developed more rapidly than over the rest of the surface. Indeed, as the ovum becomes larger and larger, the villi of the surface outside of this area become more and more scanty, lose their vascularity and finally disappear. That portion of the allantois upon which the villi persist and increase in length and in the number of their branches is destined to form connections with the mucous membrane of the uterus and constitutes the fœtal portion of the placenta. This change begins at about the end of the second month, and the placenta becomes distinctly limited at about the end of the third month.

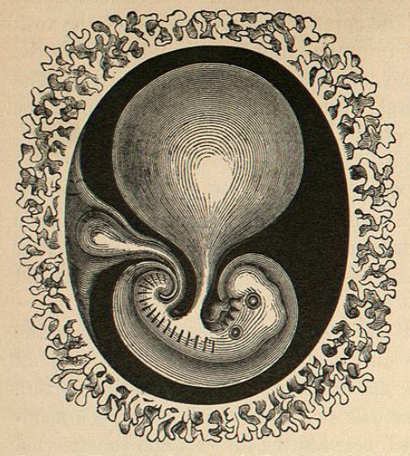

FIG. 296.—*Human embryon at the third week, showing villi covering the entire chorion* (Haeckel).

It must be remembered that as the changes go on which result in the formation of the permanent chorion and the limitation of the fœtal portion of the placenta, the formation of the umbilical vesicle and the enlargement of the amnion are also progressing. The amnion is gradually distended by the increase in the quantity of amniotic fluid. It reaches the internal surface of the chorion at about the end of the fourth month, extends over the umbilical cord to form its external covering, including the cord of the umbilical vesicle, and the umbilical vesicle itself lies in the gelatinous matter between the two membranes.

At about the beginning of the fifth month the ovum is constituted as follows:

The fœtus floats freely in the amniotic fluid, attached to the placenta by the umbilical cord; the chorion presents a highly vascular, thickened and villous portion, the fœtal portion of the placenta; the rest of the chorion is a simple membrane, without villi and without blood-vessels; the amnion lines the internal surface of the chorion and also forms the external covering of the umbilical cord; the umbilical vesicle has become atrophied and has lost its vascularity; the hernia at the point of connection of the umbilical vesicle with the intestine of the fœtus has closed; and finally the fœtus has undergone considerable development.

Umbilical Cord.—From the description given of the mode of development of the chorion and the amnion, it is evident that the umbilical cord is nothing more than the pedicle which connects the embryon with that portion of the chorion which enters into the structure of the placenta. It is, indeed, a process of the allantois, in which the vessels eventually become the most important structures. The cord is distinct at about the end of the first month; and as development advances, the vessels consist of two arteries

coming from the body of the fœtus, which are twisted usually from left to right, around the single umbilical vein. In addition to the spiral turns of the arteries around the vein, the entire cord may be more or less twisted, probably from the movements of the fœtus.

The fully developed cord extends from the umbilicus of the fœtus to the central portion of the placenta, in which its insertion usually is oblique; although it may be inserted at other points, and even outside of the border of the placenta, its vessels penetrating this organ from the side. Its usual length, which varies very considerably, is about twenty inches (50·8 centimetres). It has been observed as long as sixty (152·4 centimetres), and as short as seven inches (17·8 centimetres). When the cord is very long, it sometimes presents knots, or it may be wound around the neck, the body or any of the members of the fœtus; and this can be accounted for only by the movements of the fœtus in utero.

The external covering of the cord is a process of the amnion; and as it extends over the vessels, it includes a gelatinous substance (the gelatine of Wharton) which surrounds the vessels and protects them from compression. This gelatinous substance is identical with the so-called membrana intermedia, or the substance included between the amnion and the chorion. The entire cord, covered with the gelatine of Wharton and the amnion, usually is about the size of the little finger. According to Robin, the umbilical cord will sustain a weight of about twelve pounds (5·4 kilos). As the amniotic fluid accumulates and distends the amniotic membrane, this membrane becomes more and more closely applied to the cord. The pressure extends from the placental attachment of the cord toward the fœtus, and it gradually forces into the abdomen of the fœtus the loop of intestine, which, in the early periods of intraüterine life, forms an umbilical hernia.

The vessels of the cord, the arteries as well as the vein, are provided with valves. These are simple inversions of the walls of the vessels, and they do not exist in pairs nor do they seem to influence the current of blood. In the arteries these folds are situated at intervals of half an inch to two inches (12·7 to 58·8 mm.), and they are more abundant where the vessels are very contorted. In the vein the folds are most abundant near the placenta. They are very irregularly placed, and in a length of four inches (10 centimetres), fifteen folds were found (Berger). It is not apparent that these valvular folds have any physiological importance.

As the allantois is developed, it presents, in the early stages of its formations, three portions; an external portion, which becomes the chorion, an internal portion, enclosed in the body of the embryon, and an intermediate portion. The intermediate portion becomes the umbilical cord. As the umbilicus of the fœtus closes around the cord, it shuts off a portion of the allantois, contained in the abdominal cavity, which becomes the urinary bladder; but there is a temporary communication between the internal portion and the lower portion of the cord, called the urachus. This generally is obliterated before birth and is reduced to the condition of an impervious cord; but it may persist during intraüterine life, in the form of a narrow

canal extending from the bladder to the umbilicus, which is closed soon after birth.

Membranæ Deciduæ.—In addition to the two membranes connected with the fœtus, there are two membranes formed from the mucous membrane of the uterus, which are derived from the mother and which serve still farther to protect the ovum. The chorion is for the protection of the fœtus; but a portion of this membrane—about one-third of its surface—becomes closely united with a corresponding portion of the uterine mucous membrane, to form the placenta.

As the fecundated ovum descends into the uterus, it is invested with a shaggy covering, which is either the permanent chorion or one of the membranes which invests the ovum previous to the complete development of the allantois. At this time the mucous membrane of the uterus has undergone certain changes by which it is prepared for the reception of the ovum. The changes which this membrane undergoes in menstruation have already been described. It has been seen that during an ordinary menstrual period, the membrane is increased three or four times in thickness and becomes more or less rugous. If a fecundated ovum descend into the uterus, the changes in the mucous membrane progress. The glands enlarge and the mucous membrane becomes thicker, so that at the end of the first month it measures about two-fifths of an inch (10 mm.). This thickening is due chiefly to development of tissue between the glands, and the membrane becomes soft and pulpy. In the mean time the ovum has effected a lodgement between the folds, usually at the fundus, near the opening of one of the Fallopian tubes; and the adjacent parts of the mucous membrane extend over the ovum so that it is at last completely enclosed. This occurs at the twelfth or thirteenth day (Reichert). The extension of the mucous membrane which covers the ovum becomes the decidua reflexa; the changed mucous membrane which lines the uterus becomes the decidua vera; and the portion of the mucous membrane which remains at the site of the placenta becomes the decidua serotina. The vascular villosities of the chorion probably do not, as was once thought, penetrate the uterine tubules, but they become surrounded by tissues developed between these tubules.

As development advances, the decidua vera becomes extended, loses its vessels and glands and is reduced to the condition of a simple membrane. The cylindrical epithelium of the mucous membrane of the body of the uterus, soon after fecundation, becomes exfoliated, and its place is supplied by flattened cells. This change is effected at the sixth or the eighth week. The epithelium of the cervix retains its cylindrical character, but most of the cells lose their cilia. The decidua reflexa, which is thinner than the decidua vera, has neither blood-vessels, glands nor epithelium.

During the first periods of utero-gestation, the two layers of decidua are separated by a small quantity of an albuminous and sometimes a sanguinolent fluid; but this disappears at about the end of the fourth month, and the membranes then come in contact with each other. They soon become so closely adherent as to form a single membrane, which is in contact with the

chorion. Sometimes, at full term, the membranes of the fœtus can be separated from the decidua; but frequently all of the different layers are closely adherent to each other.

The changes just described are not participated in by the mucous membrane of the neck of the uterus. The glands in this situation secrete a semi-solid, transparent, viscid mucus, which closes the os and is sometimes called the uterine plug.

Toward the fourth month a very delicate, soft, homogeneous layer appears over the muscular fibres of the uterus, beneath the decidua vera, which is the beginning of a new mucous membrane. This is developed very gradually, and the membrane is completely restored about two months after parturition.

Formation of the Placenta.—At about the end of the second month the villi of the chorion become enlarged and arborescent over that part which eventually forms the fœtal portion of the placenta. They are then highly vascular and are embedded in the soft substance of the hypertrophied mucous

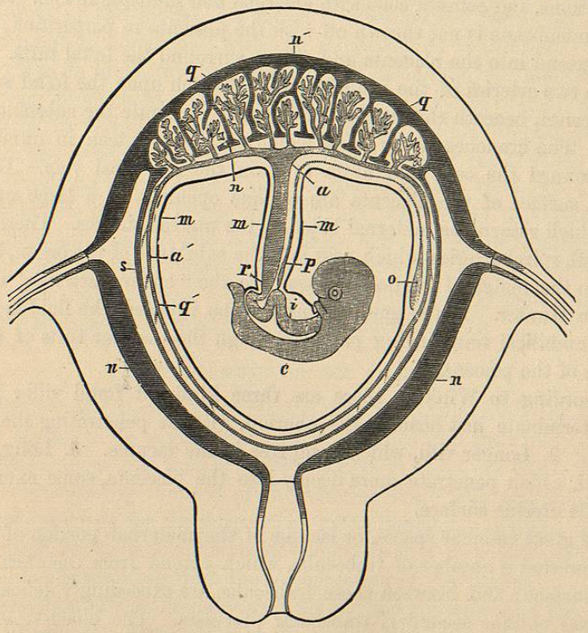

FIG. 297.—*Diagrammatic figure, showing the placenta and deciduæ* (Liégeois).
c, embryon; *i*, intestine; *p*, pedicle of the umbilical vesicle; *o*, umbilical vesicle; *m*, *m*, *m*, amnion; *a'*, chorion; *a*, lower end of the umbilical cord; *q*, *q*, vascular tufts of the chorion, constituting the fœtal portion of the placenta; *n'*, *n*, maternal portion of the placenta; *n*, *n*, decidua vera; *s*, decidua reflexa.

membrane. At the same time the villi over the rest of the chorion are arrested in their growth, and they finally disappear during the third month. The blood-vessels penetrate the villi in the form of loops at about the fourth week; and the placenta is distinctly marked at about the end of the third

month. The placenta then rapidly assumes the anatomical characters observed after it may be said to be fully developed.

The fully formed placenta occupies about one-third of the uterine mucous membrane, and generally is rounded or ovoid in form, with a distinct border connected with the decidua and the chorion. It is seven to nine inches (18 to 23 centimetres) in diameter, a little more than an inch (2·5 centimetres) in thickness at the point of penetration of the umbilical cord, slightly attenuated toward the border, and weighs fifteen to thirty ounces (425 to 850 grammes). Its fœtal surface is covered with the smooth, amniotic membrane, and its uterine surface, when detached, is rough, and divided into irregular lobes, or cotyledons, half an inch to an inch and a half (12·7 to 38·1 mm.) in diameter. Between these lobes, are membranes, called dissepiments, which penetrate into the substance of the placenta, and at its border extend as far as the fœtal surface.

Upon the uterine surface of the placenta, is a thin, soft membrane, the decidua serotina. This is composed of amorphous matter, a large number of granulations, and colossal cells with enlarged and multiple nuclei. A portion of this membrane is not thrown off with the placenta in parturition, but processes extend into the placenta and closely surround the fœtal tufts.

The two arteries of the umbilical cord branch upon the fœtal surface of the placenta, beneath the amnion, and finally penetrate the substance of the organ. The branches of the veins, which are about sixteen in number, converge toward the cord and unite to form the umbilical vein. Upon the uterine surface of the placenta are oblique openings of a large number of veins which return the maternal blood to the uterine sinuses. There are also the small, spiral arteries, which pass into the substance of the organ, to supply blood to the maternal portion. These are the "curling arteries," described by John Hunter. If the umbilical arteries be injected, the fluid is returned by the umbilical vein, having passed through the vascular tufts of the fœtal portion of the placenta.

According to Winkler, there are three kinds of fœtal villi: 1. Those which terminate just beneath the chorion, without penetrating the vascular lacunæ. 2. Longer villi, which hang free in the lacunæ. 3. Long, branching villi, which penetrate more deeply into the placenta, some extending as far as its uterine surface.

The great vascular spaces, or lacunæ of the maternal portion of the placenta, present a number of trabeculæ, which extend from the uterine to the fœtal surface; and between these trabeculæ, are exceedingly delicate, transverse and oblique secondary trabecular processes. The blood-vessels of the fœtal tufts are surrounded with a gelatinous, connective-tissue structure, and as late as the sixth month (Heinz) are covered with a layer of chorionic cells.

The mode of formation of the vascular spaces in the placenta has been a subject of much discussion. The following, however, seems to be the most reasonable view with regard to this question: That portion of the uterine mucous membrane which becomes the maternal portion of the placenta extends from the decidua serotina and surrounds the villi, which are embedded

in its substance. As the arborescent villi extend, they encroach upon the blood-vessels of the prolongations from the serotina, which latter become much enlarged and finally form the great vascular spaces traversed by the trabeculæ mentioned above. At term, however, according to Heinz (1888), the fœtal vessels have lost their covering of epithelium, which is observed in the earlier months of pregnancy. Thus the most important parts of the placenta are formed by an interlacement of the villi of the chorion with the altered structures of the mucous membrane of the uterus.

In the human subject the maternal and fœtal portions of the placenta are so closely united that they can not be separated from each other. In parturition the curling arteries and the veins on the uterine surface of the placenta are torn off, and the placenta then consists of the parts just described; the torn ends of the vessels attached to the uterus are closed by the contractions of the surrounding muscular fibres; and the blood which is discharged is derived mainly from the placenta itself.

Uses of the Placenta.—The placenta is the respiratory, excretory and nutritive organ of the fœtus. Its action as a respiratory organ has already been mentioned in connection with the physiology of respiration. It certainly serves as an organ for the elimination of carbon dioxide, and probably also for other products of excretion. It is the only source of materials for the development and nutrition of the fœtus. It is thought that cells derived from the serotina elaborate a fluid called uterine milk, which is absorbed by the fœtal tufts. This fluid has been collected from between the fœtal tufts of the placenta of the cow, and has been found to contain fatty matter, albuminous matters and certain salts, but no sugar or caseine (Gamgee). It is not probable, however, that such a fluid exists in the human placenta; although "uterine milk" of the ruminants was mentioned distinctly by Haller, and was alluded to by even earlier writers.

Development of the Ovum.

The product of generation retains the name of ovum until the form of the body begins to be apparent, when it is called the embryon. At the fourth month, about the time of quickening, it is called the fœtus, a name which it retains during the rest of intraüterine life. The membranes are appendages developed for the purposes of protection and nutrition; and the embryon itself, in the mammalia, is developed from a restricted portion of the layers of cells resulting from the segmentation of the vitellus.

The formation of the blastodermic cells and the appearance of the groove which is subsequently developed into the neural canal have already been described. At this portion of the ovum, there is a thickening of the blastoderm, which then presents three layers, the mesoblast, the thickest and most important, being developed from the opposite surfaces of the epiblast and the hypoblast. The earliest stages of development have been studied almost exclusively in the chick; and it is probable that the appearances here observed nearly represent the earlier processes of development in the human subject.

Development of the Cavities and Layers of the Trunk, in the Chick.—As

an introduction to a description of the development of special organs in the human subject and in mammals, it will be found very useful to study the first stages of development in the chick, which will give an idea of the arrangement of the different blastodermic layers and the way in which they are developed into the different parts of the trunk, with the mode of formation of the great cavities. The figures by which this description is illustrated are those of Brücke, which were photographed on wood from diagrams made from actual preparations by Seboth. These figures, therefore, can hardly be called diagrammatic.

Fig. 298 shows one of the earliest stages of development in the chick. In this figure, the upper layer of dark cells (B, B) represents the epiblast. The

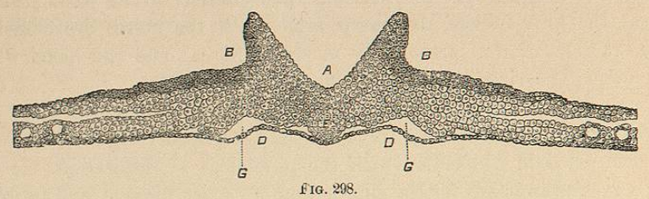

Fig. 298.

lower layer of dark cells (D, D) represents the hypoblast. The middle layer of lighter cells is the mesoblast, which, toward the periphery, is split into two layers. This figure represents a transverse section. At A, is a transverse section of the groove which is subsequently developed into the canal for the spinal cord. Beneath this groove, is a section of a rounded cord (E), the chorda dorsalis. The openings (G, G) represent the situation of the two aortæ. The other cavities are as yet indistinct in this figure.

Fig. 299 shows the same structures at a more advanced stage of development. The dorsal, or vertebral plates, which bound the furrow (A) in Fig.

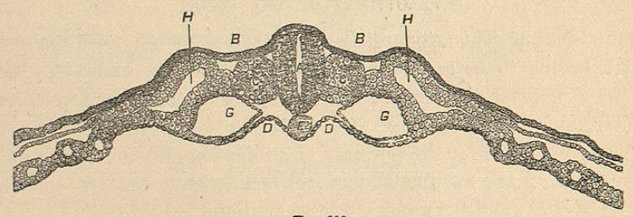

Fig. 299.

298, are closed above, and include (A) the neural canal. The chorda dorsalis (E) is separated from the cells surrounding it in Fig. 298. The epiblast (B, B) and the hypoblast (D, D) present certain curves which follow the arrangement of the cells of the mesoblast. By the sides of the boundaries of the neural canal, are two distinct masses of cells (C, C), which are developed into the vertebræ. Outside of these masses of cells, are two smaller collections of cells, afterward developed into the Wolffian bodies. Beneath those two masses, are two large cavities (G, G), the largest cavities shown in

Fig. 299, presenting an irregular form, which are sections of the two primitive aortæ. The two openings (H, H) afterward become the pleuro-peritoneal cavity.

In Fig. 300 the parts are still farther developed. The neural canal is represented (A) nearly the same as in Fig. 299, with the chorda dorsalis (E) just beneath it. A groove, or gutter (D) has been formed in front, which is the groove of the intestinal canal. This remains open at this time and is lined by the hypoblast. Just above D, is a single opening (G), which is formed by the union of the two openings (G, G) in Figs. 298 and 299; and this is the abdominal aorta, which has here become single. The two openings (H, H) represent a section of the pleuro-peritoneal cavity. The outer wall of this cavity is the outer visceral plate, which is developed into the muscular walls of the abdomen. The lower and inner wall is the inner visceral plate, which forms the main portion of the intestinal wall. The outer wall is the outer layer of the mesoblast, and the inner wall is the inner layer of the same membrane. The two round orifices (I, I) are sections of the Wolffian ducts. The space (*b*, *b*) is the amniotic cavity.

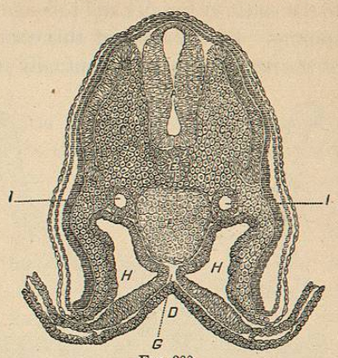

Fig. 300.

The figures just described, it must be borne in mind, represent transverse sections of the body of the chick, made through the middle portion of the abdomen. The posterior parts, it is seen, are developed first, the situation of the vertebral column being marked soon after the enclosure of the neural canal, by the vertebral plates; and at about the same time, the two aortæ make their appearance, with the first traces of the pleuro-peritoneal cavity. The next organs in the order of development, after the vascular system, are the Wolffian bodies. The intestinal canal is then a simple groove, and the embryon is entirely open in front. In the farther process of development, the visceral plates advance and close over the abdominal cavity, as the medullary plates have closed over the neural canal. Thus there is formed a closed tube, the intestine, lined by the hypoblast, the walls of the intestine being formed of the inner layer of the mesoblast. This brings the external layer of the mesoblast around the intestine, to form the muscular walls of the abdomen, the cavity (Fig. 300, H, H) being the peritoneal cavity, and the external covering being the epiblast. At this time the Wolffian bodies lie next the spinal column, between the intestine and the abdominal walls, with the single, abdominal aorta situated behind the intestine.

Development of the Skeleton, Muscular System and Skin.

Chorda Dorsalis.—One of the earliest structures observed in the developing embryon is the chorda dorsalis, or notochord. This is situated beneath

the neural canal and extends the entire length of the body. It is formed of a cord of simple cells, and marks the situation of the vertebral column, though it is not itself developed into the vertebræ, which grow around it and encroach upon its substance until it finally disappears. In many mammals the notochord presents a slight enlargement at the cephalic extremity, which extends to the auditory vesicles and it is somewhat diminished in size at the caudal extremity. By the sides of this cord are masses of cells which unite in front of the neural canal and eventually are developed into the vertebræ. These are called protovertebræ, or somites, and are shown in Fig. 303 (C, in A and B). Twelve pairs of protovertebræ are shown in Fig. 303, C. In the chick, two pairs are first formed in the upper cervical region, on the second day. They rapidly increase in number, from above downward, until at the fourth day there are twenty-one or twenty-two pairs. They are not formed in the region of the head or at the lowest part of the vertebral column. The vertebræ, as they are developed, are formed of temporary cartilaginous structure, gradually extending around the chorda dorsalis,

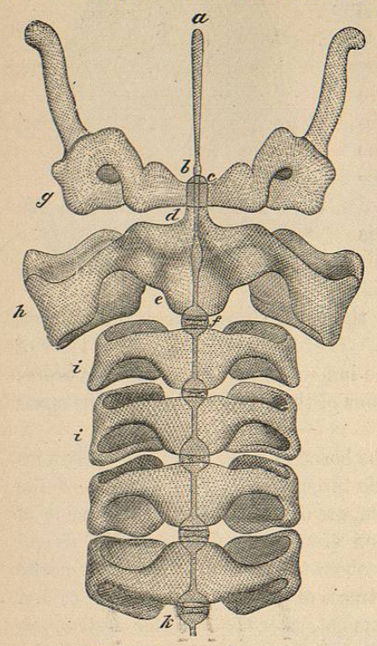

FIG. 301.—*The first six cervical vertebræ of the embryon of a rabbit one inch in length* (Robin).

a, *b*, cephalic portion of the notochord, exposed by the removal of the cartilage; *b*, portion of the chorda dorsalis slightly enlarged, which, in this embryon, was situated between the atlas and the occipital bone; *c*, odontoid process; *d*, base of the odontoid process; *e*, inferior, or second part of the body of the axis; *f*, *k*, enlargements of the chorda dorsalis, between the vertebræ; *g*, cartilage of the lateral portion of the atlas; *h*, lateral portion of the axis; *i*, *i*, transverse apophyses of vertebræ.

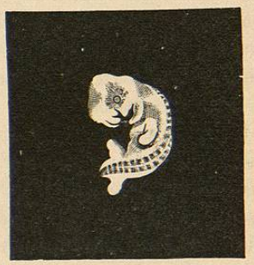

FIG. 302.—*Human embryon, about one month old, showing the large size of the head and upper parts of the body, the twisted form of the spinal column, the rudimentary condition of the upper and lower extremities and the rudimentary tail at the end of the spinal column* (Dalton).

which then occupies the axis of the spinal column. These cartilages are not divided at the lines of separation of the protovertebræ, but the protovertebræ fuse together and the cartilages which are to be developed into the bodies of the vertebræ are so divided off, that one cartilage occupies the place of the adjacent halves of two protovertebræ. Between the bodies of the vertebræ, the chorda dorsalis presents regular enlargements surrounded by a delicate membrane. As ossification of the spinal column advances, that portion of

the chorda dorsalis which is surrounded by the bodies of the vertebræ disappears, leaving the enlargements between the vertebræ distinct. These enlargements, which are not permanent, are gradually invaded by fibrous tissue, their gelatinous contents disappear, and the intervertebral disks, composed of fibro-cartilaginous structure, remain. These disks are permanent between the cervical, the dorsal and the lumbar vertebræ; but they eventually disappear from between the different parts of the sacrum and coccyx, as these are consolidated, this occurring, in the human subject, between the ninth and the twelfth years.

Vertebral Column, etc.—In Figs. 299 and 300 (C, C), are seen the two masses of cells (protovertebræ) situated by the sides of the neural canal, which are destined to be developed into the vertebræ. These cells extend around and encroach upon the chorda dorsalis, and form the bodies of the vertebræ. They also extend over the neural canal, closing above, and their processes are called the medullary, or dorsal plates. Sometimes the dorsal plates fail to close at a certain point in the spinal column, and this constitutes the malformation known as spina bifida. From the sides of the bodies of the vertebræ, the various processes of these bones are formed. As the spinal column is developed, its lower portion presents a projection beyond the pelvis, which constitutes a temporary caudal appendage, curved toward the abdomen; but this no longer projects after the bones of the pelvis are fully developed. At the same time the entire vertebral column is curved toward the abdomen, and it is twisted upon its axis, from left to right, so that the anterior face of the pelvis presents a right angle to the upper part of the body; but as the inferior extremities and the pelvis are developed, the spine becomes straight. The vertebræ make their appearance first in the middle of the dorsal region, from which point they rapidly extend upward and downward, until the spinal column is complete.

At the base of the skull, on either side of the superior prolongation of the chorda dorsalis, are two cartilaginous processes, which are developed into the so-called cranial vertebræ. In this cartilaginous mass, three ossific points appear, one behind the other. The posterior point of ossification is for the basilar portion of the occipital bone, which is developed in the same way as one of the vertebræ; the middle point is for the posterior portion of the sphenoid; and the anterior point is for the anterior portion of the sphenoid. The frontal bone, the parietal bone, the temporal bone and a portion of the occipital bone are developed from the connective tissue, without the intervention of pre-existing cartilaginous structure. At the time when the vertebræ are developed, with their laminæ and their spinous and transverse processes, the ribs extend over the thorax, and the clavicle, scapula and sternum make their appearance.

At about the beginning of the second month, four papillary prominences, which are the first traces of the arms and legs, appear on the body of the embryon. These progressively increase in length, the arms appearing near the middle of the embryon, and the legs, at the lower portion. Each extremity is divided into three portions, the arm, forearm and hand, for the upper