholic solution is the best. Into this the embryo may be removed directly from 90% alcohol, left for 24 hours, and then placed again in alcohol until required.

With picric-carmine.

This reagent is useful as will be seen later for staining mammalian segmenting ova and very young blastodermis; it is used with the greatest success after hardening in oxalic acid.

There are several methods of making picric-carmine, the following is the simplest, and we have found it answer our purpose fairly well.

To a solution made up of 1 grm. of carmine 4 cc. of liquor ammonia and 200 cc. of distilled water add 9 grms. of picric acid; agitate the mixture for some minutes, and then decant, leaving the excess of acid.

The decanted fluid must remain for several days, being stirred up from time to time; eventually evaporated to dryness in a shallow vessel, and to every 3 grms. of the residue add 100 cc. of distilled water.

With alum carmine.

To make it, boil a strong aqueous solution of ammonia alum with excess of carmine for 10 to 20 minutes, filter, and dilute the nitrate until it contains from 1 to 5 p.c. of alum. Add a few drops of carabolic acid to prevent the growth of fungus.
matroxylin, and should be removed directly into the hematoxylin.

The time required for staining varies with the size of the object and the strength of the staining fluid. Hematoxylin will not stain if the embryo is not quite free from acid.

If the embryo is stained too dark, it should be treated with a solution of 70 p.c. alcohol acidulated with nitric acid (25 p.c. of acid until the excess of staining is removed; and in all cases the hematoxylin staining is improved by treating the embryo with acidulated 70 p.c. alcohol.

After staining the embryo must be well washed in 70 and placed in 90 p.c. spirit.

5 With borax-carmine.

Make an aqueous solution of 2 to 3 p.c. carmine and 4 p.c. borax by heating; add an equal volume of 70 p.c. alcohol, and let the mixture stand for thirty-six hours; after which carefully filter.

Stain the object thoroughly by leaving it in this solution for one or even two days; it will attain a dull maroon colour; transfer it then to acidulated alcohol (see 6) until it becomes bright red, and afterwards keep it as before in 90 p.c. alcohol.

This staining solution permeates more thoroughly and uniformly a large object than the hematoxylin; therefore when a four or five day chick is to be stained, borax-carmine is the best staining reagent to use. Embryos that have been preserved in corrosive sublimate will
found to stain more thoroughly in this than in the haematoxylin solution.

c. With carmine.

Beale's carmine or some alcoholic solution is the best. Into this the embryo may be removed directly from 90 p.c. alcohol, left for 24 hours, and then placed again in alcohol until required.

d. With picro-carmine.

This reagent is useful as will be seen later for staining mammalian segmenting ova and very young blastoderms; it is used with the greatest success after hardening in osmic acid.

There are several methods of making picro-carmine, the following is the simplest, and we have found it answer our purpose fairly well.

To a solution made up of 1 grm. of carmine 4 cc. of liquor ammonia and 200 cc. of distilled water add 5 grms. of picric acid; agitate the mixture for some minutes, and then decant, leaving the excess of acid.

The decanted fluid must remain for several days, being stirred up from time to time; eventually evaporated to dryness in a shallow vessel, and to every 2 grms. of the residue add 100 cc. of distilled water.

e. With alum carmine.

To make it, boil a strong aqueous solution of ammonia-alum with excess of carmine for 10 to 20 minutes, filter, and dilute the filtrate until it contains from 1 to 5 p.c. of alum. Add a few drops of carbolic acid to prevent the growth of fungus.
Well hardened tissues may be left in this aqueous solution for 24 hours. It is especially good for staining nuclei; as a rule the staining is not diffuse, but it is necessary after staining to treat with acid alcohol (see \( a \)).

3. **Imbedding and Cutting Sections.**

It is not possible to obtain satisfactory sections of embryos without employing some method of imbedding, and using a microtome. Many imbedding solutions and methods of cutting sections have been used, but we find the following far superior to any other. It combines several advantages; in the first place it renders it comparatively easy to obtain, what is so essential, a complete *consecutive series* of sections of the embryo; and secondly, all the sections when mounted are in the same relative position; and the various parts of each section retain their normal position with regard to each other.

\( a \). **Imbedding.**

The substance we prefer for imbedding is paraffin. As will be seen below it is necessary to have at hand paraffins of various melting points, according to the temperature of the room at the time when the sections are cut.

It will be found most convenient to obtain paraffins of the highest and lowest melting points and to mix them together as experience dictates.

Place the stained embryo in absolute alcohol until completely dehydrated (two hours is sufficient for small embryos); and when ready
to immerse rock in ‘turpentine’ until it is completely saturated; and transfer it theme with as little turpentine as possible to a dish of melted paraffin.

In cases of very delicate tissues, it is better to use chloroform instead of turpentine. The chloroform should be cautiously added by means of a pipette to the absolute alcohol in which the tissue is placed. The chloroform sinks to the bottom of the bottle or tube and the embryo, which at first lies at the junction of the two liquids, gradually sinks into the chloroform. When this is accomplished, remove off the absolute with a pipette and add pieces of solid paraffin to the chloroform. Gently warm this on a water bath till all the chloroform is driven off; then immerse the usual way.

Care must be taken that no more heat is used than is necessary to melt the paraffin; for this purpose the paraffin should be warmed over a water bath the temperature of which is kept constant (from 60 to 66°C, but not more than 60°C).

A paraffin melting at 44°C is of the proper consistence for embedding where the temperature of the room is 15°C. (60°F).

With care a porcelain evaporating dish and a gas flame may be made to answer, but the student is advised not to immerse without a water bath.

The embryo may be left in the paraffin two, three or more hours, after which it is individuated by placing it along with the melted paraffin in either a box made by bending up the sides and folding in the corners of a piece of stiff paper, or what is better, a box formed by two Debeaux.

If the alcohol is not quite absolute benzene should be used instead of turpentine.
Well hardened tissues may be left in the aqueous solution for 24 hours. It is especially good for staining nuclei; as a rule the staining is not diffuse, but it is necessary after staining to treat with acid alcohol (see a).

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Care must be taken that no more heat is used than is necessary to melt the paraffin; for this purpose the paraffin should be warmed over a water bath the temperature of which is kept constant (from 50 to 60°C. but not more than 60°C.).

A paraffin melting at 44°C. is of the proper consistency for cutting when the temperature of the room is 15°C. (60°F).

With care a porcelain evaporating dish and a gas flame may be made to answer, but the student is advised not to imbed without a water bath.

The embryo may be left in the paraffin two, three or more hours, after which it is imbedded by placing it along with the melted paraffin in either a box made by bending up the sides and folding in the corners of a piece of stiff paper, or what is better, a box formed by two L-shaped

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1 If the alcohol is not quite absolute kreasote should be used instead of turpentine.
pieces of lead, placed on a glass slide in such a manner as to enclose a space. The latter is preferable because the object can be placed in any position required with great ease by moving it with a hot needle, and the whole can be cooled rapidly. It is advisable, at any rate at first, to arrange the embryo so as to cut it into transverse sections.

When cool a block of paraffin is formed, in the midst of which is the embryo.

Other imbedding agents have been used. The best of these are, (1) pure cocoa butter; (2) a mixture of spermaceti and castor oil or cocoa butter (4 parts of the former to one of the latter). With these imbedding substances, it is generally necessary to moisten the razor, either with olive oil or turpentine and ribbons of sections cannot be made (see b).

b. Cutting sections.

When the imbedding block is cold pare away the edges, then gradually slice it away until the end of the embryo is near the surface, and place it in a microtome.

The microtome we are most accustomed to is a ‘sliding microtome’ made by Jung of Heidelberg; it gives excellent results. Recently however Messrs Caldwell and Threlfall have designed an automatic microtome which has been used with success at the Cambridge Morphological Laboratory and promises to effect a great saving of time and trouble in cutting sections (vide p. 471 and Proceedings of the Cambridge Phil. Soc. 1883). A convenient small microtome is one made by Zeiss of Jena (also by the Cambridge Scientific Instrument Company), in which the object is fixed and by means of a finely divided screw
raised through a hole in a glass plate, series, which a razor held in the hand is pushed. We will briefly describe the method of manipulation for the small microtome; it will be found easily applicable to Jung's sliding microtome.

The paraffin block is pared in such a manner that the edge nearest to the operator and that opposite to him are parallel. A dry razor is then pushed upon the glass plate over the hole through which the block of paraffin projects upward, and a section cut which remains upon the razor. Care must be taken that the edge of the razor is parallel to the parallel edges of the paraffin block. The block having been raised by the razor, a second section is made in the same way and on the same part of the razor as the first; in consequence of which, the first section will be pushed backwards by the second. Similarly each new section pushes backwards those already made, and a villous of sections formed, which, if the paraffin is of the right consistency, will adhere firmly together.

Experience must teach the manipulator how to mix the paraffin in such a manner that it is neither too hard nor too soft; if it is too hard, the sections will not adhere together and will curl up on the razor; if too soft, they will stick to the razor and be found to be creased. When it is not possible to keep the temperature of the room constant, it will be found convenient to use a hard paraffin, and when necessary to raise the temperature by means of a lamp.

The paraffin should completely surround the embryo and fill up all the spaces within it.
pieces of tape, placed on a clean slide in such a manner as to enclose a space. The latter, by preferable because the object can be placed in any position required with great ease by moving it with a hot needle, and the whole can be cooled rapidly. It is advisable, at any rate at first, to arrange the embryo so as to cut it into transverse sections.

When a block of enucleated is formed, in the table of which is the embryo.

Other embedding agents have been used. The best of these are: (1) pure bone flour; (2) a mixture of gum aspic and kerosene oil or various butters of parts of the brains in one of the tables. With these embedding substances, it is generally necessary to macerate the pieces, which may be of various sizes, with olive oil or benzine and ribbons of asbestos must be made (see b).

Cutting sections.

When the embedding block is cold parts away the edges, then gradually slice it away until the end of the embryo is near the surface, and place it in a microtome.

The microtome we are most accustomed to is a 'Brocking microtome' made by Jung of Heidelberg. It gives excellent results. Recently however Messrs Caldwell and Thrall have designed an electric microtome which has been used with success at the Cambridge Morphological Laboratory and promises to afford a great saving of time and trouble in cutting sections (vide p. 42 and Proceedings of the Cambridge Phil. Soc. 1883).

A convenient small microtome is one made by Zais of Zena (also by the Cambridge Scientific Instrument Company), in which the object is fixed by means of a finely divided screw.
raised through a hole in a glass plate, across which a razor held in the hand is pushed. We will briefly describe the method of manipulation for the small microtome, it will be found easily applicable to Jung's sliding microtome.

The paraffin block is pared in such a manner that the edge nearest to the operator and that opposite to him are parallel. A dry razor is then pushed upon the glass plate over the hole through which the block of paraffin projects upwards, and a section cut which remains upon the razor. Care must be taken that the edge of the razor is parallel to the parallel edges of the paraffin block. The block having been raised by the screw, a second section is made in the same way and on the same part of the razor as the first; in consequence of which, the first section will be pushed backwards by the second. Similarly each new section pushes backwards those already made; and a ribbon of sections formed which, if the paraffin is of the right consistency, will adhere firmly together.

Experience must teach the manipulator how to mix the paraffin in such a manner that it is neither too hard nor too soft; if it is too hard, the sections will not adhere together and will curl up on the razor, if too soft they will stick to the razor and be found to be creased. When it is not possible to keep the temperature of the room constant it will be found convenient to use a hard paraffin, and when necessary to raise the temperature by means of a lamp.

The paraffin should completely surround the embryo and fill up all the spaces within it.
c. **Mounting sections.**

When the sections are cut, place them in rows on a slide prepared in the following manner. Make a solution of white shellac in kreasote by heating, and let it be of the consistency of glycerine, or slightly more fluid. With a camel's hair-brush paint a very thin and uniform layer of this gum over the slide which must be clean and *dry*, and while the gum is wet place the sections in rows upon it. Now place the slide on a water bath which is heated up to the melting point of the paraffin. The sections sink down into the thin layer of shellac and kreasote, the kreasote slowly evaporates and the shellac becoming hard fixes the section in the position in which it was placed on the slide. When the kreasote has been evaporated, pour turpentine carefully upon the slide, this dissolves the paraffin and clears the sections which may at once be mounted in canada balsam.

A turpentine or chloroform solution of canada balsam should be used.

This method of cutting ribbons of sections was first introduced by Mr Caldwell, to whom we are also indebted for the account given above for mounting sections (vide Note B, p. 471). The latter however is a modification and improvement of Dr Giesbrecht's method. (*Zoologischer Anzeiger* No. 92, 1881.)

C. **Preservation of the embryo as a whole.**

Chick embryos of the first or second day may be easily preserved whole as microscopic objects. For this purpose, the embryo, which has been preserved
II. Examination of a 38 to 38 week embryo.

The embryo will first be fixed by the use of a good fixative with the study of an embryo of this age. The fixation is not difficult, and the method will be sufficiently simple to allow some hands to carry it out. Earlier embryos are much easier to handle. Experience has been gained, and the details are not so many as to render it tedious or difficult with them.

A. Opening the Egg.

Take the egg and place it in a large dish of hot water, and place it in a warm, but not hot, solution. Since the blastoderm will not be the same in all, it can be found at the upper or lower end of the egg. The small, thin, large tank of water should be covered with black. In a day or two it will be necessary to place the embryos in the mouth of a hot water bath. As the upper surface is heated, the embryo will fall without making any effort. The time is not over 5 per cent. in 30 minutes. When heated to 38°C, as well as for those which have not the break through the shell of the air chamber, and 80°C, the already bent position, they will be ready for fixation.
Mounting sections.

When the sections are cut, place them in a bath prepared in the following manner. Make a solution of white shellac in kerosene by heating and let it be of the consistency of glycerine, or slightly more fluid. With a camel’s hair brush paint a very thin and uniform layer of this gum over the slide which must be clean and dry, and while the gum is wet place the sections in rows upon it. Now place the slide on a water bath which is heated up to the melting point of the paraffin. The sections sink down into the thin layer of shellac and kerosene, the kerosene slowly evaporates and the shellac becoming hard fixes the section in the position in which it was placed on the slide. When the kerosene has been evaporated, pour turpentine over the slide, this dissolves the paraffin and shows the sections which may at once be mounted in Canada balsam.

A suspension of thymolform solution of Canada balsam would be said.

This method of cutting ribbons of sections was first introduced by Mr. Caldwell, to whom we are also indebted for the account given above for mounting sections (see Note B, p. 471). The latter however is a modification and improvement of Dr. Schleiden’s method. (Zeitschrift Anzeiger No. 52, 2881.)

Preservation of the embryo as a whole.

Chick embryos of the first or second day may be easily preserved whole as microscopic objects. For this purpose the embryo, which has been preserved
in the ordinary way (B, a) should be stained *slightly*, dehydrated, soaked in oil of cloves until transparent and mounted in balsam.

Whole embryos of a later date cannot be satisfactorily preserved as microscopic objects.

**PRACTICAL DIRECTIONS FOR OBTAINING AND STUDYING CHICK EMBRYOS.**

II. **Examination of a 36 to 48 hours' embryo.**

The student will find it by far the best plan to begin with the study of an embryo of this date. The manipulation is not difficult; and the details of structure are sufficiently simple to allow them to be readily grasped. Earlier embryos are troublesome to manage until some experience has been gained; and the details of later ones are so many as to render it undesirable to begin with them.

A. **Opening the Egg.**

Take the egg warm from the hen or the incubator, and place it (it does not matter in what position, since the blastoderm will at this stage always be found at the uppermost part of the egg) in a small basin large enough to allow the egg to be covered with fluid. It is of advantage, but not necessary, to place at the bottom of the basin a mould, *e.g.* a flat piece of lead with a concavity on the upper surface, in which the egg may rest securely without rolling. Pour into the basin so much of a *75* per cent. solution of sodium chloride warmed to 38°C. as will cover the egg completely. With a sharp tap break through the shell at the broad end over the air-chamber, and let out as much air as has already been gathered there. Unless this is done,
the presence of air in the air-chamber will cause the broad end to tilt up. At this date there will be very little air, but in eggs of longer incubation, inconvenience will be felt unless this plan be adopted.

Instead of being broken with a blow, the shell may be filed through at one point, and the opening enlarged with the forceps; but a little practice will enable the student to use the former and easier method without doing damage.

With a blunt pair of forceps, remove the shell carefully bit by bit, leaving the shell-membrane behind; begin at the hole made at the broad end, and work over the upper part until about a third or half of the shell has been removed.

Then with a finer pair of forceps remove the shell-membrane; it will readily come away in strips, torn across the long axis of the egg in a somewhat spiral fashion. The yolk and embryo will now come into view.

It is the practice of some simply to break the egg across and pour the yolk and white together into a basin, very much as the housewife does. We feel sure, however, that the extra trouble of the method we have given will be more than repaid by the results.

During this time, and indeed during the whole period of the examination of the embryo in situ, the basin and its contents must be maintained, either by renewal of the salt solution, or by the basin being placed on a sand-bath, at about 38°C.

B. Examination of the blastoderm in situ.

This may be done with the naked eye, or with a simple lens of low power. Observe:—
1. Lying above the long axis of the egg in a crescentic area, in the middle of which the nucleus lies obliterated, seen as a white streak.

2. The intestinal crescent area, with the cells beginning to be formed.

3. A. The amnion first spreading over the yolk, with no changes in the yolk around its periphery.

4. (With a simple lens), the chorion and the yolk, perhaps the outlines of the head of the embryo may be detected.

C. Removal of the yolk:

Place one blade of a sharp pair of scissors through the outer membrane, but outside the inner membrane of the amniotic area, and slowly cut the inner membrane completely, and when the circle is complete, avoid as much as possible any agitation of the liquid in the dish.

With a forceps and with a needle, dipped by gentle shaking, remove the piece of vitelline membrane covering the blastoderm.

If any yolk adheres to the blastoderm, it may be transferred to a watch-glass, paste being taken to keep it as flat as possible. With a pair of forceps or with a needle, placed by gentle shaking, remove the piece of vitelline membrane covering the blastoderm.

If any yolk adheres to the blastoderm, it may be transferred to a watch-glass, paste being taken to keep it as flat as possible. With a pair of forceps or with a needle, placed by gentle shaking, remove the piece of vitelline membrane covering the blastoderm.

The blastoderm should now be removed from the watch-glass to a microscope glass slide to be difficult in the form of the embryo to portray the forms of the blastoderm from curling up.
the properties of air in the still-chamber will cause the shell-end to sink up. At this date there will be very little air, but in eggs of longer incubation, its convenience will be felt unless this plan be adopted.

Instead of being broken with a blow, the shell may be filed through at one point, and the opening enlarged with the forceps; but a little practice will enable the student to use the former and easier method without doing damage.

With a sharp pair of forceps, remove the shell carefully bit by bit, leaving the shell-membrane behind; begin at the hole made at the broad end, and work over the upper part until about a third or half of the shell has been removed.

Then, with a finer pair of forceps, remove the shell-membrane, it will readily come away in strips, from across the long axis of the egg in a somewhat spiral fashion. The yolk and embryo will now come into view.

It is the practice of some simply to break the egg across and pour the yolk and white together into a basin, very much as the housewife does. We feel sure, however, that the extra trouble of the method we have given will be more than repaid by the results.

During this time, and indeed during the whole period of the examination of the embryo in situ, the basin and its contents must be maintained, either by renewal of the salt solution, or by the basin being placed on a sand-bath, at about 38°C.

B. Examination of the Blastoderm in situ.

This may be done with the naked eye, or with a simple lens of low power. "Observer:"
1. Lying across the long axis of the egg, the *pellucid area*, in the middle of which the *embryo* may be obscurely seen as a white streak.

2. The mottled *vascular area*, with the blood-vessels just beginning to be formed.

3. The *opaque area* spreading over the yolk with the changes in the yolk around its periphery.

4. (With a simple lens), the contractions of the heart; perhaps the outlines of the head of the embryo may be detected.

C. *Removal of the embryo*.

Plunge one blade of a sharp fine pair of scissors through the blastoderm, just outside the outer margin of the vascular area, and rapidly carry the incision completely round until the circle is complete, avoid as much as possible any agitation of the liquid in the basin.

With a little trouble, the excised blastoderm may now be floated into a watch-glass, care being taken to keep it as flat as possible. With a pair of forceps or with a needle, aided by gentle shaking, remove the piece of vitelline membrane covering the blastoderm.

If any yolk adheres to the blastoderm, it may with a little gentle agitation easily be washed off. Sometimes it is of advantage to suck up the yolk with a glass syringe, replacing the fluid removed with clean (·75 p.c.) salt solution.

The blastoderm should now be removed from the watch-glass to a microscopic glass slide; since it is difficult in the former to prevent the edges of the blastoderm from curling up.
The transference may easily be effected, if both the watch-glass and slide are plunged into a basin of clean warm salt solution. With a little care, the blastoderm can then be floated from the one to the other, and the glass slide, having the blastoderm with its upper surface uppermost spread flat upon it, very gently raised out of the liquid.

A thin ring of putty may now be placed round the blastoderm, a small quantity of salt solution gently poured within the ring, and the whole covered with a glass slide, which may be pressed down until it is sufficiently close to the embryo. The presence of any air-bubbles must of course be avoided.

Provided care be otherwise taken to keep the embryo well covered with liquid, the putty ring and the coverslip may be dispensed with. They are often inconvenient, as when the embryo has to be turned upside down.

The object is now ready for examination with a simple lens or with a compound microscope of low objective. It is by far the best for the student to begin at least with the simple lens. In order that everything may be seen at its best, the slide should be kept warmed to about 38°, by being placed on a hot stage.

D. Surface view of the transparent embryo from above.

The chief points to be observed are:

1. The head-fold.
2. The indications of the amnion; especially the false amnion, or outer amniotic fold.
The neural tube: the hint of coalescence of the medullary folds, the first cervical vertebra, the commencing optic vesicles, the indications of the second and third cervical vertebrae, the as yet open medullary folds at the tail end.

4. The heart seen dimly through the neural tube; note its pulsation if present.

5. The fold of the somatopleure anterior to the heart (generally very faintly shown).

6. The fold of the splanchnopleure (more distinctly seen); the vitelline veins.

7. The mesoblastic segment.

8. Indications of the vitelline arteries.

9. The as yet barely formed tail fold.

10. The commencing blood-vessels in the pellucid and vascular areas.

E. **Surface view of the transparent embryo from below**

The coverslip must now be removed and the glass slide again immersed in a vessel of clean sea water. By gently retching the narrow edge of the opaque area with a pair of forceps, as difficulty will be found in so fractioning the blastoderm, as to turn it upside down, and then to replace it on the slide with the under surface upwards.

The points which most deserve attention in this view, are:

1. The heart: its position, its relation with the vitelline veins, its arterial end.
The transplantation may readily be effected, if both the wafer, glass and slide are plunged into a basin of clear warm salt solution. With a little care, the blastoderm can then be floated from one to the other, and the glass slide, having the blastoderm with its upper surface uppermost spread flat upon it, very gently raised out of the liquid.

A thin ring of putty may now be placed round the blastoderm, a small quantity of salt solution gently poured within the ring, and the whole covered with a glass slide, which may be pressed down until it is sufficiently close to the embryo. The presence of any air bubbles must of course be avoided.

Provided care be otherwise taken to keep the embryo well covered with liquid, the putty ring and the coverlet may be dispensed with. They are often inconvenient, as when the embryo has to be turned upside down.

The object is now ready for examination with a simple lens or with a compound microscope of low objective. It is by far the best for the student to begin at least with the simple lens. In order that everything may be seen at its best, the slide should be kept warmed to about 36° by being placed on a hot stage.

D. Surface view of the transparent embryo from above.

The chief points to be observed are:

1. The homb-fold.
2. The indications of the amnion; especially the false amnion, or outer amniotic fold.
3. The neural tube: the line of coalescence of the medullary folds, the first cerebral vesicle, the commencing optic vesicles, the indications of the second and third cerebral vesicles, the as yet open medullary folds at the tail end.

4. The heart seen dimly through the neural tube; note its pulsation if present.

5. The fold of the somatopleure anterior to the heart (generally very faintly shewn).

6. The fold of the splanchnopleure (more distinctly seen): the vitelline veins.

7. The mesoblastic somites.

8. Indications of the vitelline arteries.

9. The as yet barely formed tail-fold.

10. The commencing blood-vessels in the pellucid and vascular areas.

E. Surface view of the transparent embryo from below.

The coverslip must now be removed and the glass slide again immersed in a vessel of clean salt solution. By gently seizing the extreme edge of the opaque area with a pair of forceps, no difficulty will be found in so floating the blastoderm, as to turn it upside down, and thus to replace it on the slide with the under surface uppermost.

The points which most deserve attention in this view, are:

1. The heart: its position, its union with the vitelline veins, its arterial end.
2. The fold of the splanchnopleure marking the hind limit of the gut; the vitelline veins running along its wings.

3. The mesoblastic somites on each side of the neural canal behind the heart; farther back still, the vertebral plates not divided into somites.

F. *The examination of the embryo as an opaque object.*

This should never be omitted. Many points in the transparent embryo only become intelligible after the examination of it as an opaque object.

Having removed the putty ring and coverslip, if previously used, allow the blastoderm so far to become dry, that its edge adheres to the glass slide. Care must of course be taken that the embryo itself does not become at all dry. Place the glass slide with the blastoderm extended flat on it, in a shallow vessel containing a solution of picric acid (I. B.).

If the blastoderm be simply immersed by itself in the picric acid solution, the edges of the opaque area will curl up and hide much of the embryo. The method suggested above prevents these inconveniences.

The embryo thus hardened and rendered opaque by immersion in the acid (a stay of 2 to 3 hours in the solution will be sufficient) may be removed to a watch-glass, containing either some of the solution, or plain water, and examined with a simple lens, under a strong direct light. The compound microscope will be found not nearly so advantageous for this purpose as the simple lens. A piece of black paper placed under the watch-glass, will throw up the lights and
sections of the embryo, with benefit. The watch-
glass should have a flat bottom, or a shallow 
glass cell should be used instead.

a. Looking at the embryo from above, observe:

1. The head-fold, the head distinctly projecting from 
the plane of the blastoderm, and formed chiefly by 
the forebrain and optic vesicles.

2. The elevation of the medullary canal, and the 
indications of the skin walls of the embryo.

3. The indications of the tail.

4. The Amnion partly covering the head. Tear it 
open with needles. Observe its two folds.

b. Having turned the blastoderm upside down, 
observe the following points, looking at the embryo 
from below.

1. The hinder limit of the splanchnopleure in the 
head-fold, marking the hind limits of the fore-
part. The opaque folds now conceal the head almost 
entirely from view.

2. The commencing tail-fold, and the shallow boat-
shaped cavity (of the alimentary canal) between it 
and the head-fold.

The student should not fail to make sketches 
of the embryo, both at a transparent, and as an 
opaque object, seen from below as well as from 
above. These sketches will be of great service to 
him, when he comes to study the sections of the 
same embryo.
2. The fold of the amnion-sacure marking the third fold of the gut, the vitelline veins running along the sides.

3. The hemislides remain on each side of the neural canal behind the heart, further back will, the ventral plate not divided into somites.

4. The examination of the embryo as an opaque object.

This should never be omitted. Many points in the transparent embryo only become intelligible after the examination of it as an opaque object.

Having removed the putty ring and coverslip, if previously used, allow the blastoderm to dry in the air. Then, if the edge adheres to the glass slide, care must also be taken that the embryo itself does not become at all dry. Place the glass slide, with the blastoderm extended flat on it, in a small vessel containing a solution of picric acid (1:10).

If the blastoderm be simply immersed in the picric acid solution, the edges of the opaque area will curl up and hide much of the embryo. This method suggested above prevents these inconveniences.

The embryo thus hardened and rendered opaque by immersion in the acid (a stay of 3 to 5 hours in the solution will be sufficient) may be removed to a watch-glass, containing either some of the solution, or plain water, and examined with a simple lens, under a strong direct light. The compound microscope will be found not nearly so advantageous for this purpose as the simple lens. A piece of black paper placed under the watch-glass, will throw up the lights and
shadows of the embryo, with benefit. The watch-glass should have a flat bottom; or a shallow flat glass cell should be used instead.

a. Looking at the embryo from above, observe:—

1. The head-fold; the head distinctly projecting from the plane of the blastoderm, and formed chiefly by the forebrain and optic vesicles.

2. The elevation of the medullary canal, and the indications of the side walls of the embryo.

3. The indications of the tail.

4. The Amnion partly covering the head. Tear it open with needles. Observe its two folds.

b. Having turned the blastoderm upside down, observe the following points, looking at the embryo from below.

1. The hinder limit of the splanchnopleure in the head-fold, marking the hind limits of the foregut. The opaque folds now conceal the head almost entirely from view.

2. The commencing tail-fold, and the shallow boat-shaped cavity (of the alimentary canal) between it and the head-fold.

The student should not fail to make sketches of the embryo, both as a transparent, and as an opaque object, seen from below as well as from above. These sketches will be of great service to him when he comes to study the sections of the same embryo.
G. The following transverse sections will perhaps be the most instructive.

Manipulation as in I. B. 3.

1. Through the optic vesicles, shewing the optic stalks.

2. Through the hind-brain, shewing the auditory sacs.

3. Through the middle of the heart, shewing its relations to the splanchnopleure and alimentary canal.

4. Through the point of divergence of the splanchnopleure folds, shewing the venous roots of the heart.

5. Through the dorsal region, shewing the medullary canal, mesoblastic somites and commencing cleavage of the mesoblast.

6. Through a point where the medullary canal is still open, shewing the mode in which its closing takes place.

   Longitudinal sections should also be made and compared with the transverse sections.

III. Examination of an Embryo of about 48—50 hours.

A. Opening the egg—as in II. A.

B. Examination of the blastoderm in situ.

   Observe

   1. The form of the embryo, which is much more distinct than at the earlier stage.

   2. The beating of the heart.

   3. The general features of the circulation.
C. Removal of the Embryo from the tube, as in R. C.

D. Surface view of the internally empty female ova.

Notice —

1. General form of the ova.
   a. Umbilical umbilical opening.
   b. End test and end joint.

2. Section. Notice the general structural structure, limbs and connective tissue, with a saucer. Where an embryo has been removed the section of the ovary will be much more filiform shape.

3. The ovum of ova.
   a. Form. Deposition of the test mediately under compact.
   b. Anyly, extending into a deep, or a narrow opening to the pelvis.

4. The brain.
   a. The vesicles of the men, chief, and sub-tenture.
   b. The occipital vesicle.
   c. The central nervous taking place at the fore brain.

E. Transparent embryo from before.

Manipulation as in R. C.

Notice —

1. The increase of the beginnings of the men, auditory, and sphincters, being especially in length, and the commencement of these behind the wall.
G. The following transverse sections will perhaps be the most instructive.

Manipulation as in I. B. 3.

1. Through the optic vesicle, showing the optic stalk.

2. Through the hind-brain, showing the auditory canal.

3. Through the middle of the heart, showing its relation to the spleen, pancreas and alimentary canal.

4. Through the point of divergence of the splanchic nerves, showing the venous roots of the heart.

5. Through the spinal region, showing the medullary canal and its anterior median fissures and commencing cleavage of the cephalic plate.

6. Through the point where the medullary canal is still open, showing the plates in which its closing takes place.

Transversal sections should also be made and compared with the transverse sections.

III. Examination of an Embryo of about 48-50 hours.

A. Opening the egg—as in II. A.

B. Examination of the Blastoderm in situ.

Observe

1. The form of the embryo, which is much more distinct than at the earlier stage.

2. The beating of the heart.

3. The general features of the circulation.
C. Removal of the Embryo from the yolk, as in II. C.

D. Surface view of the transparent embryo from above.

Notice:—

1. General form of the embryo.
   a. Commencing cranial flexure.
   b. The tail and side folds.

2. Amnion. Notice the inner and outer (false amnion) limbs and remove them with a needle. When the amnion has been removed the features of the embryo will be much more clearly visible.

3. The organs of sense.
   a. Eye. Formation of the lens already nearly completed.
   b. Auditory involution, now a deep sac with a narrow opening to the exterior.

4. The brain.
   a. The vesicles of the fore-, mid-, and hind-brain.
   b. The cerebral vesicle.
   c. The cranial flexure taking place at the mid-brain.

E. Transparent embryo from below.

Manipulation as in II. E.

Notice:—

1. The increase of the head-folds of the somatopleure and splanchnopleure, especially the latter, and the commencement of these folds at the tail.
2. The now \( \mathcal{O} \)-shaped heart; for further particulars vide Chap. iv.

3. The commencing 1st and 2nd visceral clefts and the aortic arches.

4. The circulation of the yolk sac, vide Fig. 36. Make out all the points there shewn and ascertain by examination that what have been called the veins and arteries in that figure, are truly such.

F. The embryo as an opaque object.

Treatment as in II. F.

FROM ABOVE:

Observe the amnion, which is a very conspicuous object, and remove it with needles if not done previously. The external form of the brain and the auditory sac appear very distinctly.

FROM BELOW:

Observe the nature of the head- and tail-folds, which are much more easily understood from the opaque than from the transparent embryos.

Observe also the alimentary canal, the widely open hind end of the fore-gut, and the front end of the as yet very short hind-gut.

G. Sections.

Manipulation as in I. B. 3.

The more important sections to be observed, are

1. Through optic lobes, shewing:
   a. The formation of the lens.
   b. The involution of the primary optic vesicle.
   c. The constriction, especially from above, of the optic stalk.
1. Though auditory and skewing.
2. Auditory still open.
3. The thin root and thick sides of the hind-brain.
5. Head.

7. Through dorsal region, showing the general appearance of a section of an embryo at this stage, which should be compared with a similar section of the earlier stage.

8. In these:
   a. The commencement of the side folds; the alimentary canal still however open below.
   b. The Wolffian duct lying close under the epiblast on the outside of the somatopleura inversa.
   c. The nephrostome with the ureter on each side.

IV. Examination of an Embryo at the end of the third day.

A. Opening the egg as in II. A.

B. Examination of the blastoderm in situ.

Observations:

1. The great increase of the segments—seen both in size and distinctness. The circulation is now better seen in side than after the blastoderm has been removed.

2. That the embryo now lies completely on its left side and that it is only connected with the yolk-sac by a somewhat broad stalk.
3. The new unshaped head; for further particulars, see Chap. iv.

4. The convoluted 1st and 2nd visceral sheets and the ventricles.

5. The convolutions of the wall seen, vide Fig. 38. Make out all the points there shown and ascertain by examination that what have been called the villi and villaries in that figure are truly such.

6. The embryo as an opaque object.

Treatments as in U. F.

Examined:

Observe the size of the embryo, which is a very complicated object, and compare it with needles if not done previously. The vascular form of the brain and the rudimentary organs appear very distinctly.

Examined:

Observe the nature of the head and tail folds which are much more easily understood from the opaque than from the transparent embryo.

Observe also the alimentary canal, the widely open hind end of the form-gut, and the front end of the so-called very short blind-gut.

G. Sections.

Manipulation as in I. F. 1.

The more important sections to be observed are:

1. Through optic lobe, showing:

a. The formation of the lens.

b. The investment of the primary optic vesicle.

c. The constriction, especially from above, of optic stalk.
2. Through auditory sac, shewing:
   a. Auditory sac still open.
   b. The thin roof and thick sides of the hind-brain.
   c. Notochord.
   d. Heart.
   e. Closed alimentary canal.

3. Through dorsal region, shewing the general appearance of a section of an embryo at this stage, which should be compared with a similar section of the earlier stage.

   It shews:
   a. The commencement of the side folds; the alimentary canal still however open below.
   b. The Wolffian duct lying close under the epiblast on the outside of the mesoblastic somites.
   c. The notochord with the aortæ on each side.

IV. Examination of an Embryo at the end of the third day.

A. Opening the egg, as in II. A.

B. Examination of the blastoderm in situ.

   Observe:—
   1. The great increase of the vascular area both in size and distinctness. The circulation is now better seen in situ than after the blastoderm has been removed.
   2. That the embryo now lies completely on its left side and that it is only connected with the yolk-sac by a somewhat broad stalk.
C. *Removal of the embryo.* See II. C.

It is now unnecessary to remove the whole of the blastoderm with the embryo; indeed it is better to cut away the vascular area unless it is wanted for examination.

D. *Surface view of the transparent embryo.*

Since the embryo now lies on its side we shall not have to speak of the view from above and below. The views from the two sides differ chiefly as to the appearance of the heart.

The embryo (freed from the blastoderm and the amnion) is to be floated on to a glass slide in the usual way. It is necessary to protect it while under examination, with a coverslip, which must not be allowed to compress it. To avoid this, we have found it a good plan to support the coverslip at one end only, since by moving it about when thus supported, a greater or less amount of pressure can be applied at will to the object.

The details which can at this stage be seen in a transparent embryo are very numerous and we recommend the student to try and verify everything shewn in Fig. 37. Amongst the more important and obvious points to be noticed are

1. The increase of the *cranial flexure* and the *body-flexure.*

2. The condition of the *brain.* The mid-brain now forms the most anterior point of the head.

The fore-brain consists of the inconspicuous vesicle of the third ventricle and the two large cerebral lobes.
The hind-brain consists of a front portion, the cerebellum, with a thickened roof; and a hinder portion, the fourth ventricle with a very thin and delicate roof.

2. Organs of sense.

The eye especially is now in a very good state to observe. The student may refer to Fig. 31 and the description there given.

The carotids will be seen either just closing or completely closed.

3. In the region of the heart, attention must now be paid to:

- The visceral adhesions.
- The investing mass, i.e., the growth of mesoblast taking place around the end of the notochord.
- The condition of the heart.

4. In the region of the body, the chief points to be observed are:

- The increase in the number of the somites.
- The Wolffian duct, which can be seen as a streak along the outer side of the hinder somites.
- The aortic arch, which is now a small vessel lying between the folds of the somatopleure and splanchnopleure at the hind end of the body, but as yet hardly projects beyond the body cavity.

E. The embryo as an opaque object.

Preparation as in II. F.

The general form of the embryo can be very satisfactorily seen when it is hardened and stained as an opaque object; but the most important points to be
... Removable of the embryo, Sec. II. C.

If it were necessary to remove the whole of the
bladder into the cavity of the embryo; not only it is better to
not enter the muscular area unless it is wanted for
examination.

D. The front view of the thickened embryo.

Most the embryo now lies on its side we shall
not have to speak of the view from above and below.
The views from the two sides differ chiefly as to the
appearance of the heart.

... The embryo (from the bladder and the
muscle) is to be placed on a clean slide in the
usual way. As it necessary to protect it while under
examination, with a screwclip, which may not be
allowed to displace it. To avoid this, we have found
in a good dish to support the cover slip at one end
only, since by moving it about when thus supported,
a greater or lesser amount of pressure can be applied
as will to the object.

The details which can at this stage be seen in a
thickened embryo are very numerous and we re-
commend the student to try and verify everything
shown in Fig. 67. Among the more important and
obvious points to be noticed are

1. The increase of the cranial fissure and the brain
fissure.

2. The condition of the brain. The mid-brain area
forms the most anterior point of the head.

The fore-brain consists of the mesencephalic
ventricles of the third ventricles and the two large
cerebral lobes.
The hind-brain consists of a front portion, the cerebellum with a thickened roof; and a hinder portion, the fourth ventricle with a very thin and delicate roof.

3. **Organs of sense.**

The *eye* especially is now in a very good state to observe. The student may refer to Fig. 51, and the description there given.

The *ear-vesicle* will be seen either just closing or completely closed.

4. In the region of the heart attention must also be paid to:
   a. The *visceral clefts*.
   b. The *investing-mass*, i.e. the growth of mesoblast taking place around the end of the notochord.
   c. The condition of the *heart*.

5. In the region of the body the chief points to be observed are:
   a. The increase in the number of the *somites*.
   b. The *Wolffian duct*, which can be seen as a streak along the outer side of the hinder somites.
   c. The *allantois*, which is now a small vesicle lying between the folds of the somatopleure and splanchnopleure at the hind end of the body, but as yet hardly projects beyond the body cavity.

E. **The embryo as an opaque object.**

Preparation as in II. F.

The general form of the embryo can be very satisfactorily seen when it is hardened and examined as an opaque object; but the most important points to be
PRACTICAL DIRECTIONS. [APP.

made out at this stage in the hardened specimens are those connected with the visceral clefts and folds and the mouth.

If the amnion has not been removed it will be necessary to pick it completely away with needles. Without further preparation a view of the visceral folds and clefts may be obtained from the side; but a far more instructive view is that from below, in order to gain which the following method may be adopted.

Pour a small quantity of melted black wax (made by mixing together lampblack and melted wax) into a watch-glass, using just enough to cover the bottom of the glass. While still soft make a small depression in the wax with the rounded end of a pen-holder or handle of a paint-brush and allow the wax to cool. In the meantime cut off the head of the hardened embryo by a sharp clean transverse incision carried just behind the visceral clefts, transfer it to the watch-glass and cover it with water or spirit. By a little manipulation the head of the embryo may now be shifted into the small depression in the wax, and thus be made to assume any required position. It should then be examined with a simple lens under a strong reflected light, and a drawing made of it.

When the head is placed in the proper position, the following points may easily be seen.

1. The opening of the mouth bounded below by the first pair of visceral folds, and commencing to be enclosed above by the now very small buds which are the rudiments of the superior maxillary processes. Compare Fig. 56.
F. Sections. Manipulation as in I. B. &

The most important sections are:

1. Through the eyes in the three planes, side Fig. S3,
A, B, C.

2. Through the auditory sac.

3. Through the dorsal region, showing the general changes which have taken place.

Amongst these, notice

a. The change of the mesodermic regions, the commencing formation of the maxill plates.

b. The position of the Wolfian duct and the formation of the germinal epithelium.

c. The aortic and the cardinal veins.

d. The great increase in depth and relative diminution in breadth of the section.

V. Examination of an Embryo of the Fourth Day.

A. Opening the egg, as in II. A.

Great care will be required not to injure the embryo, which now lies close to the shell-membrane.

B. Examination in side. Observe—

1. The new conspicuous region:

2. The allantois, a small and yet haem cry vascular vessel, beginning to project from the embryo into the space between the true and the false amnion.

3. The rapidly narrowing amniotic stalk.
Some portions only of the hardened specimen are seen connected with the visceral clefts and folds and the mouth.

If the solution has not been removed it will be necessary to pick it completely away with needles. Without further preparation a view of the visceral clefts and clefts may be obtained from the side, but a far more instructive view is that from below, in order to give which the following method may be adopted.

Pour a small quantity of melted black wax (made by mixing together lampblack and melted wax) into a watch-glass, using just enough to cover the bottom of the glass. While still soft make a small depression in the wax with the rounded end of a pen-holder or handle of a pen-brush and allow the wax to cool. In the meantime cut off the head of the hardened embryo by a sharp clean transverse incision carried just behind the visceral clefts, transfer it to the watch-glass and cover it with water or spirit. By a little manipulation the head of the embryo may now be snipped into the small depression in the wax, and thus be made to assume any required position. It should then be examined with a simple lens under a strong reflected light, and a drawing made of it.

When the head is placed in the proper position, the following points may easily be seen.

1. The opening of the mouth bounded below by the first pair of visceral folds, and commencing to be prefixed above by the now very small folds which are the vestigial of the superior auriculare process. Compare Fig. 86.
FOURTH DAY EMBRYO.

2. The second and third visceral arches and clefts.
3. The nasal pits.

F. Sections. Manipulation as in I. B. 3.

The most important sections are:

1. Through the eyes in the three planes, vide Fig. 50, A. B. C.
2. Through the auditory sac.
3. Through the dorsal region, shewing the general changes which have taken place.

Amongst these, notice

a. The changes of the mesoblastic somites: the commencing formation of the muscle-plates.

b. The position of the Wolffian duct and the formation of the germinal epithelium.

c. The aortæ and the cardinal veins.

d. The great increase in depth and relative diminution in breadth of the section.

V. Examination of an Embryo of the Fourth Day.

A. Opening the egg, as in II. A.

Great care will be required not to injure the embryo, which now lies close to the shell-membrane.

B. Examination in situ. Observe:

1. The now conspicuous amnion.

2. The allantois, a small, and as yet hardly vascular vesicle, beginning to project from the embryo into the space between the true and the false amnion.

3. The rapidly narrowing somatic stalk.
C. Removal of the embryo, as in II. C. and IV. C.

The remarks made in the latter place apply with still greater force to an embryo of the fourth and succeeding days.

D. Surface view of the transparent embryo. For manipulation, vide IV. D.

The points to be observed are:

1. The formation of the fifth, seventh, and ninth cranial nerves.
   To observe these, a small amount of pressure is advantageous.

2. The formation of the fourth visceral cleft, and the increase in size of the superior maxillary process.

3. The formation of the nasal pits and grooves.

4. The great relative growth of the cerebral lobes and the formation of the pineal gland from the roof of the vesicle of the third ventricle.

5. The great increase in the investing mass.

6. The formation and growth of the muscle-plates, which can now be easily seen from the exterior.

7. The allantois. Make out its position and mode of opening into the alimentary canal.

E. The embryo as an opaque object. Manipulation as II. F. For mode of examination vide IV. E.

The view of the mouth from underneath, shewing the nasal pit and grooves, the superior and inferior maxillary processes and the other visceral folds and clefts, is very instructive at this stage. Compare Fig. 69.
V. Section. Manipulation as in I. B. 3.

The most important sections are:

1. Through the eye.
2. Transverse section immediately behind the visceral arches, showing the origin of the lungs.
3. Transverse section just in front of the umbilical stalk, showing the origin of the heart.
4. Transverse section at about the centre of the dorsal region, to show the general features of the fourth day. Compare Fig. 68.

Amongst the points to be noticed in this section, are:

a. muscles plates.

b. spinal nerves and ganglia.

c. Wolffian duct and bodies.

d. Müller's duct.

e. Mesentery.

f. Commencing changes in the spinal cord.

6. Section passing through the opening of the allantois into the alimentary canal.

For the points to be observed in embryos of the fifth and sixth days, the student must consult the chapters devoted to those days.

In the hardened specimen, special attention should be paid to the changes which take place in the parts forming the boundaries of the mouth.

VI. Examination of a Embryos of 20 hours.

A. Opening the eye, as in II. A.

B. Examination in situ.

- It will not be found possible to make any satisfactory views satisfactory from the examination of a human
C. Removal of the embryo, as in H. C. and IV. C.

The remarks made in the latter place apply with slight variation here to an embryo of the fourth and succeeding days.

D. Section above of the transparent embryo. For manipulation, see IV. D.

The points to be observed are:

1. The formation of the fifth, seventh, and ninth cranial nerves.

To observe these, a small amount of pressure is necessary.

2. The formation of the fourth visceral crest, and the incisions to size of the superior maxillary process.

3. The formation of the nasal pits and grooves.

4. The great relative growth of the cerebral lobes and the development of the pineal gland from the roof of the ventricle of the third ventricle.

5. The great increase in the incisive max.

6. The formation and growth of the muscle-plates, which can now be easily seen from the exterior.

7. The alveolar. Make out its position and mode of opening into the alimentary canal.

E. The embryo as an opaque object. Manipulation as H. H. For mode of examination see IV. E.

The view of the mouth from underneath, showing the nasal pits and grooves, the superior and inferior maxillary processes and the other visceral folds and dents, is very instructive at this stage. Compare Fig 69.
F. Sections. Manipulation as in I. B. 3.

The most important sections are,

1. Through the eyes.
2. Transverse section immediately behind the visceral arches, shewing the origin of the lungs.
3. Transverse section just in front of the umbilical stalk, shewing the origin of the liver.
4. Transverse section at about the centre of the dorsal region, to shew the general features of the fourth day. Compare Fig. 68.

Amongst the points to be noticed in this section, are

b. Spinal nerves and ganglia.
c. Wolffian duct and bodies.
d. Müller's duct.
e. Mesentery.
f. Commencing changes in the spinal cord.

5. Section passing through the opening of the allantois into the alimentary canal.

For the points to be observed in embryos of the fifth and sixth days, the student must consult the chapters devoted to those days.

In the hardened specimens, especial attention should be paid to the changes which take place in the parts forming the boundaries of the mouth.

VI. Examination of a Blastoderm of 20 hours.

A. Opening the egg, as in II. A.

B. Examination in situ.

It will not be found possible to make out anything very satisfactory from the examination of a blasto-
derm in situ at this age. The student will however not fail to notice the halones, which can be seen forming concentric rings round the blastoderm.

C. Removal of the embryo.

Two methods of hardening can be adopted at this age. One of these involves the removal of the blastoderm from the yolk, as in II. C. In the other case, the yolk is hardened as a whole. If the latter method be employed, the embryo cannot be viewed as a transparent object.

In the cases where the blastoderm is removed from the yolk, the manipulation is similar to that described under II. C, with the exception of more care being required in freeing the blastoderm from the vitelline membrane.

D. Surface view transparent, from above.

Observe:—

1. The medullary groove between the two medullary folds, whose hind ends diverge to enclose between them the end of the primitive groove.

2. The head-fold at the end of the medullary groove.

3. The one or two pairs of mesoblastic somites flanking the medullary groove.

4. The notochord as an opaque streak along the floor of the medullary groove.

E. Surface view transparent, from below.

Same points to be seen as from above, but less clearly.
F. Embryo as an opaque object.

As an opaque object, whether the embryo is hardened in situ or after being removed from the yolk, the same points are to be seen as when it is viewed as a transparent object, with the exception of the notochord and mesoblastic lamellae (slide D). The various grooves and folds are however seen with far greater clearness.

G. Hardening

Two methods of hardening may be employed; (1) with the embryo in situ, (2) after it has been removed.

To harden the blastoderm in situ the yolk must be hardened as a whole. After opening the egg either leave the yolk in the egg-shell or pour it out into a Röhm capsule; in any case freeing it as much as possible from the white, and taking especial care to remove the more adherent layer of white which immediately surrounds the yolk.

Place it in picric acid or a weak solution of chromic acid (first of 9 p.c. and then of 5 p.c.) with the blastoderm uppermost and leave it in that position for two or three days.

Care must be taken that the yolk does not roll about; the blastoderm must not be allowed to alter its position; otherwise it may be hard to find it when everything has become opaque. If at the end of the second day the blastoderm is not sufficiently hard the strength of the solution, if necessary, may be increased and the exposure lengthened for another day.

After it has become hardened by this method the yolk should be washed with water and poured into
dern to age at this age. The student will however not fail to notice the blastome, which can be seen forming successive rings round the blastoderm.

C. Removal of the blastome.

Two methods of hardening can be adopted at this stage. One of these involves the removal of the blastoderm from the yolk, as in H. C. In the other case, the yolk is hardened as a whole. If the latter method is employed, the embryo cannot be viewed as a separate object.

In the case where the blastoderm is removed from the yolk, the manipulation is similar to that described under H. C., with the exception of care being exercised in freeing the blastoderm from the vitelline membrane.

D. Anterior view transparent, from above.

Observe—

1. The medullary groove between the two medullary fields, whose blind ends diverge to surface between them the end of the primitive groove.

2. The head-field at the end of the medullary groove.

3. The one or two pairs of mesoblastic somites flanking the medullary groove.

4. The entoderm as an opaque streak along the floor of the medullary groove.

E. Surface view transparent, from below.

Same points as to be seen as from above, but less clearly.
F. *Embryo as an opaque object.*

As an opaque object, whether the embryo is hardened *in situ* or after being removed from the yolk, the same points are to be seen as when it is viewed as a transparent object, with the exception of the notochord and mesoblastic somites (*vide* D). The various grooves and folds are however seen with far greater clearness.

G. *Sections.*

Two methods of hardening may be employed; (1) with the embryo *in situ*, (2) after it has been removed.

To harden the blastoderm *in situ* the yolk must be hardened as a whole. After opening the egg either leave the yolk in the egg-shell or pour it out into a Berlin capsule; in any case freeing it as much as possible from the white, and taking especial care to remove the more adherent layer of white which immediately surrounds the yolk.

Place it in picric acid or a weak solution of chromic acid (first of .1 p.c. and then of .5 p.c.) with the blastoderm uppermost and leave it in that position for two or three days.

Care must be taken that the yolk does not roll about; the blastoderm must not be allowed to alter its position: otherwise it may be hard to find it when everything has become opaque. If at the end of the second day the blastoderm is not sufficiently hard, the strength of the solution, if chromic acid be used, should be increased and the specimen left in it for another day.

After it has become hardened by the acid, the yolk should be washed with water and treated suc-
cessively with weak and strong spirit, *vide* I. B. After it has been in the strong spirit (90 p.c.) for two days, the vitelline membrane may be safely peeled off and the blastoderm and embryo will be found *in situ*. The portion of the yolk containing them must then be sliced off with a sharp razor, and placed in absolute alcohol.

The staining, &c. may be effected in the ordinary way.

If osmic acid, which we believe will be found serviceable for these early stages, is employed, it will be necessary to remove the blastoderm from the yolk before treating it with the reagent.

The following transverse sections are the most important at this stage:

1. Through the medullary groove, shewing
   a. The *medullary folds* with the thickened *mesoblast*.
   b. The *notochord* under the medullary groove.
   c. The commencing *cleavage of the mesoblast*.

2. Through the region where the medullary folds diverge, to enclose the end of the primitive groove, shewing the greatly increased width of the medullary groove, but otherwise no real alteration in the arrangement of the parts.

3. Through the front end of the primitive groove with the so-called *axis cord* underneath it, while on each side of it are still to be seen the medullary folds.

4. Through the primitive groove behind this point, shewing the typical characters of the primitive groove.
VII. Examination of the material substance.

A. Opening the egg. *Vita IV.*

B. Examination of the material substance.

Observe the central white opaque substance, more transparent toward the chorioallantoic and the amnion around it.

C. Removal of the blastoderm. *Vita V.*

With the uninjured blastoderm, a sharp blade is required to remove this; but the blastoderm is separable, and there is no especial necessity to avoid any injury. It is essential to harden the inner spaces, and

D. Surface view transparent from above.

Observe the absence of the central opacity.

E. Surface view transparent from underneath.

Nothing further to be observed than these alone.

F. As an opaque object.

There is nothing to be learnt from this.

G. Sections.

Manipulation as in *Vita IV.*

The sections show:

1. The distinct plate.
2. The lower layer forms a mass differentiated into two lobes and several layers.
3. The thickest edge of the blastoderm.
4. The segmentation cavity and formation of...
securely with weak and strong spirit, page 1. After it has been in the strong spirit (90 per.) for two days, the vitelline membrane may be safely peeled off and the blastoderm and embryo will be found in case. The portion of the yolk containing them must then be sliced off with a sharp razor, and placed in absolute alcohol.

The staining, die may be effected in the ordinary way.

If tannic acid, which we believe will be found serviceable for these early stages, is employed, it will be necessary to remove the blastoderm from the yolk before treating it with the reagent.

The following transverse sections are the most important at this stage:

1. Through the medullary groove, showing
   a. The medullary folds with the thickened mesoblast.
   6. The notochord under the medullary groove.
   c. The commencing cleavage of the mesoblast.

2. Through the region where the medullary folds diverge, to expose the end of the primitive groove, showing the greatly increased width of the medullary groove, but otherwise no real alteration in the arrangement of the parts.

3. Through the front end of the primitive groove with the so-called axis cord, underneath it, while on each side of it are still to be seen the medullary folds.

4. Through the primitive groove behind this point, showing the typical characters of the primitive groove.
VII. Examination of an unincubated Blastoderm.

A. Opening the egg. Vide II. A.

B. Examination of the blastoderm in situ.

Observe the central white spot and the peripheral more transparent portion of the blastoderm and the halones around it.

C. Removal of the blastoderm. Vide VI. C.

With the unincubated blastoderm still greater care is required in removal than with the 20 hours' blastoderm, and there is no special advantage in doing so unless it is intended to harden it with osmic acid.

D. Surface view transparent from above.

Observe the absence of the central opacity.

E. Surface view transparent from underneath.

Nothing further to be observed than from above.

F. As an opaque object.

There is nothing to be learnt from this.

G. Sections.

Manipulation as in VI. G.

The sections shew

a. The distinct epiblast.

b. The lower layer cells not as yet differentiated into mesoblast and hypoblast.

c. The thickened edge of the blastoderm.

d. The segmentation cavity and formative cells.
VIII. Examination of the process of Segmentation.

To observe the process of segmentation it will be found necessary to kill a number of hens which are laying regularly. The best hens lay once every 24 hours, and by observing the time they usually lay (and they generally lay pretty regularly about the same time), a fair guess may be made beforehand as to the time the egg has been in the oviduct. By this means a series of eggs at the various stages of segmentation may usually be obtained without a great unnecessary sacrifice of hens. For making sections, the yolk must in all cases be hardened as a whole, which may be done as recommended in VI. G. Chromic acid is an excellent reagent for this and it will be found very easy to make good sections.

In the sections especial attention should be paid,

1. To the first appearance of nuclei in the segments, and their character.

2. To the appearance of the horizontal furrows.

3. As to whether new segments continue to be formed outside the limits of the germinal disc, or whether the fresh segmentation merely concerns the already formed segments.

4. In the later stages, to the smaller central and larger peripheral segments, both containing nuclei.

   For surface views, the germinal disc, either fresh or after it has been hardened, can be used. In both cases it should be examined by a strong reflected light. The chief point to be noticed is the more rapid segmentation of the central than of the peripheral spheres.
IX. Examination of the later changes of the Embryo.

For the later stages, and especially for the development of the skull and the vascular system of the body of the chick, it will be found necessary to dissect the embryo. This can be done either with the fresh embryo or more advantageously with embryos which have been preserved in spirit.

If the embryos are placed while still living into spirit a natural injection may be obtained. And such an injection is the best for following out the arrangement of the blood-vessels.

Sections of course will be available for study, especially when combined with dissections.

X. Study of the development of the Blood-vessels.

Observations on this subject must be made with blastoderms of between 30-40 hours. These are to be removed from the egg, in the usual way (side II. A. and C.), spread out over a glass slip and examined from below, side II. F.

The blastoderm when under examination must be protected by a cover-slip with the usual precautions against pressure and evaporation, and a hot stage must also be employed.

Fresh objects so prepared require to be examined with a considerable magnifying power (400 to 600 diameters). From a series of specimens between 30 and 40 hours old all the points we have mentioned in Chapter IV. p. 52, can without much difficulty be observed.

Especial attention should be paid in the earlier specimens to the masses of nuclei enveloped in protoplasm and connected with each other by proto-
VIII. Examination of the process of segmentation.

To observe the process of segmentation it will be found necessary to keep a number of hens which are laying regularly. The best hens lay once every 24 hours, and by observing the time they usually lay (and they generally lay pretty regularly about the same time) a fair guess may be made beforehand as to the time the egg has been in the ovary. By this means a series of eggs at the various stages of segmentation may usually be obtained without a great unnecessary sacrifice of hens. For making sections, the soft masses in all cases be hardened as a whole, which may be done as recommended in VI. C. Carboxy acid is an excellent reagent for this and it will be found very easy to make good sections.

In the sections especial attention should be paid,

1. To the first appearance of nuclei in the segments, and their character.

2. To the appearance of the horizontal furrows.

3. As to whether new segments continue to be formed outside the limits of the germinal disc, or whether the fresh segmentation merely concern the already formed segments.

4. In the later stages, to the smaller central and larger peripheral segments, both containing nuclei.

For surface views, the germinal disc, either fresh or after it has been hardened, can be used. In both cases it should be examined by a strong reflected light. The chief point to be noticed is the more rapid segmentation of the central than of the peripheral spheres.
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If the embryos are placed while still living into spirit a natural injection may be obtained. And such an injection is the best for following out the arrangement of the blood-vessels.

Sections of course will be available for study, especially when combined with dissections.

X. Study of the development of the Blood-vessels.

Observations on this subject must be made with blastoderms of between 30—40 hours. These are to be removed from the egg, in the usual way (vide II. A. and C.), spread out over a glass slip and examined from below, vide II. E.

The blastoderm when under examination must be protected by a coverslip with the usual precautions against pressure and evaporation, and a hot stage must also be employed.

Fresh objects so prepared require to be examined with a considerable magnifying power (400 to 800 diameters). From a series of specimens between 30 and 40 hours old all the points we have mentioned in Chapter iv. p. 92, can without much difficulty be observed.

Especial attention should be paid in the earlier specimens to the masses of nuclei enveloped in protoplasm and connected with each other by proto-
plasmic processes; and in the later stages to the breaking up of these masses into blood corpuscles and the conversion of the protoplasmic processes into capillaries, with cellular walls.

Blastoderms treated in the following ways may be used to corroborate the observations made on the fresh ones.

*With gold chloride.*

Immerse the blastoderm in gold chloride (0.5 p.c.) for one minute and then wash with distilled water and mount in glycerine and examine.

By this method of preparation, the nuclei and protoplasmic processes are rendered more distinct, without the whole being rendered too opaque for observation.

The blastoderm after the application of the gold chloride should become a pale straw colour; if it becomes in the least purple, the reagent has been applied for too long a time.

*With potassium bichromate.*

Immerse in a 1 p.c. solution for one day and then mount in glycerine.

*With osmic acid.*

Immerse in a 5 p.c. solution for half an hour and then in absolute alcohol for a day, and finally mount in glycerine.

**Practical directions for obtaining and studying mammalian embryos.**

**XI. Animals and breeding.**

For class work the Rabbit is the most convenient animal from which to obtain embryos, it will breed
freely in the early spring months of the year and will give ample opportunity for the student to observe the same time when the season is correct. A number of does should be kept together in a large pen, and two or three boxes in separate small cages also placed within the pen; at the period of heat, the box should be temporarily closed with the box, and the exact time of copulation noted, the age of the embryos being calculated from that time.

XII. Examination of pregnant ewes.

It will be well to mention here that although a doe may have been satisfactorily covered, embryos are not always obtained from her. A uterine examination of the ovaries will determine whether or not fertilized ova are present. If one have been recently discharged from the ovary, the ovarian follicles from which they were discharged will be found to be of a distinctly red colour. In cases so with 'corpora lutea,' as they are called are present further search is useless.

A. To obtain ova from 1 to 95 hours old.

Cut open the abdomen from pubis to sternum, and from the pubis round the thigh of each side, and turn back the flaps of the body wall so formed. Remove the viscera and observe below (dorsal) the single median vagina, from the anterior end of which the uterine horns branch.

Observe at the anterior end of each uterine horn a small, much-cleft tube, theoviduct (Fallopian tube) near the anterior end of which a little below the kidney lies the ovary. Cut out the ovaries andoviduct together and lay them in a small dissecting
plasma processes, and in the later stages to the breaking up of these masses into blood corpuscles and the secretion of the protoplasmic processes into capillaries, with cellular walls.

Blastodermes treated in the following ways may be used to corroborate the observations made on the fresh ones.

**With gold chloride**

Immerse the blastoderm in gold chloride (5 p.p.) for one minute and then wash with distilled water and mount in glycerine and examine.

By this method of preparation, the nuclei and protoplasmic processes are rendered more distinct, without the whole being rendered too opaque for observation.

The blastoderm after the application of the gold chloride should become a pale straw colour; if it becomes in the least purple, the reagent has been applied for too long a time.

**With potassium bichromate**

Immerse in a 1 p.p. solution for one day and then mount in glycerine.

**With acetic acid**

Immerse in a 0.1 p.p. solution for half an hour and then in absolute alcohol for a day, and finally mount in glycerine.

**Practical Directions for Obtaining and Studying Mammalian Embryos**

2. **Animals and breeding**

For these work the Rabbit is the most convenient animal from which to obtain embryos, it will breed...
freely in the early spring months of the year and will give ample opportunity for the student to observe the exact time when the female is covered. A number of does should be kept together in a large pen, and two or three bucks in separate small cages also placed within the pen; at the period of heat, the doe should be temporarily placed with the buck and the exact time of copulation noted, the age of the embryo being calculated from that hour.

XII. **Examination of segmenting ova.**

It will be well to mention here that although a doe may have been satisfactorily covered, embryos are not always obtained from her. A superficial examination of the ovaries will determine whether or no fertilized ova are present. If ova have been recently dehisced from the ovary, the Graafian follicles from which they were discharged will be found to be of a distinctly red colour. In case no such 'corpora lutea' as they are called are present further search is useless.

A. **To obtain ova from 1 to 60 hours old.**

Cut open the abdomen from pubis to sternum, and from the pubis round the thigh of each side, and turn back the flaps of the body wall so formed. Remove the viscera and observe below (dorsal) the single median vagina, from the anterior end of which the uterine horns diverge.

Observe at the anterior end of each uterine horn a small much coiled tube, the oviduct (Fallopian tube) near the anterior end of which a little below the kidney lies the ovary. Cut out the uterus and oviduct together and lay them in a small dissecting
PRACTICAL DIRECTIONS.

dish. Carefully stretch out the oviduct by cutting the tissue which binds it, and separating it from the uterus, taking care to obtain its whole length, lay it upon a glass slide.

With the aid of a lens it is frequently possible to distinguish the ovum or ova, through the wall of the oviduct. In this case cut a transverse slit into the lumen of the duct with a fine pair of scissors a little to one side of an ovum; press with a needle upon the oviduct on the other side of the ovum, which will glide out through the slit, and can be with ease transported upon the point of a small scalpel, or what is better spear-headed needle. In case the ovum cannot be distinguished in the oviduct by superficial observation, the latter must be slit up with a fine pair of scissors, when it will easily be seen with the aid of an ordinary dissecting lens.

B. Treatment of the ovum.

The ovum may be examined fresh in salt solution, it is however more instructive when preserved and stained in the following manner.

a. Immerse it in a $\frac{1}{5}$ p.c. solution of osmic acid for 5 or even 10 minutes, transfer it thence to the picrocarmine solution described above (I). After staining the ovum should then be washed in distilled water and placed in a weak solution of glycerine in a watch-glass—half glycerine, half water. It should be allowed to remain thus under a bell jar for several days (7 to 14 or longer) in a warm room until the water has evaporated. By this means shrinkage and distortion are avoided, the glycerine becoming
EXAMINATION OF OVUM.

Examination of the ovum.

The most instructive stages to observe are ova of

1. 18 hours old, when four segmentation spheres will be observed.

2. 30 hours old, when the segmentation is more advanced and the spheres numerous.

The chief points to be noted are:

1. The number and size of the segmentation spheres; in each of which, when treated as described in R. a, a large deeply stained nucleus will be visible. The spheres themselves are also stained slightly.

2. The presence of one or two polar bodies on the outer side of the segments in ova of not more than 48 hours old; these also are slightly stained.

3. The zona radiata immediately surrounding the segments, and

4. The thick albuminous coat marked with concentric rings.

Examination of the ovum.

Another method of preservation is used, but does not appear to us so successful as the one already described. It consists of an immersion of the ovum for 5 minutes in 1/2 to 1 p.c. acetic acid, subsequent treatment with Muller's fluid for two or three days, and finally mounting in glycerine.
Proceed to extract out the oveinct by cutting two slits which leave it, and separating it from the sacrum, taking care to obtain its whole length, by it were a piece of cake.

With the aid of a lens it is frequently possible to a second cut into the ovum through the wall of the ovum. In these cases cut a transverse slit into the ovum of the ovum with a fine pair of scissors a little on the side of the ovum; press with a needle upon the ovum on the other side of the ovum, which will slip off together with the slit, and can be with ease transferred with the point of a small scalpel, or what is commonly called a needle. In case the ovum cannot be distinguished by the ovum by superficial observation, the latter must be slit up with a fine pair of scissors, when it will easily be seen with the aid of an ordinary magnifying glass.

(3) Preparation of the ovum.

The ovum may be examined fresh in salt solution,  it is necessary more instinctive when preserved and described in the following manner:

1. In a beaker take a 10 per cent solution of oveinc acid for 10 or even 10 minutes, transfer it to a beaker, and place it in a weak solution of glycerine in a watch-glass—half glycerine, half water. It should be allowed to remain there until a half hour for several days (or 1 or 2 days) in a warm room until the oveinc becomes separated. By this means shrinkage and softening are avoided, the glycerine becomes,
very gradually more and more dense. It should be mounted in glycerine in which 1 p.c. formic acid has been mixed to prevent fungoid growths. Care must be taken that there is no pressure upon the ovum this being insured by the insertion of a couple of slips of paper one on each side of the ovum under the cover glass.

b. Another method of preservation is used, but does not appear to us so successful as the one already described. It consists of an immersion of the ovum for 5 minutes in $\frac{1}{5}$ to $\frac{1}{2}$ p.c. osmic acid, subsequent treatment with Müller's fluid for two or three days, and finally mounting in glycerine.

C. Examination of the ovum.

The most instructive stages to observe are ova of

a. 18 hours old, when four segmentation spheres will be observed.

b. 36 hours old when the segmentation is more advanced and the spheres numerous.

The chief points to be noted are:

1. The number and size of the segmentation spheres; in each of which, when treated as described in B. a., a large deeply stained nucleus will be visible. The spheres themselves are also stained slightly.

2. The presence of one or two polar bodies on the outer side of the segments in ova of not more than 48 hours old; these also are slightly stained.

3. The zona radiata immediately surrounding the segments, and

4. The thick albuminous coat, marked with concentric rings.
D. *The fully segmented ovum. 70 hours old.*

The fully segmented ovum is found in the uterus at its anterior end close to the place where the oviduct opens into the uterus.

To obtain this stage the uterus must be slit open and examined carefully with a dissecting lens: the ovum will be seen as a somewhat opaque spot on the glistening moist mucous epithelium of the uterus.

It may be treated in the manner described under B. a., but the segments being closely pressed together their outlines are not rendered distinct by this method. A more advantageous mode of treatment is the following: wash the ovum rapidly in distilled water, and place it in a 1 p.c. solution of silver nitrate for about 3 minutes: then expose it to the light in a dish of distilled water until it be tinged a brown colour.

The brown colour is due to the reduction of the silver, which takes place chiefly in the cement substance between the cells and thus defines very exactly their size and shape. The ovum may now be treated with glycerine and mounted as described in B.

The points to be observed are:

1. The division of the segmentation spheres into the layers—an outer layer of cubical hyaline cells, and an inner of rounded granular cells.

2. The blastopore of van Beneden.

3. The presence of a thin layer of mucous outside the concentrically ringed albuminous coat of the ovum.
XIV. Examination of a histological section of a skin, in which the entire keratin and papillary structure are present.

A. To obtain the sections.

On opening the body near the base, the skin is found to be uniformly detached and very transparent.

Remove the tissues and open a slightly larger fine incision along the line, and proceed, after taking care to keep the dermis in its place, to the interior alone, against the stack.

Observe

1. The nail 
2. The skin 
3. The hair 
4. The muscles 
5. The vessels 
6. The lymphatic vessels.
The fully-encapsulated ovum is found in the uterus so far behind and close to the place where the ovum originally left the ovary.

To obtain this stage the ovum must be slit open and examined successively with a dissecting lens; the ovum will then appear as a somewhat opaque spot on the glistening inner mucous epithelium of the uterus.

It may be assisted in the manner described under B, but the segments being closely pressed together inside the uterus are not rendered distinct by this method. A more advantageous mode of treatment is the following: wash the ovum rapidly in distilled water, and place it in a 1 p.c. solution of silver nitrate for about 5 minutes; then expose it to the light in a dish of distilled water until it be tinged a brown color.

The brown color is due to the reduction of the silver, which takes place chiefly in the opaque substance between the cells and thus defines very exactly their size and shape. The ovum may now be treated with glycerine and mounted as described in B.

The points to be observed are:

1. The division of the segmentation spheres into the layers—an outer layer of cubical hyaline cells, and an inner of thimble granular cells.

2. The Blastopore of van Beneden.

3. The presence of a thin layer of mucous outside the constantly ringed chlamydons coat of the ovum.
XIII. Examination of the blastodermic vesicle, 72—90 hours.

A. To obtain the embryo see XII. D.

B. Prepare the ovum either as in XII. B. or D. or in picric acid see I. B. 1.

C. Surface view, or in section see I. B. 3.

Observe:—

1. The great increase in size of the ovum and the reduction in the thickness of the membranes.

2. The flattened layer of outer cells enclosing a cavity.

3. The rounded cells of the inner mass attached as a lens-shaped mass to one side of the vesicle.

XIV. Examination of a blastodermic vesicle of 7 days, in which the embryonic area and primitive streak are present.

A. To obtain the embryo.

On opening the body cavity the uterus will be found to be uniformly swollen and very vascular.

Remove the uterus and open it carefully with fine scissors along the free, non-mesometric edge, taking care to keep the point of the scissors within the uterus close against its wall.

Observe

1. The oval thin-walled vesicles lying at intervals on the walls of the uterus.

2. The presence of the pyriform embryonic area, at the posterior end of which is seen the primitive streak.
3. The commencement of the area vasculosa around the hind end of the area. This is seen better after treatment with picric acid.

B. Treatment and Examination of the embryo.

a. Preserve the vesicle in picric see I. B. 1. Stain in haematoxylin, cut out the embryonic area, leaving a considerable margin, imbed and cut into sections.

b. In transverse sections observe:—

1. At the anterior end of the area the single row of columnar epiblast and the single row of flattened hypoblast cells.

2. Immediately in front of the primitive streak between these two layers a few irregularly shaped mesoblast cells.

3. Through the middle of the primitive streak,

a. Several layers of rounded mesoblast cells attached to, and continuous with, the epiblast in the middle line, and stretching out laterally beyond the edge of the area.

b. A single layer of flattened hypoblast.

4. The epiblast outside the embryonic area in the form of flattened cells and, except in the region around the primitive streak, overlying a layer of flattened hypoblast.

XV. Examination of an eight days' embryo.

A. To obtain the embryo.

The uterus will be found here and there to be swollen. In these swellings the embryos lie; and
owing to the fact that the wall of the embryonic vessel is exceedingly thin, and attached to the uterine wall, they are very difficult to obtain whole.

Cut the uterus transversely on each side of the swellings and pin the pieces so obtained slightly stretched out in small dissecting dishes. Cover the tissue with picric acid solution and allow it to remain unparched for an hour. Then, with two pairs of fine pointed forceps carefully tear the uterus longitudinally, slightly to one side of the median line of the free side. This operation will necessarily take some time, for but a small portion should be done at once, the picric acid being allowed time to penetrate into that part of the uterus which has been most recently torn open.

With care, however, the student will be able to open completely the swelling and will observe within the thin-walled vessel. Great care must also be exercised in freeing the vessels from the uterus.

This dissection should be performed with the aid of a dissecting lens. In case the embryonic vessels are burst, it will still be possible to extract the embryonic area which lies on the mesometrial side of the uterus; the area itself is not attached to the uterine wall.

B. Examination of surface view.

Observe:
1. The increased size of the embryonic area.
2. In the anterior region the nephalic folds diverging behind and enclosing between them.
3. The primitive streak.
4. The area opaca now completely surrounding the embryo.
X. The成enmation of the area vasculosa around the front end of the area. This is seen better after treatment with picric acid.

II. Treatment and Examination of the embryo.

1. Preserve the ovum in formalin. A. A. sheet in the direction of the embryonic area, leaving a considerable margin, intact and without sections.

2. In transverse sections observe:

a. At the anterior end of the area the single row of columnar epithelium and the single row of flattened hypoblast cells.

b. Immediately in front of the primitive streak between these two forms a few irregularly shaped mesoblast cells.

c. Through the middle of the primitive streak.

d. Several layers of rounded mesoblast cells attached to and continuous with the epiblast in the middle line, and stretching out laterally beyond the edge of the area.

3. A single layer of flattened hypoblast.

4. The epiblast inside the embryonic area in the form of flattened cells and, except in the region around the primitive streak, overlying a layer of flattened hypoblast.

XV. Examination of an eight days' embryo.

A. To obtain the embryo.

The uterus should be found here and there to be perforated. In these swellings the embryo lies; and
owing to the fact that the wall of the embryonic vesicle is exceedingly thin, and attached to the uterine wall, they are very difficult to obtain whole.

Cut the uterus transversely on each side of the swellings and pin the pieces so obtained slightly stretched out in small dissecting dishes. Cover the tissue with picric acid solution and allow it to remain untouched for an hour. Then with two pairs of fine pointed forceps carefully tear the uterus longitudinally, slightly to one side of the median line of the free side. This operation will necessarily take some time, for but a small portion should be done at once, the picric acid being allowed time to penetrate into that part of the uterus which has been most recently torn open.

With care, however, the student will be able to open completely the swelling and will observe within the thin walled vesicle. Great care must also be exercised in freeing the vesicle from the uterus.

This dissection should be performed with the aid of a dissecting lens. In case the embryonic vesicle is burst it will still be possible to extract the embryonic area which lies on the mesometric side of the uterus; the area itself is not attached to the uterine walls.

B. Examination of surface view.

Observe:

1. The increased size of the embryonic area.
2. In the anterior region the medullary folds; diverging behind and enclosing between them,
3. The primitive streak.
4. The area opaca now completely surrounding the embryo.
C. *Examination of sections.*

Prepare and cut into transverse sections as advised in XIV. B.

Notice

1. In the sections of the anterior region,
   
   a. The lateral epiblast composed of several layers of columnar cells.
   
   b. The epiblast in the median line one layer thick and in the form of a groove (medullary groove).
   
   c. The lateral plates of mesoblast.
   
   d. The flattened lateral hypoblast, and columnar hypoblast underlying medullary groove (notochord).

2. In sections through the anterior end of the primitive streak.
   
   Note the continuation of the epiblast, mesoblast and hypoblast in the middle line.

3. In sections through the posterior end of the area the same points to be seen as in XIV. B. 6. 3.

XVI. *Examination of an embryo about 8 days 12 hours.*

A. *Manipulation as in XV. A.*

B. In surface view observe (cf. Fig. 106):

1. Area pellucida surrounding embryo, outside which is the well marked area vasculosa.

2. Widely open neural canal, at anterior end dilated, and partially divided into the three primary vesicles of the brain: note the optic vesicles. At the posterior end, the sinus rhomboidalis.

3. The mesoblastic somites, 4 to 8.
XVII. Examination of the fetal membranes of an embryo of 14 days.

A. To obtain the embryo, with its membranes.

Manipulate as in XV. A., only distend under solution of picro-iodine instead of picro-acid.

B. Observe before removing the embryo from the uterus:

1. The attachment of the umbilicus to the mesenteric side of the uterus near a discoidal area, the placental area.
2. The position and shape of the placenta.

C. Remove the embryo with its membranes intact and observe:

1. the vascular villi, extending completely round the chorion with the exception of a comparatively small area where the allantois is situated. The vascularity of the allantois. The focal villi projecting into the maternal placental tissue.
E. Examination of sections.

Prepare and cut into whichever sections as advised in XIV. B.

1) In the sections of the anterior region:
   a. The neural管clast composed of several layers of columnar cells.
   b. The embryonic disc, one layer thick, in the form of a groove (medullary groove).
   c. The lateral plate of mesoblast.
   d. The dense area anterior, hypoblast, and columnar hypoblast underlying medullary groove (note nuclei).

2) In sections through the anterior end of the primitive streak.
   Note: the continuation of the mesoblast, mesoblast, and hypoblast in the middle line.

3) In sections through the posterior end of the area vesicae, to be seen as in XIV. B. A. 3.

XVI. Examination of an embryo about 8 days, 12 hours.

A. Manipulation as in XV. A.

B. In sections, view observe (cf. Fig. 106):

1. Area palliata surrounding embryo, outside which is the well-marked area vasculosa.

2. Tender sac or neural canal, at anterior end dilated and partially divided into the three primary vessels of the brain; note the optic vessels. As the processes enter the olfactory chamber.

3. The mesoblastic somites, 4 to 8.
4. The two lateral tubes of the heart, and the commencement of the two vitelline veins.

5. The rudiment of the primitive streak.

6. The commencing head and tail folds.

7. The commencing folds of the amnion.
   Compare Fig. 106.

XVII. Examination of the foetal membranes of an embryo of 14 days.

A. To obtain the embryo, with its membranes.
   Manipulate as in XV. A. only dissect under salt solution instead of picric acid.

B. Observe before removing the embryo from the uterus;

1. The attachment of the vesicle to the mesometric side of the uterus over a discoidal area, the placental area.

2. The position and form of the placenta.

C. Remove the embryo with its membranes intact,
   and observe:

1. the vascular yolk sac, extending completely round the chorion with the exception of a comparatively small area where

2. the allantois is situated. The vascularity of the allantois. The foetal villi projecting into the maternal placental tissue.
D. *Separate the membranes from one another without tearing them,*

and notice:

1. The embryo surrounded by the amnion.
2. The allantois; its position dorsal to the embryo; its attachment to the chorion; its circulation.
3. The flattened yolk sac, ventral to the embryo; its long stalk; its circulation.
4. The heart.

E. *The embryo in surface view.*

The points to be observed are

1. The cranial and body flexure, the spiral curvature of the hinder portion of the body.
2. The vesicles of the brain: cerebral hemispheres, fore-brain, mid-brain and hind-brain.
3. The eye, and the ear.
4. The heart.
5. The visceral arches and clefts.
6. The fore and hind limbs, and the tail.
Note A.

Since writing the account of section-cutting on p. 434, we have obtained more experience as to the practical working of Messrs. Caldwell and Thrawl's microtome than was anticipated. We find that it cuts more accurately and better than any other microtome with which we are acquainted, and can confidently recommend it to investigators and teachers with large classes. In the Cambridge Laboratory, it is driven by a small water engine and will cut at a rate of 600 a minute, without detriment to the sections.

Note B.

Mr. Thrawl, of Caines College, has recently elaborated a method of mounting sections which, in our opinion, has many important advantages over the shallow methods. It is as follows. Make a solution of pure India-rubber in benzine or chloroform. Spread a thin film of this on a clean glass slide, and allow it to dry. Arrange the sections on the film, and the varnish; allow the slide to stand, then immerse the slide for a moment in benzine (liqueur paraffin), which dissolves the varnish, and mount in balsam. The chief advantages of this method are that the sections do not adhere to the India-rubber until warmed, and they can be cleaned after they are fixed on the slide if necessary. For the latter purpose, wash the benzine away with absolute alcohol; next a weaker alcohol; then, return to absolute; then with oil of cloves or kerosene, and mount in balsam (see Zoology, by Lusig, 1883).
D. Separate the membranes from one another without tearing them,

and notice:

1. The embryo surrounded by the amnion.
2. The allantois; its position dorsal to the embryo; its attachment to the chorion; its circulation.
3. The flattened yolk sac, ventral to the embryo; its long stalk; its circulation.
4. The heart.

E. The embryo in surface views.

The points to be observed are:

1. The cranial and body flexure, the spiral curvature of the broader portion of the body.
2. The vesicles of the brain: cerebral hemispheres, fore-brain, mid-brain and hind-brain.
3. The epi- and the endo.
4. The heart.
5. The visceral arches and aorta.
6. The fore and hind limbs, and the tail.
Note A.

Since writing the account of section-cutting on p. 434, we have obtained more experience as to the practical working of Messrs. Caldwell and Threlfall's microtome there mentioned. We find that it cuts more accurately and better than any other microtome with which we are acquainted, and can confidently recommend it to investigators and teachers with large classes. In the Cambridge Laboratory, it is driven by a small water engine and will cut at a rate of 500 a minute, without detriment to the sections.

Note B.

Mr Threlfall, of Caius College, has recently elaborated a method of mounting sections which in our opinion has many important advantages over the shellac method. It is as follows. Make a solution of pure india-rubber in benzine or chloroform. Spread a thin film of this on a clean glass slide, and allow it to dry. Arrange the sections on the film; melt the paraffin; allow the slide to cool, then immerse the slide for a moment in benzoline (liquid paraffin), which dissolves the paraffin, and mount in balsam. The chief advantages of this method are that the sections do not adhere to the india-rubber until warmed, and they can be stained after they are fixed on the slide if necessary. For the latter purpose, wash the benzoline away with absolute alcohol; treat with weaker alcohol; stain; return to absolute; clear with oil of cloves or kreasote, and mount in balsam (vide Zoologischer Anzeiger, 1883).
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