for the absence of valves, and moderates the flow of blood through it.[1]

Distinct knots are not unfrequently observed in the cord, but they rarely have the effect of obstructing the circulation through it. They no doubt form when the fœtus is very small. They may sometimes also be produced in labor by the child being propelled through a coil of the cord lying circularly around the os uteri. The so-called false knots are merely accidental nodosities due to local enlargements of the vessels.

CHAPTER II.

THE ANATOMY AND PHYSIOLOGY OF THE FŒTUS.

It is obviously impossible to attempt anything like a full account of the development of the various fœtal structures, or of their growth during intra-uterine life. To do so would lead us far beyond the scope of this work, and would involve a study of complex details only suitable in a treatise on embryology. It is of importance, however, that the practitioner should have it in his power to determine approximately the age of the fœtus in abortions or premature labors, and for this purpose it is necessary to describe briefly the appearance of the fœtus at various stages of its growth.

1st Month. The fœtus in the first month of gestation is a minute gelatinous and semi-transparent mass, of a grayish color, in which no definite structure can be made out, and in which no head or extremities can be seen. It is rarely to be detected in abortions, being lost in surrounding blood-clots. In the few examples which have been carefully examined it did not measure more than a line in length. It is, however, already surrounded by the amnion, and the pedicle of the umbilical vesicle can be traced into the unclosed abdominal cavity.

2d Month. The embryo becomes more distinctly apparent, and is curved on itself, weighing about sixty-two grains, and measuring six to eight lines in length. The head and extremities are distinctly visible—the latter in the form of rudimentary projections from the body. The eyes are to be seen as small black spots on the side of the head. The spinal column is divided into separate vertebræ. The independent circulatory system of the fœtus is now beginning to form, the heart consisting of only one ventricle and one auricle, from the former of which both the aorta and pulmonary arteries arise. On either side of the vertebral column, reaching from the heart to the pelvis, are two

[1 In some instances the disproportionate length of the vein causes the cord to assume a screw-like form, which may be very regular, as is exhibited to a remarkable degree by one in my possession, in which there are between thirty and forty turns, involving the whole funis, which is of average length in a straight line.—Ed.]

large glandular structures, the *corpora Wolffiana*, which consist of a series of convoluted tubes opening into an excretory duct, running along their external borders, and connected below with the common cloaca of the genito-urinary and digestive tracts. They seem to act as secreting glands, and fulfil the functions of the kidneys before they are formed. Toward the end of the second month they atrophy and disappear, and the only trace of them in the fœtus at term is to be found in the parovarium lying between the folds of the broad ligaments. At this stage of development there are met with in the human embryo, as in that of all mammals, four transverse fissures opening into the pharynx, which are analogous to the permanent branchiæ of fishes. Their vascular supply is also similar, as the aorta at this time gives off four branches on each side, each of which forms a branchial arch, and these afterward unite to form the descending aorta. By the end of the sixth week these, as well as the transverse fissures to which they are distributed, disappear. By the end of the second month the kidneys and supra-renal capsules are forming, and the single ventricle is divided into two by the growth of the inter-ventricular septum. The umbilical cord is quite straight, and is inserted into the lower part of the abdomen. Centres of ossification are showing themselves in the inferior maxillary bones and the clavicle.

3d Month. The embryo weighs from seventy to three hundred grains, and measures from two and a half to three and a half inches in length. The forearm is well formed, and the first traces of the fingers can be made out. The head is large in proportion to the rest of the body, and the eyes are prominent; the mouth is closed by the lips, and is separated by them from the nasal cavity. The umbilical vesicle and allantois have disappeared, and the alimentary canal is now situated entirely within the abdominal cavity. The greater portion of the chorion villi have atrophied, and the placenta is distinctly formed.

4th Month. The weight is from four to six ounces, and the length about six inches. The convolutions of the brain are beginning to develop. The sex of the child can now be ascertained on inspection. Hairs begin to be formed on the head. The muscles are sufficiently formed to produce distinct movements of the limbs. Ossification is extending, and can be traced in the occipital and frontal bones, and in the mastoid processes. The sexual organs are differentiated.

5th Month. Weight about ten ounces. Length, nine or ten inches. Hair is observed covering the head, which forms about one-third of the length of the whole fœtus. The nails are beginning to form, and ossification has commenced in the ischium. The fœtal movements are distinct, and in cases of premature delivery, may continue for some time after the birth of the child.

6th Month. Weight about one pound. Length, eleven to twelve and a half inches. The hair is darker. The eyelids are closed, and the membrana pupillaris exists; eyelashes have now been formed. Some fat is deposited under the skin. The testicles are still in the abdominal cavity. The clitoris is prominent. The pubic bones have begun to ossify.

7th Month. Weight from three to four pounds. Length, thirteen to fifteen inches. The skin is covered with unctuous, sebaceous matter, and there is a more considerable deposit of subcutaneous fat. The eyelids are open. The testicles have descended into the scrotum. Children born at this time may occasionally survive.

8th Month. Weight from four to five pounds. Length, sixteen to eighteen inches, and the fœtus seems now to grow in thickness rather than in length. The nails are completely developed. The membrana pupillaris has disappeared.

Fœtus at Term.—At the completion of pregnancy the fœtus weighs on an average, six and a half pounds, and measures about twenty inches in length. These averages are, however, liable to great variation. Remarkable histories are given by many writers of fœtuses of extraordinary weight, which have been probably greatly exaggerated. Out of 3000 children delivered under the care of Cazeaux at various charities, one only weighed ten pounds. There are, however, several carefully recorded instances of weight far exceeding this; but they are undoubtedly much more uncommon than is generally supposed. Dr. Ramsbottom mentions a fœtus weighing sixteen and a half pounds; Cazeaux tells us of one which he delivered by turning, which weighed eighteen pounds and measured two feet one and a half inches; and the birth of one weighing twenty-one pounds has been recently recorded.[1] Such overgrown children are almost invariably stillborn.[2]

The average size of male children at birth, as in after-life, is somewhat greater than that of female. Thus Simpson[3] found that out of 100 cases the male children averaged ten ounces more in weight than the female, and half an inch more in length.

[Some mothers of average size never bear a fœtus of even six pounds in weight, although begotten by a husband of full vigor. One of my patients bore a daughter of three and a half pounds; a second of two and three-quarters; and a son of five and a half pounds. The first daughter has given birth to a girl of one and a half pounds, now living at the age of two. The second died at eight months; and the son is a vigorous youth of sixteen. Such small children sometimes grow to very large size and live to advanced age, as witness the fact that one in this city became a large, tall woman, and died at the age of eighty-seven years.—Ed.]

A newborn child at term is generally covered to a greater or less extent with a greasy, unctuous material, the *vernix caseosa*, which is formed of epithelial scales and the secretion of the sebaceous glands, and which is said to be of use in labor by lubricating the surface of the child. The head is generally covered with long dark hair, which

[1] Brit. Med. Journ., Feb. 1, 1879.

[2] Probably the largest fœtus on record was that of Mrs. Captain Bates, the Nova Scotia giantess, a woman of seven feet nine inches, whose husband is also of gigantic build, reaching seven feet seven inches in height. This child, born in Ohio, was their second, and was lost in its birth, as no forceps could be procured of sufficient size to grasp the head. The fœtus weighed twenty-three and three-quarter pounds, and was thirty inches in length. Their first infant weighed eighteen pounds. We have had children born in this city (Philadelphia) at maturity and live, that weighed but one pound. The well-remembered "Pineus baby" weighed a pound and an ounce. (Harris, note to 3d American edition).

[3] Selected Obstetrical Works, p. 327.

frequently falls off or changes in color shortly after birth. Dr. Wiltshire[1] has called attention to an old observation, that the eyes of all newborn children are of a peculiar dark steel-gray color, and that they do not acquire their permanent tint until some time after birth. The umbilical cord is generally inserted below the centre of the body.

Anatomy of the Fœtal Head.—The most important part of the fœtus from an obstetrical point of view is the head, which requires a separate study, as it is the usual presenting part, and the facility of the labor depends on its accurate adaptation to the maternal passages.

The chief anatomical peculiarity of interest, in the head of the fœtus at term, is that the bones of the skull, especially of its vertex—which, in the vast majority of cases, has to pass first through the pelvis—are not firmly ossified as in adult life, but are joined loosely together by membrane or cartilage. The result of this is that the skull is capable of being moulded and altered in form to a very considerable extent by the pressure to which it is subjected, and thus its passage through the pelvis is very greatly facilitated. This, however, is chiefly the case with the cranium proper, the bones of the face and of the base of the skull being more firmly united. By this means the delicate structures at the base of the brain are protected from pressure, while the change of form which the skull undergoes during labor implicates a portion of the skull where pressure on the cranial contents is least likely to be injurious.

The divisions between the bones of the cranium are further of obstetric importance in enabling us to detect the precise position of the head during labor, and an accurate knowledge of them is therefore essential to the obstetrician.

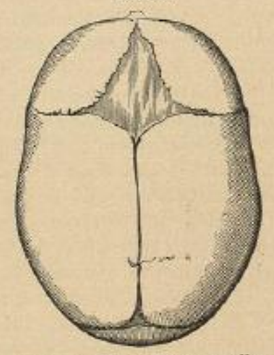
We talk of them as *sutures* and *fontanelles:* the former being the lines of junction between the separate bones, which overlap each other to a greater or less extent during labor; the latter, membranous interspaces where the sutures join each other.

The principal sutures are: 1st. The *sagittal*, which separates the two parietal bones, and extends longitudinally backward along the vertex of the head. 2d. The *frontal*, which is a continuation of the sagittal, and divides the two halves of the frontal bone, at this time separate from each other. 3d. The *coronal*, which separates the frontal from the parietal bones, and extends from the squamous portion of the temporal bone across the head to a corresponding point on the opposite side. 4th. The *lambdoidal*, which receives its name from its resemblance to the Greek letter Λ, and separates the occipital from the parietal bones on either side. The fontanelles (Fig. 65) are the membranous interspaces where the sutures join—the *anterior* and larger being lozenge-shaped, and formed by the junction of the frontal, sagittal, and two halves of the coronal sutures. It will be well to note that there are, therefore, four lines of sutures running into it, and four angles, of which the anterior, formed by the frontal suture, is most elongated and well marked. The *posterior* fontanelle (Fig. 66) is

[1] Lancet, February 11, 1871.

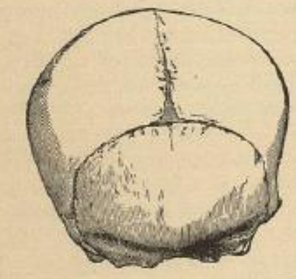
formed by the junction of the sagittal suture with the two legs of the lambdoidal. It is, therefore, triangular in shape, with three lines of sutures entering it in three angles, and is much smaller than the anterior fontanelle, forming merely a depression into which the tip of the finger can be placed, while the latter is a hollow as big as a shilling, or even larger. As it is the posterior fontanelle which is generally

FIG. 65.



Anterior and posterior fontanelles.

FIG. 66.

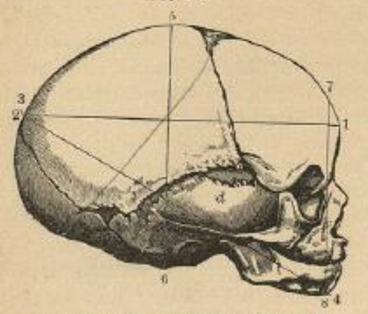


Bi-parietal diameter, sagittal and lambdoidal sutures, with posterior fontanelle.

lowest, and the one most commonly felt during labor, it is important for the student to familiarize himself with it, and he should lose no opportunity of studying the sensations imparted to the finger by the sutures and fontanelles in the head of the child after birth.

The Diameters of the Fœtal Skull.—For the purpose of understanding the mechanism of labor, we must study the measurements of the fœtal head in relation to the cavity through which it has to pass. They are taken from corresponding points opposite to each other, and are known as the diameters of the skull (Fig. 67). Those of most importance are: 1st. The *occipito-mentalis* (O. M), from the occipital protuberance to the point of the chin, 5.25″ to 5.50″. 2d. The *occipito-frontalis* (O. F), from the occiput to the centre of the forehead, 4.50″ to 5″. 3d. The *sub-occipito-bregmatica* (S. O. B), from a point midway between the occipital protuberance and the margin of the foramen magnum to the centre of the anterior fontanelle, 3.25″. 4th. The *cervico-bregmatica* (C. B), from the anterior margin of the foramen magnum to the centre of the anterior fontanelle, 3.75″. 5th. *Transverse*, or *bi-parietalis* (BI-P),

FIG. 67.



1—2. Diameter occipito-frontalis (O. F).
3—4. " occipito-mentalis (O. M).
5—6. " cervico-bregmatica (C. B).
7—8. " fronto-mentalis (F. M).

between the parietal protuberances, 3.75″ to 4″. 6th. *Bi-temporalis* (BI-T), between the ears, 3.50″. 7th. *Fronto-mentalis* (F. M), from the apex of the forehead to the chin, 3.25″.

The length of these respective diameters, as given by different writers, differs considerably—a fact to be explained by the measurements having been taken at different times; by some just after birth, when the head was altered in shape by the moulding it had undergone; by others when this had either been slight, or after the head had recovered its normal shape. The above measurements may be taken as the average of those of the normally shaped head, and it is to be noted that the first two are most apt to be modified during labor. The amount of compression and moulding to which the head may be subjected, without proving fatal to the fœtus, is not certainly known, but it is doubtless very considerable. Some interesting examples of the extent to which the head may be altered in shape in difficult labors have been given by Barnes,[1] who has shown by tracings of the shape of the head taken immediately after delivery, that in protracted labor the occipito-mental (O. M) and occipito-frontal (O. F) diameters may be increased more than an inch in length, while lateral compression may diminish the bi-parietal (BI-P) diameter to the same length as the inter-auricular. The fœtal head is movable on the vertical column to the extent of a quarter of a circle; and it seems probable that the laxity of the ligaments admits with impunity a greater circular movement than would be possible in the adult.

On taking the average of a large number of measurements, it is found that the heads of male children are larger and more firmly ossified than those of females, the former averaging about half an inch more in circumference. Sir James Simpson attributed great importance to this fact, and believed that it was sufficient to account for the larger proportion of stillbirths in male than in female children, as well as for the greater difficulty of labor and the increased maternal mortality that are found to attend on male births. His well-known paper on this subject, which has given rise to much controversy, is full of the most elaborate details, and so great did he believe the fœtal influence to be, that he calculated that between the years 1834 and 1837 there were lost in Great Britain, as a consequence of the slightly larger size of the male than of the female head at birth, about 50,000 lives, including those of about 46,000 or 47,000 infants, and of between 3000 and 4000 mothers who died in childbed.[2] It is probable that race and other conditions, such as civilization and intellectual culture, have considerable influence on the size of the fœtal skull, but we are not in possession of sufficiently accurate data to justify any very positive opinion on these points.

In the very large majority of cases the fœtus lies *in utero* with head downward, and is so placed as to be adapted in the most convenient way to the cavity in which it is placed. The uterine cavity is most roomy at the fundus, and narrowest at the cervix, and the greatest bulk of the fœtus is at the breech, so that the largest part of the child

[1] Obst. Trans., 1866, vol. vii. p. 171.

[2] Selected Obst. Works, p. 368.

usually lies in the part of the uterus best adapted to contain it. The various parts of the child's body are, further, so placed in regard to each other as to take up the least possible amount of space. (See Plates I., II.) The body is bent so that the spine is curved with its convexity outward, this curvature existing from the earliest period of development; the chin is flexed on the sternum; the forearms are flexed on the arms, and lie close together on the front of the chest; the legs are flexed on the thighs, and the thighs drawn up on the abdomen; the feet are drawn up toward the legs; the umbilical cord is generally placed out of reach of injurious pressure, in the space between the arms and the thighs. Variations from this attitude, however, are not uncommon, and are not, as a rule, of much consequence. Although the cranial presentations are much the most common, averaging 86 out of every 100 cases, other presentations are by no means rare, the next most frequent being either that of the breech, in which the long diameter of the child lies in the long diameter of the uterine cavity; or some variety of transverse presentation, in which the long diameter of the fœtus lies obliquely across the uterus, and no longer corresponds to its longitudinal axis.

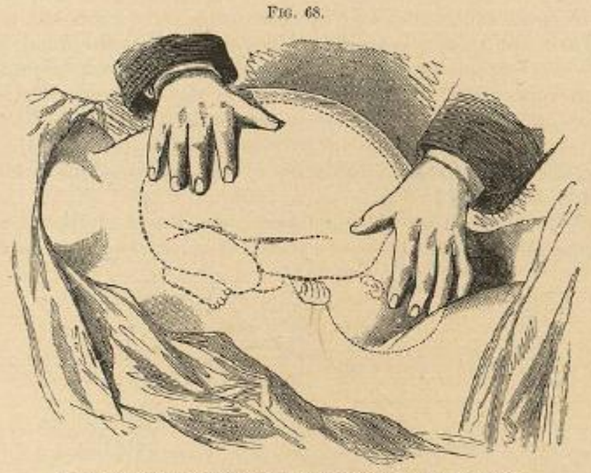
It was long believed that the head presentation was only assumed toward the end of pregnancy, when it was supposed to be produced by a sudden movement on the part of the fœtus, known as the *culbute*. It is now well known that, in the large majority of cases, the head is lowest during all the latter part of pregnancy, although changes in position are more common than is generally believed to be the case, and presentation of parts other than the head is much more frequent in premature labor than in delivery at term. In evidence of the last statement, Churchill says that in labor at the seventh month the head presents only 83 times out of 100 when the child is living, and that as many as 53 per cent. of the presentations are preternatural when the child is stillborn. The frequency with which the fœtus changes its position before delivery has been made the subject of investigation by various German obstetricians, and the fact can be readily ascertained by examination. Valenta[1] found that out of nearly 1000 cases, carefully and frequently examined by him, in 57.6 per cent. the presentation underwent no change in the latter months of pregnancy, but in the remaining 42.4 per cent. a change could be readily detected. These alterations were found to be most frequent in multiparæ, and the tendency was for abnormal presentations to alter into normal ones. Thus it was common for transverse presentations to alter longitudinally, and but rare for breech presentations to change into head. The ease with which these changes are effected no doubt depends, in a considerable degree, on the laxity of the uterine parietes, and on the greater quantity of amniotic fluid, by both of which the free mobility of the fœtus is favored.

The facility with which the position of the fœtus *in utero* can be ascertained by abdominal palpation has not been generally appreciated

[1] Monats. f. Geburt., 1865, Bd. xxiv. S. 172; and 1866, Bd. xxviii. S. 361. "Geburtshülfliche Studien."

in obstetric works, and yet, by a little practice, it is easy to make it out. Much information of importance can be gained in this way, and it is quite possible, under favorable circumstances, to alter abnormal presentations before labor has begun. For the purpose of making this examination, the patient should lie at the edge of the bed, with her shoulders slightly raised, and the abdomen uncovered. The first observation to make is to see if the longitudinal axis of the uterine tumor corresponds with that of the mother's abdomen; if it does, the presentation must be either a head or a breech. By spreading the hands over the uterus (Fig. 68), a greater sense of resistance can be

FIG. 68.



Mode of ascertaining the position of the fœtus by palpation.

felt, in most cases, on one side than on the other, corresponding to the back of the child. By striking the tips of the fingers suddenly inward at the fundus, the hard breech can generally be made out, or the head still more easily, if the breech be downward. When the uterine walls are unusually lax, it is often possible to feel the limbs of the child. These observations can be generally corroborated by auscultation, for in head presentations the fœtal heart can usually be heard below the umbilicus, and in breech cases above it. Transverse presentations can even more easily be made out by abdominal palpation. Here the long axis of the uterine tumor does not correspond with the long axis of the mother's abdomen, but lies obliquely across it. By palpation the rounded mass of the head can be easily felt in one of the mother's flanks, and the breech in the other, while the fœtal heart is heard pulsating nearer to the side at which the head is detected.

The reason why the head presents so frequently has been made the subject of much discussion. The oldest theory was, that the head lay over the os uteri as the result of gravitation, and the influence of gravity, although contested by many obstetricians, prominent among whom were Dubois and Simpson, has been insisted upon as the chief

cause by others, Dr. Duncan being one of the most strenuous advocates of this view. The objections urged against the gravitation theory were drawn partly from the result of experiments, and partly from the frequency with which abnormal presentations occur in premature labors, when the action of gravity cannot be supposed to be suspended. The experiments made by Dubois went to show, that when the fœtus was suspended in water, gravitation caused the shoulders, and not the head, to fall lowest. He, therefore, advanced the hypothesis that the position of the fœtus was due to instinctive movements, which it made to adapt itself to the most comfortable position in which it could lie. It need only be remarked that there is not the slightest evidence of the fœtus possessing any such power. Simpson proposed a theory which was much more plausible. He assumed that the fœtal position was due to reflex movements produced by physical irritations to which the cutaneous surface of the fœtus is subjected from changes of the mother's position, uterine contractions, and the like. The absence of these movements, in the case of the death of the fœtus, would readily explain the frequency of malpresentations under such circumstances.

The obvious objection to this theory, complete as it seems to be, is the absence of any proof that such constant extensive reflex movements

FIG. 69.

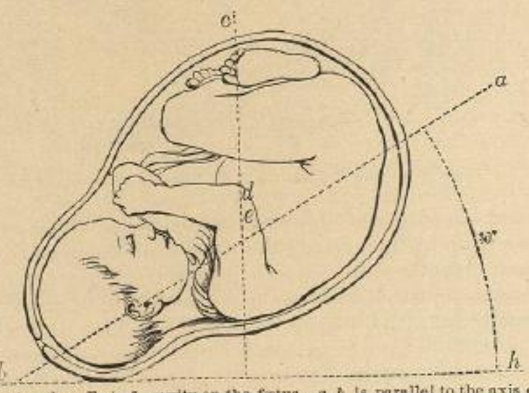
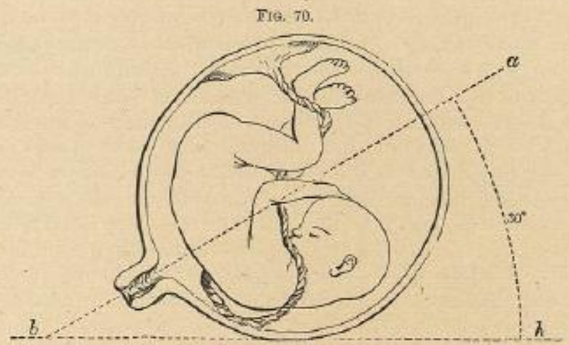


Diagram illustrating the effect of gravity on the fœtus. *a*, *b*, is parallel to the axis of the pregnant uterus and pelvic brim. *c*, *d*, *e*, is a perpendicular line. *e*, the centre of gravity of the fœtus. *d*, the centre of flotation. (After DUNCAN.)

really do occur *in utero*. Dr. Duncan has very conclusively disposed of the principal objections which have been raised against the influence of gravitation, and, when an obvious explanation of so simple a kind exists, it seems useless to seek further for another. He has shown that Dubois's experiments did not accurately represent the state of the fœtus *in utero*, and that during the greater part of the day, when the woman is upright, or lying on her back, the fœtus lies obliquely to the horizon at an angle of about 30°. The child thus lies, in the former case, on an inclined plane, formed by the anterior uterine wall

and the abdominal parietes, in the latter by the posterior uterine wall and the vertebral column. Down the inclined plane so formed the force of gravity causes the fœtus to slide, and it is only when the woman lies on her side that the fœtus is placed horizontally, and is not subjected in the same degree to the action of gravity (Fig. 69). The frequency of mal-presentations in premature labors is explained by Dr. Duncan partly by the fact that the death of the child (which so frequently precedes such cases) alters its centre of gravity, and partly by the greater mobility of the child and the greater relative amount of liquor amnii (Fig. 70). The effect of gravitation is probably

FIG. 70.



Illustrating the greater mobility of the fœtus and the larger relative amount of liquor amnii in early pregnancy. *a*, *b*. Axis of pregnant uterus. *b*, *h*. A horizontal line. (After DUNCAN.)

greatly assisted by the contractions of the uterus which are going on during the greater part of pregnancy. The influence of these was pointed out by Dr. Tyler Smith, who distinctly showed that the contractions of the uterus preceding delivery exerted a moulding or adapting influence on the fœtus, and prevented undue alterations of its position. Dr. Hicks proved[1] that these uterine contractions are of constant occurrence from the earliest period of pregnancy, and there can be little doubt that they must have an important influence on the body contained within the uterus. The whole subject has been recently considered by Pinard,[2] who shows that many factors are in action to produce and maintain the usual position of the fœtus *in utero*, which may be either of an active or a passive character: the former being chiefly the active movements of the fœtus and the contractions of the uterus and the abdominal muscles; the latter, the form of the uterus and the fœtus, the slippery surface of the amnion, pressure of the amniotic fluid, etc. When any of these factors are at fault, mal-presentation is apt to occur.

The functions of the fœtus are in the main the same, with differences depending on the situation in which it is placed, as those of the separate being. It breathes, it is nourished, it forms secretions, and

[1] Obst. Trans., 1872, vol. xiii. p. 216.
[2] Annal. de Gyn., 1878, tom. ix. p. 321.

its nervous system acts. The mode in which some of these functions are carried on in intra-uterine life requires separate consideration.

Nutrition.—During the early part of pregnancy, and before the formation of the umbilical vesicle and the allantois, it is certain that nutritive material must be supplied to the ovum by endosmosis through its external envelope. The precise source, however, from which this is obtained is not positively known. By some it is believed to be derived from the granulations of the discus proligerus which surround it as it escapes from the Graafian follicle, and subsequently from the layer of albuminous matter which surrounds the ovum before it reaches the uterus; while others think it probable that it may come from a special liquid secreted by the interior of the Fallopian tube as the ovum passes along it. As soon as the ovum has reached the uterus, there is every reason to believe that the umbilical vesicle is the chief source of nourishment to the embryo, through the channel of the omphalo-mesenteric vessels, which convey matters absorbed from the interior of the vesicle to the intestinal canal of the fœtus. At this time the exterior of the ovum is covered by numerous fine villosities of the primitive chorion, which are imbedded in the mucous membrane of the uterus, and it is thought that they may absorb materials from the maternal system, which may be either directly absorbed by the embryo, or which may serve the purpose of replacing the nutritive matter which has been removed from the umbilical vesicle by the omphalo-mesenteric vessels. This point it is, of course, impossible to decide. Joulin, however, thinks that these villi probably have no direct influence on the nourishment of the fœtus, which is at this time solely effected by the umbilical vesicle, but that they absorb fluid from the maternal system, which passes through the amnion and forms the liquor amnii. As soon as the allantois is developed, vascular communication between the fœtus and the maternal structures is established, and the temporary function of the umbilical vesicle is over; that structure, therefore, rapidly atrophies and disappears, and the nutrition of the fœtus is now solely carried on by means of the chorion villi, lined as they now are by the vascular endochorion, and chiefly by those which go to form the substance of the placenta.

This statement is opposed to the views of many physiologists, who believe that a certain amount of nutritive material is conveyed to the fœtus through the channel of the liquor amnii, itself derived from the maternal system, which is supposed either to be absorbed through the cutaneous surface of the fœtus, or carried to the intestinal canal by deglutition. The reasons for assigning to the liquor amnii a nutritive function are, however, so slight, that it is difficult to believe that it has any appreciable action in this way. They are based on some questionable observations, such as those of Weydlich, who kept a calf alive for fifteen days by feeding it solely on liquor amnii, and the experiments of Burdach, who found the cutaneous lymphatics engorged in a fœtus removed from the amniotic cavity, while those of the intestine were empty. The deglutition of the liquor amnii for the purposes of nutrition has been assumed from its occasional detection in the stomach of the fœtus, the presence of which may, however, be readily explained by spasmodic efforts at respiration, which the fœtus undoubtedly often makes before birth, especially when the placental circulation is in any way interfered with, and during which a certain quantity of fluid would necessarily be swallowed. The quantity of nutritive material, however, in the liquor amnii is so small—not more than 6 to 9 parts of albumin in 1000—that it is impossible to conceive that it could have any appreciable influence in nutrition, even if its absoption either by the skin or stomach were susceptible of proof.

That the nutrition of the fœtus is effected through the placenta is proved by the common observation that whenever the placental circulation is arrested, as by disease of its structure, the fœtus atrophies and dies. The precise mode, however, in which nutritive materials are absorbed from the maternal blood is still a matter of doubt, and must remain so until the mooted points as to the minute anatomy of the placenta are settled. The various theories entertained on this subject by the upholders of the Hunterian doctrine of placental anatomy, and by those who deny the existence of a sinus system, have already been referred to in the chapter on the Anatomy of the Placenta, to which the reader is referred (pp. 115–122).

Respiration.—One of the chief functions of the placenta, besides that of nutrition, is the supply of oxygenated blood to the fœtus. That this is essential to the vitality of the fœtus, and that the placenta is the site of oxygenation, is shown by the fact that whenever the placenta is separated, or the access of fœtal blood to it arrested by compression of the cord, instinctive attempts at inspiration are made, and if aërial respiration cannot be performed, the fœtus is expelled asphyxiated. Like the other functions of the fœtus during intra-uterine life, that of respiration has been made the subject of numerous more or less ingenious hypotheses. Thus many have believed that the fœtus absorbed gaseous material from the liquor amnii, which served the purpose of oxygenating its blood, St. Hilaire thinking that this was effected by minute openings in its skin, Beclard and others through the bronchi, to which they believed the liquor amnii gained access. Independently of the entire want of evidence of the absorption of gaseous materials by these channels, the theory is disproved by the fact that the liquor amnii contains no air which is capable of respiration. Serres attributed a similar function to some of the chorion villi, which he believed penetrated the utricular glands of the decidua reflexa and absorbed gas from the hydroperione, or fluid situated between it and the decidua vera, and in this manner he thought the fœtal blood was oxygenated until the fifth month of intra-uterine life, when the placenta was fully formed.

This hypothesis, however, rests on no accurate foundation, for it is certain that the chorion villi do not penetrate the utricular glands in the manner assumed; or, even if they did, the mode in which the oxygen thus absorbed by the chorion villi reaches the fœtus, which is separated from them by the amnion and its contents, would still remain unexplained.

The mode in which the oxygenation of the fœtal blood is effected before the formation of the placenta remains, therefore, as yet un-

known. After the development of that organ, however, it is less difficult to understand, for the fœtal blood is everywhere brought into such close contact with the maternal, in the numerous minute ramifications of the umbilical vessels, that the interchange of gases can readily be effected. The activity of respiration is doubtless much less than in extra-uterine life, for the waste of tissue in the fœtus is necessarily comparatively small, from the fact of its being suspended in a fluid medium of its own temperature, and from the absence of the processes of digestion and of respiratory movements. The quantity of carbonic acid formed would, therefore, be much less than after birth, and there would be a correspondingly small call for oxygenation of venous circulation.

Circulation.—The functions of the lungs being in abeyance, it is necessary that all the fœtal blood should be carried to the placenta to receive oxygen and nutritive materials. To understand the mode in which this is effected we must bear in mind certain peculiarities in the circulatory system which disappear after birth.

1. The two sides of the fœtal heart are not separate as in the adult. The right ventricle in the adult sends all the venous blood to the lungs through the pulmonary arteries, to be aërated by contact with the atmosphere. In the fœtus, however, only sufficient blood is passed through the pulmonary arteries to insure their being pervious and ready to carry blood to the lungs immediately after birth.

An aperture of communication, the *foramen ovale*, exists between the two auricles, which is arranged so as to permit the blood reaching the right auricle to pass freely into the left, but not *vice versâ*. By this means a large portion of the blood reaching the heart through the venæ cavæ, instead of passing, as in the adult, into the right ventricle, is directed ~~into~~ the right auricle. into the left auricle

2. Even with this arrangement, however, a larger portion of blood would pass into the pulmonary arteries than is required for transmission to the lungs, and a further provision is made to prevent its going to them by means of a fœtal vessel, the *ductus arteriosus* (Fig. 71), which arises from the point of bifurcation of the pulmonary arteries, and opens into the arch of the aorta. In consequence of this arrangement only a very small portion of the blood reaches the lungs at all.

FIG. 71.

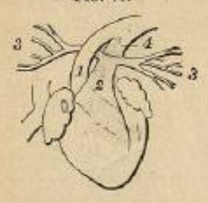


Diagram of fœtal heart. 1. Aorta. 2. Pulmonary artery. 3, 3. Pulmonary branches. 4. Ductus arteriosus. (After DALTON.)

3. The fœtal hypogastric arteries are continued into large arterial trunks, which, passing into the cord, form the *umbilical arteries*, and carry the impure fœtal blood into the placenta.

4. The purified blood is collected into the single *umbilical vein*, through which it is carried to the under surface of the liver, from which point it is conducted, by means of another special fœtal vessel, the *ductus venosus*, into the ascending vena cava and the right auricle.

In order to understand the course of the fœtal blood it may be most conveniently traced from the point where it reaches the under

surface of the liver through the umbilical vein. Part of it is distributed to the liver itself, but the greater quantity is carried directly into the inferior vena cava, through the ductus venosus. The inferior vena cava also receives the blood from the fœtal veins of the lower extremities, and that portion of the blood of the umbilical vein which has passed through the liver. This mixed blood is carried up to the right auricle, from which by far the greater part of it is immediately directed into the left auricle, through the foramen ovale. From thence it passes into the left ventricle, which sends the greater part of it into the head and upper extremities through the aorta, a comparatively small quantity being transmitted to the inferior extremities. The blood which is thus sent to the upper part of the body is collected into the vena cava superior, by which it is thrown into the right auricle. Here the mass of it is probably directed into the right ventricle, which expels it into the pulmonary arteries, and from thence, through the ductus arteriosus, into the descending aorta. By this arrangement it will be seen that the descending aorta conveys to the lower part of the body the comparatively impure blood which has already circulated through the head, neck, and upper extremities. From the descending aorta a small quantity of blood is conveyed to the lower extremities, the greater part of it being carried for purification to the placenta through the umbilical arteries.

As soon as the child is born it generally cries loudly and inflates its lungs, and, in consequence, the pulmonary arteries are dilated and the greater portion of the blood of the right ventricle is at once sent to the lungs, from whence, after being arterialized, it is returned to the left auricle, through the pulmonary veins. The left auricle, therefore, receives more blood than before, the right less, and, the placental circulation being arrested, no more passes through the umbilical vein. In consequence of this, the pressure of the blood in the two auricles is equalized, the mass of the blood in the right auricle no longer passes into the left (the valve of the foramen ovale being closed by the equal pressure on both sides), but directly into the right ventricle and from thence into the pulmonary arteries, and the ductus arteriosus soon collapses and becomes impervious. The mass of blood in the descending aorta no longer finds its way into the hypogastric arteries, but passes into the lower extremities, and the adult circulation is established.

The changes which take place in the temporary vascular arrangements in the fœtus, prior to their complete disappearance, are of some practical interest. The ductus arteriosus, as has been said, collapses, chiefly because the mass of blood is drawn to the lungs, and partly, perhaps, by its own inherent contractility. Its walls are found to be thickened, and its canal closes, first in the centre, and subsequently at its extremities, its aortic end remaining longer pervious on account of the greater pressure of blood from the left side of the heart (Fig. 72). Practical closure occurs within a few days after birth, although Flourens states that it is not completely obliterated until eighteen months or two years have elapsed.[1] According to Schroeder its walls unite

[1] Acad. des Sciences, 1854.

without the formation of any thrombus. The foramen ovale is soon closed by its valve, which contracts adhesion with the edges of the aperture, so as effectually to occlude it. Sometimes, however, a small canal of communication between the two auricles may remain pervious for many months, or even a year or more, without, however, any admixture of blood occurring. A permanently patulous condition of this aperture, however, sometimes exists, giving rise to the disease known as cyanosis.

FIG. 72.

Diagram of heart of infant. 1. Aorta. 2. Pulmonary artery. 3, 3. Pulmonary branches. 4. Ductus arteriosus becoming obliterated. (After DALTON.)

The umbilical arteries and veins and the ductus venosus soon also become impermeable, in consequence of concentric hypertrophy of their tissue and collapse of their walls. The closure of the former is aided by the formation of coagula in the interior. According to Robin, a longer time than is usually supposed elapses before they become completely closed, the vein remaining pervious until the twentieth or thirtieth day after delivery, the arteries for a month or six weeks. He has also described[1] a remarkable contraction of the umbilical vessels within their sheaths, at the point where they leave the abdominal walls, which takes place within three or four days after birth, and seems to prevent hemorrhage taking place when the cord is detached.

Function of the Liver.—The liver, from its proportionately large size, apparently plays an important part in the fœtal economy. It is not until about the fifth month of utero-gestation that it assumes its characteristic structure, and forms bile, previous to that time its texture being soft and undeveloped. According to Claude Bernard, after this period one of its most important offices is the formation of sugar, which is found in much larger amount in the fœtus than after birth. Sugar is, however, found in the fœtal structures long before the development of the liver, especially in the mucous and cutaneous tissues, and it seems probable that these, as well as the placenta itself, then fulfil the glycogenic function, afterward chiefly performed by the liver. The bile is secreted after the fifth month of pregnancy, and passes into the intestinal canal, and is subsequently collected in the gall-bladder. By some physiologists it has been supposed that the liver, during intra-uterine life, was the chief seat of depuration of the carbonic acid contained in the venous blood of the fœtus. It is, however, more generally believed that this is accomplished solely in the placenta. The bile, mixed with the mucous secretion of the intestinal tract, forms the *meconium* which is contained in the intestines of the fœtus, and which collects in them during the whole period of intra-uterine life. It is a thick, tenacious, greenish substance, which is voided soon after birth in considerable quantity.

The Urine.—Urine is certainly formed during intra-uterine life, as

[1] Ibid., 1860.

is proved by the fact familiar to all accoucheurs, that the bladder is constantly emptied instantly after birth. It has generally been supposed that the fœtus voids its urine into the cavity of the amnion, and the existence of traces of urea in the liquor amnii, as well as some cases of imperforate urethra, in which the bladder was found to be enormously distended, and some cases of congenital hydro-nephrosis associated with impervious ureters, have been supposed to corroborate this assumption. The question has been very fully studied by Joulin, who has collected together a large number of instances in which there was imperforate urethra without any undue distention of the bladder. He holds also, that the amount of urea found in the liquor amnii is far too minute to justify the conclusion that the urine of the fœtus was habitually passed into it, although a small quantity may, he thinks, escape into it from time to time; and he therefore believes that the urine of the fœtus is only secreted regularly and abundantly after birth, and that during intra-uterine life its retention is not likely to give rise to any functional disturbance.

Function of the Nervous System.—There is no doubt that the nervous system acts to a considerable extent during intra-uterine life, and some authors have even supposed that the fœtus was endowed with the power of making instinctive or voluntary movements for the purpose of adapting itself to the form of the uterine cavity. Most probably, however, the movements the fœtus performs are purely reflex. That it responds to a stimulus applied to the cutaneous nerves is proved by the experiments of Tyler Smith, who laid bare the amnion in pregnant rabbits, and found that the fœtus moved its limbs when these were irritated through it. Pressure on the mother's abdomen, cold applications, and similar stimuli will also produce energetic fœtal movements. The gray matter of the brain in the newborn child is, however, quite rudimentary in its structure, and there is no evidence of intelligent action of the nervous system until some time after birth, and *à fortiori* during pregnancy.

CHAPTER III.

PREGNANCY.

Changes in the Uterus.—As soon as conception has taken place a series of remarkable changes commence in the uterus, which progress until the termination of pregnancy, and are well worthy of careful study. They produce those marvellous modifications which effect the transformation of the small undeveloped uterus of the non-pregnant state into the large and fully developed uterus of pregnancy, and have no parallel in the whole animal economy.