1853

THE

ANATOMY

AND

PHYSIOLOGY

OF THE

FŒTAL CIRCULATION

David Greig
1853.

The plan I have adopted in this short sketch of the Foetal Circulations, is just of all to give a plain description of the position and use of the blood vessels, after that the circulation itself with its physiology, then the changes which take place at birth, and last of all a few of the abnormalities which sometimes occur in the vessels of the foetus. As a circulation has no commencement or end, it is necessary to break in upon it at some point in order to trace its course. I will therefore commence at the point the blood enters the body of the foetus, and following its course, describe the vessels in their turn, until I again arrive at my starting point. At first sight we are astonished that the circulatory system of the foetus in utero should be of such a complex
Nature considering that the digestive and respiratory organs are in subsequence, but when all the peculiarities have been fully examined and understood, the whole will be seen to be a most beautiful example of the wisdom, force, and facility with which nature adapts the means to the end. It will be evident also, that all these peculiarities are absolutely necessary, that they are admirably adapted for the purposes they serve, and that, after both when no longer necessary, they are either easily removed, or retained as useful, in performing functions, necessary to the new state of being.
In the Tunica after the Umbilical
Vein enters the wall of the Abdomen at
the Umbilicus it is directed upwards,
in front of the Peritoneum, for about
half an inch, until it enters the Longi-
tudinal, or great fissure, of the Liver.
Shortly after it has entered this fissure,
it gives off two or three branches to each
lobe, but those given off to the left
side are distinctly larger than those
given off to the right.
About the middle of the longitudinal
fissure the Umbilical Vein divides
into three larger branches, one of which,
nearely as large as the other two, is given
to the right lobe of the Liver, and another
to the left, the former traverses the trans-
verse fissure before dividing, but the
latter immediately after being given
off pieces the substance of the left
lobe and is soon lost by dividing.
These two branches are given off almost
at right angles to the direct course of
the Veins whilst the third which seems
to be the direct continuation of the (Vein),
jaccs off straight from between the other two, and this branch being one of the great peculiarities of the foetal circulation, as will be hereafter shown, is called the "Ductus Omouzus".

Soon after the right or great division of the Umbilical Vein enters the transverse fissure, it is joined by the Cava Porta or true vein of the Liver.

The Cava Porta is joined by the union of the Splenic and Superior Mesenteric Veins. Shortly after the former has been joined by the Gastric and Superior Mesenteric, the two unite behind the fissure and thus ascend through the right border of the lesser curvature, lying between the Stomach's interior (which goes to supply the substance of the Liver) and the Ductus Communis Cholodhius, and joins the right division of the Umbilical Vein.

The Ductus Omouzus is the third branch of the Umbilical Vein and is given off from between the other two branches, inclining rather more to the right than to the left, it is about half an inch in
length and about one third the size of the right division, it occupies the continuation of the longitudinal fissure and joins the hepatic point. From this one sees that the blood which is circulated through the left side comes wholly from the placenta, whilst that circulated through the right is only in part placental, as it is mixed with that which is brought from the phleothoracic vessels by the cava portae. After the blood has made its circulation through the liver it is conveyed to the cava cava inferior and joins it at about half an inch before it enters the right auricle of the heart.

And as the heart is the great functional agent of the blood, and I may say the most important organ of the animal system, I cannot commence with its description until I have given a rough sketch of its development.

Owing to various difficulties the first appearance of a heart in the human
Embryo has never been fully determined. It can however be seen as a dilated sac lying in the foetal part of the embryo of the chick sometimes as early as the twenty second hour of incubation. In the early stages of its development it resembles the heart of the human foetus, receiving the blood at one end and sending off the artery at the other. This dilated sac now is soon becomes bent upon itself, and at the same time is subdivided into three cavities, one on either side of receiving cavity, a ventricle or forming cavity, and the third is a dilatation called atrioventricles, from which certain arteries are given off. From the arterial bulb fine arteries are given off which meeting in front of the ventricles form a vessel which is the future thoracic aorta. These arteries are developed from before backwards the one being obliterated as soon as the other is formed. (Duain)
The series of changes which occur after
The pericardial cavity is divided by a septum, and the pericardial cavity undergoes the same change, but not completely being pierced by the former valve, and partly the bulbus otonous is divided into the pulmonary artery and aorta. At this time the two vessels terminated in the auricles of the heart represent the two venae cavae, the superior terminating in the right and the inferior in the left. This however is soon changed, the sinuses cavae inferior enter at the right auricle and passing through it as it were, enter the left. From this time until birth no further change takes place.

The heart is a full grown foetus measuring about an inch in breadth and one and a half in thickness; it is situated almost vertically, high up, in the thorax, between the pericardium and enveloped by the large pericardium otonous.

It is composed as in the adult, of two auricles and two ventricles, each separated by a septum.

The right auricle is a quadrangular,
Cavity situated at the upper and right part of the heart, and when looked into seems to be nearly divided in two by a constriction. The anterior division is the longer, and into it may be seen opening, the auriculo-ventricular opening, the Vena Cava superior, and Coronary Vein; into the posterior division open the Vena Cava inferior and Sinuver Vein.

The constriction is formed, above by the tubercle of Locum, beneath and to the right by the Gustachian Valve, and on the left, by the anterior border of the Pericardial Membrane.

The tubercle of Locum is a thickened part of the upper wall of the right auricle and is situated immediately behind the opening of the Vena Cava superior.

The Gustachian Valve is a fold of the internal lining membrane of the heart; it is situated between the opening of the Vena Cava inferior, and the entrance of the Coronary Vein; it is of a crescentic shape and extends from the upper and anterior part of the entrance of the Vena Cava...
superior to the Foramen Ovale.

The Foramen Ovale is a communication between the two Auricles; it is not oval, as its name would lead one to suppose, but is round and situated at the lower and posterior part of the Septum Auriculare. It is surrounded by the Annulus Ovale, which is nearly the prominent margin of the opening, and is guarded on its left side by a valve.

The left Auricle is much the same, with regard to size at birth as the right, although in early fetal life it is distinctly less.

Internally there is seen the Auricles with particular reference to the opening of the Pulmonary Veins, and the Valve which covers the Foramen Ovale.

The Valve of the Foramen Ovale is wholly developed in the left Auricle, and is attached to the upper two-thirds of the left side of the opening; it is not drawn tight across the opening, but is loose, and when pushed to the left side by a probe, offers no resistance, and may be
lifted like a curtain, allowing it to fall with freedom; but when pressed to the right it rises in the form of a bow and opposes the stroke. I may also mention that in order to strengthen the valve as it were, I have found its loose margin bound to the remaining third of the border of the foramen by long tendinous bands. The openings of the pulmonary veins into the left auricle are very minute being as yet only rudimentary.

The two ventricles of the fetal heart differ in no especial manner from those in the adult; they are guarded exactly in the same manner by valves likewise the right gives off the pulmonary artery and the left the aorta.

Now, concerning the use of these parts which I have described, as situated in the different parts of the heart, and first of all the Ostachian valve. The use of this valve has afforded a wide field of discussion amongst anatomists from the time of its discovery by Bartholomew Ostachius B. D. 1570, up to the present
time, but although he was the first who noticed and described the valve, yet he could assign no use for it. It was rediscovered by Winlow, about the year 1730, and he, by linking it and the Foramen Ovale together, arrived at the conclusion, that it and the Foramen Ovale were peculiar to the foetus, that it disappeared as the Foramen Ovale closed, and was never found in the adult except when the Foramen Ovale was open, and that the Foramen Ovale was never found open except when the Pulmonary Valve was perfect. But we know that this is incorrect and that the Valve is found open, although comparatively speaking diminished, in every adult heart, although the Foramen Ovale is closed.

But Winlow, simply refuted this (mistakenly, by suggesting) that it served to direct the Blood through the Foramen Ovale into the Left Atrium and then directly to the Heart, agreeing
also with Laccius, that it might be useful also, in supporting the blood of the Cava Cava Inferior.

But Sabatini is the first who distinctly says, that the Eustachian Valve and the Foramen Oval are useful only in the foetus, and that there are two opposite currents in the right auricle of the heart, that the one goes from the Cava Cava inferior, obliged by the Eustachian Valve to the Foramen Oval, while the other from the Cava Cava superior descends straight into the right ventricle.

Haller and Wishat also agreed with Sabatini in this doctrine. Magendie on the other hand plainly states this to be impossible and ridicules the very idea of two currents in the auricle. Also John Bell agreeing with Magendie says, with regard to the Eustachian Valve, "Nothing is more certain than that the Eustachian Valve is not peculiar to the foetus; that it has no connection with the oval
Role, that the valve is often particularly large after the foramen ovale is closed, that it is often obliterated when yet the foramen ovale remains open; that in adults it is more easily demonstrated than in children; that in old age it is often petrified as the other valves are; its size neither relates to the foramen ovale nor to the ascending cavity; it relates to the auricle itself, and therefore is found in all stages of life, smaller or larger according to the size of the heart; and also with regard to the foramen ovale, says, that when we look at its mechanism its use is evident, and that only use it to transmit the blood of the right auricle to the left, and with this explanation declines all further disputes by saying, "It is far easier to impose upon a whole academy, than upon one, ingenious mind, and thus it came to pass that in the French academy, each theorist brought dissections of the heart and foramen ovale suited
to fit our destination, each when convenient changed his ground a little, and sought present directions, and thus valve and amelie, fetal and adult hearts, double rats and hermaphrodite monsters were annually exhibited in the halls of the French Academy, the society never sickened from tired, and the poors show lasted exactly one hundred years."

But from the admirable Julius of Dr. John Reid on this subject, recited in the forty-third volume of the Edinburgh Medical and Surgical Journal, I think that all discussions on the use of the Eustachian Valve and Fordemer Valve are now settled. This author, after referring to the past situation of the Formerer Valve with regard to the entrance of the Bone Cava inferior, and says to the junction of the Eustachian Valve, says, "When we consider the entrance of the two Cava themselves, the Superior passing downwards and forwards,
the inferior upwards and backwards, and add to all this the thick upper margins of the Foramen Oval. We further perceive that the blood passing down the Cava Cava inferior must fall directly into the right ventricle, to the left side of the Bifurcation Valve. He then goes on to state a series of experiments which he made in order to test the truth of this reasoning, and to ascertain to what extent the Bifurcation Valve prevented the intermingling of the two currents entering the right auricle by the two Cava Cavas.

"Since injection was made in the following manner, a red coloured injection was thrown up the Cava Cava inferior and a yellow coloured injection was thrown down the Cava Cava superior, at the same time and as much as possible in equal quantities and with equal force to endeavour to imitate the currents while flow along their course during the
Life of the Tissue. — The first was made on a tissue between five and six months, by some mistake the injection was not thrown down the Cava Inferior, and that thrown along the Cava inferior was in small quantity. — On examining the heart we found that the red injection had passed along the Cava Inferior, that some of it had passed into the right auricle, but the greater part had been diverted through the foramen ovale into the left auricle by the Eustachian Valves, so as to fill the whole of the left side of the heart, while not a single drop of injection had passed into the right ventricle. The second trial was upon a tissue at the full term, upon examination we found that, though the two currents chiefly passed in the course which we shall fully describe in the third experi-ment, yet some interruption had taken place but not to any great extent.
The third trial was upon a fatten of about seven months to judge from the size and position of its testicles, care was taken by a previous training to throw in the two currents as equally as possible; in tracing the red injection upwards, we found that it had passed through the foramen ovale and filled the left side of the heart without any interruption with the yellow except very slightly at the posterior part of the right auricle, not a drop of the yellow appeared to have accompanied the red into the left side of the heart, it ascended to the aorta and filled all the large vessels going to the head and upper extremities, the injection in all those vessels had not the slightest tinge of yellow; on tracing the yellow downwards we found it filling the right auricle, as already mentioned, from the right auricle it filled the right ventricle, passed along the pulmonary artery, and filled the ductus arteriosus and branches going to the lungs.
On entering the Aorta it passed down that vessel, filling it completely without any intermission of red, and thus all the branches of the thoracic and abdominal aorta were filled with yellow; the whole of the red fluid passed to the upper part of the body."

The first experiment although faulty in a failure, showed most distinctly the correct use of the Eustachian valve with regard to the fore and middle poles; the second, and especially the third experiment showed most beautifully in addition to this the whole course of the fetal circulation. The reason of the intermission of the two currents in the right auricle in the second experiment was no doubt owing to the Eustachian valve being imperfect at the full time there at the earlier periods.

The parts which I have next to describe are the Pulmonary artery and Aorta...
As before stated, the Bulbus Arteriosus about the second or third month becomes divided into two permanent vessels which are permanent, and end only as far as change, one arises from the right ventricle, and the other from the left; the former is named the Pulmonary artery, the latter the Aorta. The Pulmonary artery is about three fourths of an inch in length, and at about half an inch from its origin, gives off a small branch to the left lung, it then divides into another small branch which goes to the right lung, and the Aorta Arteriosus.

The Aorta Arteriosus is the direct continuation of the Pulmonary artery; it is very nearly as wide as the Pulmonary artery, and is about half an inch in length, it gives off no branches and joins the Aorta obliquely a little below the origin of the left subclavian artery. The first jet of the Aorta is named,
the Arch, and is about the same length as the Pulmonary artery and Ductus arteriosus taken together; it gives off three large branches which convey blood to the head and upper extremities; the first gives off about the middle of the Arch, is the Aorta Intermittens, which divides into the right carotid and subclavian, the next is the left carotid and the last the left subclavian. The calibre of the artery becomes less on each of these branches are given off; but it again regains its natural size when it is joined by the Ductus arteriosus. The Pulmonary artery and Aorta are each guarded by three semilunar valves; the same are in the adult, to prevent regurgitation of the blood contained in them into the heart. The part of the Aorta which consists of the thoracic and abdominal portions measures from four to five inches in length and extends from where it is joined by the Ductus arteriosus...
to its division into the two common iliac arteries which takes place opposite the fourth Lumbar vertebra. There is nothing peculiar in the foetal condition of this artery, it gives off the same branches and is in every respect similar to that in the adult. The Iliac arteries are about one inch in length, they diverge from one another, and pass downwards and outwards on each side to the margin of the pelvis; opposite the sacro-iliac symphysis they divide into two trunks, one of which is fully one third smaller than the other, is called the external iliac artery; this artery forms downwards by the side of the fascia muscle, giving off the sexual small branches in its course until it reaches the femoral canal where it becomes the femoral artery and goes to supply the lower limbs. The other, and larger, is named the internal iliac, this artery shortly after it is given off,
changes its name and becomes the Hygroscopic Artery, passes forward by the side of the fundus of the bladder to near its apex where it changes its name becoming Umbilical; it still continued to ascend along the posterior aspect of the wall of the abdomen keeping close to the Mesentery and Liver and, and converging with its fellow of the opposite side, until both of them meet at the Umbilicus, where they end and the Umbilical Veins pass out of the Abdomen forming the Umbilical Cord.

The Umbilical Cord is the connecting link between the foetus and placenta, and is attached by one end to the Umbilicus, and by the other to the placenta at a short distance from its centre. Its length is generally from eighteen to twenty-four inches, although it varies greatly in different cases, for some instance it is not more than a few inches, while in others it extends from three to five feet. It is about half an inch thick, and...
gradually tapers as it approaches the placenta, and is strongly marked by elevations corresponding to the course of its vessels. It is composed of the two umbilical arteries and the vein, the arteries are considerably longer than the vein around which they twine in a beautiful spiral manner, at the same time often forming frequent twists upon themselves; in some rare cases there is but one artery found. The trunks of the vessels are embedded in a viscid, semitransparent, gelatinous matter, and are all bound together by a tubular sheath of the amnion. The calibre of the vein is equal to that of both the arteries; and so great density slender vessels are always to be found in its intima. The cord is also supplied with lymphatics as was proved by the injections of Thomsen and Montgomery; and it is probable although not yet proved that it may possess nerves. I was informed by a friend who acted
as surgeon on board one of the whaling
vessels at Davis' Straits last summer,
that he had an opportunity of examin-
ing a foetal whale, and that he traced
veins as large as the phrenic, in
the foetal subject, running along
the cord, embedded in the gelatin.
When the vessels reach the placenta
they divide, sending off large trunks
in all directions, over it, the two
arteries generally forming a large
anastomosis before dividing.
The Placenta or after-birth, is an
organ of the most essential importance
in the foetal economy, since it is
the means of intercourse with the
mother; it makes its appearance
about the end of the second month,
and at that time covers most part
of the ovum, but at the time of birth
forms only one fourth. At first it is
formed by the adhesion of the shaggy
chorion to the internal surface of the
utero, the bloodvessels shortly after are
developed, and their minute ramifi-
cations, insert themselves into the vessels formed by the enlargement of the vessels at that part of the uterus.

On examining the human Placenta with the naked eye, we see a soft, spongy mass of dark red colour, measuring from seven to nine inches in diameter, and from one to two inches in thickness; it is of an irregular form and weighs about one pound. It has two surfaces, the maternal or surface, which is attached to the uterus, and the fetal or that next the child. The fetal surface is quite smooth, but strongly marked by the large, tortuous Bloodvessels; the maternal surface is rough, and divided by deep sulci into a great number of irregularly shaped lobules.

The two Umbilical arteries at their insertion into the internal surface of the placenta, passify and branching into its substance are minutely divided and distributed to the different lobes.
Formerly, it was believed that the blood
surface of the uterus and mother commun-
icated directly in the placenta. But from
the researches of the Moross, Kuntsen,
Wirsberg, and lately from those of
Professor Gooden and Reid, it is now
satisfactorily shown that they do not, but that
each branch of the artery is accompanied
by a branch of the vein, each divide,
in the same manner, and end in
what appears to be a rounded extremity
but which in reality is the end of the
artery and the commencement of the vein;
or, in the words of Dr. Reid's own words: "The
structure of the placenta is thus composed
of numerous trunk and branches,
each including an artery and an
accompanying vein, each one of which,
we believe, is closely invested in
prolongations of the inner coat of the
vascular system of the mother, or
at least in a membrane continuous
with it. If we adopt this view of
the structure of the placenta, the inner
coor of the vascular system of the
Another is prolonged over each individual tuft, so that when the blood of the mother flows into the placenta through the curling arteries of the uterus, it passes into a large space formed by the inner coat of the vascular system of the mother, which is interspersed in many thousands of different directions, by the placental tufts projecting into it like fringes, and pushing its thin wall before them in the form of sheaths, which closely envelope both the trunk and each individual branch composing these tufts. From this space, the maternal blood is returned by the utero-placental veins, without having been extravasated or without having left the own system of vessels. Into this space in the placenta containing the blood of the mother, the tufts of the placental cords like the bronchial vessels of certain aquatic animals, to which they have a marked analogy. This space is protected and strengthened on the foetal surface of the placenta.
by the chorion, on the uterine surface, by the decidua vera, and on the edge of the decidua reflexa.

With regard to the situation of the placenta, it may be stated as a general rule, that, it is usually situated opposite the extremity of one of the Fallopian tubes. Dr. Panglott has given the result of 660 cases, in which he used the stethoscope as a means of detecting the situation of the placenta. In 338 it was attached to the left side, in 221 to the right, in 7 to the fundus, in 13 to the anterior and in 11 over the os uteri, and in 180 it was weak or so diffused, as to be uncertain.
Now having given over all the anatomy of the circulation, I will take a general review of the circulation itself, embracing some of its physiological points. Since the digestive and respiratory systems of the foetus in utero are in abeyance, the first questions that naturally present themselves to us are: How is the foetus nourished, and how does it receive it?

First: How is the foetus nourished?

It is not as yet positively decided, how this is accomplished in the early months. Some believe it to be by the albuminous contents of the umbilical cord, this is certainly its very earliest source of nourishment, but a far more rational opinion is given by Professor Gooden, who says, "At the stage of its growth, the ovum with its external membrane, the chorion covered by tufts, is embedded in a substance which consists entirely of active, nucleated cells. The oblong cells of the tufts are constantly taking up either the matter resulting from..."
the solution of the cells of the cellular decidua, or the fluid contained in these cells. The ovum is now deriving its nourishment, not from the epithelium which it took along with it when it left the ovary, but from a matter supplied by the uterus. I am therefore inclined to look upon the cellular decidua as representing in the gestation of the marmal the albumen of the egg of the ovisfrone animal. They are both supplied by a certain portion of the oviduct, and they are both brought into play after the nourishment supplied by the ovary is exhausted, or in the course of being exhausted. The difference between them consists in this, that in the marmal the albumen is applied to use as quickly as it is absorbed; whereas, in the ovisfrone animal, after being absorbed, it is kept in reserve within the chorion until required.

In the latter months, two opinions are generally held as to how this is accomplished, some saying it is by the
May not a feral mammal be nourished by its own milk?
Sijun Amnio, other by the Placenta.
Those who hold the first suppose it to
be absorbed into the system by a variety
of ways, by the mouth, skin, mammae
vessels, etc. But this theory is opposed by
strong objections, viz.
1st. The Sijun Amnio is proportionally
diminished toward the latter months, as
the fetus requires more nourishment.
2nd. The often meets with cases where the
Sijun Amnio has been run off a week
or even more before labor has begun
without any bad results to the fetus.
3rd. It is contrary to the law of nature
that any animal can be nourished
by a portion of its own, the Sijun
Amnio being a portion of the fetus
membranes and not of the mother.
4th. The first malformations occurring
which would prevent the Sijun Amnio
passing into the fetus by these channels.
5th. From the chemical analysis of Sijun
Amnio by Dr. J. O. Tee. Little or no
nourishing matter is found in this
fluid.
The can then see no other channel by which the foetus can be nourished from the mother but by the placenta, and see a proof positive of this fact we find that in cases where the placenta is diseased to any great extent the nutrition of the foetus is seen to be affected. With regard to the kind of matter that is passed, physiologists are as yet unacquainted, but from various reasons and experiments, such as medicines given to the mother being detected in the foetus, we are led naturally to suppose that it is by the transudation of the blood plasma, and as the blood of the pregnant female has been shown by Hidemann and FERNEL to contain milk in very large in, that it is it which affords chief nourishment to the foetus. In the additional reason also, that when it is no longer required at the uterus, it appears in full quantity at, and continues to flow from the mammae.
How does it require? In the higher classes of animals ore it is impossible before birth that the function of respiration can be carried on in the same manner that it is exercised after that event and as the child at the same time have no direct intercourse with the mother, something is required which will perform the function of lungs, so long as it is retained in the foetal condition, and be of no inconvenience in after life; all this is found in the placenta where a function quite analogous to the respiration of fishes is carried on, their blood being supplied on exposure to the aerated water whilst passing through the gills, and that of the child undergo the same change by becoming exposed to the aerated blood of the mother whilst passing through the placenta. Before the child leaves the shelf its blood may be said to be directly in contact with the air, as the minute bloodvessels which
from its placenta are distributed upon the membrane lining the interior of the foetal shell; through this shell the various gases will pass with freedom, whilst the changes requisite for the life of the animal take place through the walls of its minute blood-vessels; the only difference being that in mammalia, their blood is changed by exposure to aerated blood, whilst that of the chick is changed by direct exposure to the air, and it is well known that if we warm the exterior of the shell, we stop the respiration and kill the animal. That it is the placenta which perform this function is evident from the following facts. First—The blood passing along the umbilical vein, upon a careful examination is seen to be of a redder hue than that in the arteries, or in other words, is more oxygenated. Second—If the cord be compressed while the child is in utero we find it dying, as sure are by strangulation.
Third - In cases of discussed placenta we also find the child dying not so much from want of nourishment as from want of respiration, and in proof of this Dr. Simpson has shown, that in these cases if by giving internal medicines we can rejuvenate the blood of the mother, to a higher degree, we may truly save the life of the child.

As before stated the manner in which the changes on the blood in the placenta was for a long time thought to be by direct connection with the vessels of the mother, but from the knowledge we now possess of the minute structure of the placenta, that idea has been put aside and the true and more rational one substituted, that it is only by continuity of the fetal and maternal vessels that these changes take place; and for these changes what they may, we are certain that the capillaries of the placenta being brought into close contact with the
Blood of the mother, transmit to it through their walls the venous
characteristics which they contain, and receive from it the requisites for
arterial blood; or in other words, the blood of the foetus becomes oxidised by being brought into
contact with the blood of the mother.
The blood then passes from the
placenta by the umbilical vein
to the foetus, and the first organ
it circulates through is the Liver.

Previous to birth the Liver is the
only decarbonising organ in the
system, the lungs being at that
time, inert, but as soon as the
latter come into play they deoxygenate
from the venous blood a large
proportion of the carbon with which
it is charged, and free blood is
transmitted to the Liver for that
purpose. (Carpenter) The circulation
through this organ takes place
exactly in the same manner as in
the adult, but all the blood brought
from the placenta does not circulate through the liver, about a fifth or sixth of the blood passes through the ductus venosus, generally into a small cavity formed by the junction of the two hepatic veins and from thence to the vena cava inferior. Why, the blood should only in part pass through the liver, and why there should be a communication between the umbilical vein and the vena cava inferior. According to the fact, I have never found clearly stated, on the contrary, all writers seem to show the question merely stating facts to be the fact but never regarding a why.

Some seek to explain it by saying, that the blood is sufficiently purified in the nourishment of the foetus by only part of its passing through the liver, this it must be confessed is a very true reason, but still it does not explain why nature should find the blood better suited to its purpose by being partly impure, than having
it all circulated through the liver and
from the impurities which we know
it contains, and which we find the
liver secreting from the blood even
before birth. I doubt much if even
we will be able to find out the true
reason of this arrangement, and in
the mean time we must rest contented
with the simple fact.

After the blood have passed through
the two great purifying organs, the
Placenta and Liver, and is mixed
with the impure blood returning
from the lower extremities, by the
Cena Cava inferior, it is received
into the right auricle of the Heart.
The Right Auricle of the Heart as
before mentioned is, comparatively
speaking, divided into two chambers
on Anterior and a Posterior, by the
Constriction. The anterior is the mus-
cular or contractile part, the posterior
has more of the characters of the wall
of an artery, and in all probability
serves the same purpose, none of
the foraminae, which convey blood from other parts of the body, enter the latter chamber; they all enter the anterior; the only opening into it are the Cava Cava inferior, the Foramen Ovalis, and the communication with the anterior. The blood enters this chamber by the Cava Cava inferior, passes through it and the Foramen Ovalis into the left auricle; by the contraction of this auricle it is propelled into the left ventricle; it cannot pass into the right auricle, as every time the left contracts the blood rushes upon the valve and shuts it completely, stopping all passage of blood from left to right; this valve being exactly the same as the self-acting valve of mechanics.

Upon the contraction of the left ventricle the blood is thrown into the branch of the arteria and its branches, which carry it to the hand and upper extremities, little or none at all passes into the descending aorta. As is shown from the experiments related in a former
part of this essay.

The peculiar arrangement of the bloodvessels of the foot, and the supply of fresh blood to the head and upper extremities, than to the other parts of the body, has generally been assigned as the reason of the great development of the superior parts over the inferior, but in this I am rather inclined to agree with Dr. Reid, who says, 'The supposition that the superior nutrition of the head and upper extremities over the lower, may be accounted for by the greater density of the blood sent to the upper parts of the body, does not appear, when stated in this general manner, to be borne out by facts. For example, both the suprarenal capillaries and kidneys are supplied by the blood that has already made the circulation of the upper parts of the body, and yet we find that the absolute size of the suprarenal capillaries, and the com-


in the fetus than in the adult; from the instance, one adduced, it would appear, that there is no necessity for having recourse to any arrangement of this kind, for regulating the growth of the different parts of the fetus, notwithstanding that its circulating fluids are less pure than after birth, and that the several methods augmenting the quantity of blood sent to the fetus when its nutrition is to be increased, which we find adopted after the animal is enabled to maintain an independent existence, can apparently answer the same purpose during fetal life; to this however the brain may be an exception; and it is probable that the peculiar arrangement of the circulation in the fetus may have a reference to the supply of that organ; it is perhaps necessary that an organ so delicate as the brain, whose functions at least in the adult are so easily disturbed by insufficiently oxygenated blood, should be supplied from a source source.
than that which the two can co-

urse, for though the brain is in

the fact, the state perhaps entirely

prospective, organs intended for an

independent existence, yet we must

suffer that its organization is from

the first adapted to its independent

state, and if this should be the case,

it is highly probable, that imperfectly

carbonated blood, which would be capable

of discharging its functions, would be

little favorable to its perfect develop-

ment. It may be that this answers

a similar purpose, though by differ-

ent means, to the arrangement of the

Hilusae, thus described in the crocodile,

the physiological condition of which

approaches somewhat to that of the

human factice, by which the brain

and extremities are supplied with the

best carbonated blood, while blood less

highly carbonated is circulated amongst

the viscera.

The blood is returned from the head and

upper extremities by the Vena Cava.
superior to the heart.
The Cava Cava superior enters the
right auricle at its upper and anterior
pontum, exactly opposite the right auriculo-
ventricular opening, also the blood
which is circulated through the
substance of the heart itself enters
the auricular chamber, and is then
mixed with that from the head and
upper extremities.
When the contraction of this auricle
takes place, the blood is forced into
the right ventricle; it is prevented
from re-passing into the Cava Cava
superior, as the blood in that vessel
is continually pressing onward to
the heart, nor can it force into the
junction chamber, this being already
quite full. If the blood in the junc-
tion chamber were at this time in
motion, part of that in the anterior
might be carried along into the left
auricle, but as both the auricles con-
tract at the same time, and the value
of the junction really acts simultaneouly
With the contraction, the blood in the Flexion Chamber at that time is not in motion, and therefore more liable to withstand the pressure without mixture.

To prevent a reflux of blood in the coronary vein, during the contraction of the annulus, it is also guarded by a self-acting valve.

Upon the contraction of the right ventricle the blood is thrown into the pulmonary artery, filling the two branches which go to the lungs, which are in the Vertebral state extremely small, and pushing through the Ductus Arteriosus, courses along the descending aorta.

From the descending aorta the various branches issue off the same as in the adult, and circulate blood through the various organs to which they go. At about the fourth lumbar vertebra the aorta divides into two equal parts, these again at about half an inch further on divide into two unequal parts; about one third of the blood,
is sent to the lower extremities for their nourishment, whilst the remaining two-thirds flow to the placenta, thus to be rendered fit for another circulation. The small quantity, after having circulated through the lower extremities, is received into the Cava Cava Inferior and mixed with that returning from the placenta, before it reaches the heart.

In the mature fœtus the blood does not circulate as exactly as I have described it here to do, but at an earlier period, there is reason to believe it does; in fact the Cava Cava inferior enters directly into the left auricle itself, and therefore the blood must flow to the head and upper extremities before the lower.

Gradually as the fœtus approaches maturity, at first the Cava Cava inferior flows through the left auricle, but soon the blood from it begins to mix with that from the Cava Cava superior, and at the same time the fœtus of the veins together with the other peculiarities
If the heart begin to change, and in this
measures prepare for the important change
which are soon to take place.

It is during the period arrives when the
body has reached that degree of de-
velopment which enabled it to exercise
its functions in a new sphere of existence;
and both takes place accompany-
ied with its various changes.
The design of all the peculiarities in
the circulation of the fœtus are however
to be, to compensate for the want of
respiration and to distribute the purified
blood more abundantly to some organs
than others. Immediately after, or
it may be during birth the child usually
makes a deep bend giving inspiration
and very soon thereafter all the pecu-
larities are done away.
Various opinions have been given as to
why the Child should breathe, immedi-
ately
on being born, Sweers conjectured that
the pleura was filled with an aqueous sapm
which became condensed when the child
was born.  Bastetoth believed it to be de-
pendent on the removal of external pressure,
and in his essay on Vital Motions, says
that the child is born with a natural
appetite for air, so far hunger and thirst,
naive believing that that child was now
nursed.  Over the Leiden, Ammon, attributed
it to the habit of swallowing which it
had acquired in the uterus.  Now it
is generally explained by reflex action.
By the painful impressions made on the
tender skin, efforts are made by the
child, which cause inspiration and end
in crying by which means the lungs are
inflated.  Marshall Hall is of
opinion that the first joint of nerves are
the principal agents in bringing the
first inspiration, and mentions a case
where the first inspiration was delayed,
because the child's face was protected
from the atmosphere by the bed clothes
being over it; but I think this was
only a case when the child could not get breath, because he mentions that it breathed immediately when the clothes were removed. No doubt the fifth joint of nerves may assist, but it is a well-known fact that a splash on the vertex often gives a great deal towards causing the first inspiration; and I have again and again noticed, in the Maternity Hospital, that the child always struggles and cries most when it is placed on its back in the cold iron scales, for the purpose of being weighed, showing that it does not depend upon the fifth joint of nerves more than the general surface of the body.

The capillary terminations of the pulmonary artery, which arteries were compressed by the collapsed state of the lung, are by the expansion of this organ rendered freer, and as it were a vacuum is formed. It is now evident that the blood, which passed formerly through the ductus arteriosus, is irresistibly drawn into the lungs, through the two pulmonary
Branches of the pulmonary artery, and that these must dilate to receive the extra tide, while on the other hand, the ductus arteriosus, adherent to the bow that obtains in all such cases, must shrink and become imperceptible, which generally takes place about the third or fourth day, and at least is converted into a fibrous elastic band extending between the pulmonary artery at its bifurcation, and the aorta, at a little to the left of the centre of the concavity of its arch.

When the blood returning from the lungs enters the left auricle, the valve of the foramen ovale is floated up and closed. The foramen, being left in this position as the face from the pulmonary vein is now stronger and more direct than that from the aorta comi inferior, until adhesion of the valve to the sides of the foramen takes place, which is generally about the fourth or fifth day.

As the passage of blood along the umbilical vein and arteries is stopped...
at birth, these pupils about the second or third day become closed, and remain throughout, only a strong film over it. The Septic Cerosee also about the third day becomes closed, so that all the blood sought to the liver by the Portal Vein now passes through it. These then are the principal changes which take place at birth: during the first few moments the child has been in the world, a change so magic like, so sudden, so complete, has taken place that after we have examined and comprehended what has been done and how it has been done, we are quite astonished at the facility with which it has been effected; the heart is no longer the single heart of the foetus, but the double heart of the receiving child, all the temporary peculiarities are changed and the permanent arrangement fairly established.
Various circumstances occasionally happen which prevent the changes which I have been described, taking place, and which for the most part bile the child immediately, when born or very soon afterward. These circumstances almost always depend upon some abnormal structure of the heart and great vessels arising from it, a few of which I will give a short description of.

The chief of these is the Acardine Junction, a junction without a heart; this is of very rare occurrence and generally found in Australia; in this condition the veins have no connection with the arteries, except by the capillaries. The veins are wholly destitute of valves and in them the current of blood is reversed, as they carry the pure blood brought from the placenta to all parts of the body, whilst the arteries, taking upon themselves the office of veins, return it. Acardine Junctions have almost invariably a connection with another perfect one, and the blood vessels of the two are united; or such a con

[Continued on the next page]
To this general law, the movement of the blood has generally been attributed to the force in the capillary vessels to supply the place of the heart, up to the period of birth, after which the circulation must stop for want of a due oxidation of the blood; but it is still probable that in the absence of the heart, some parts of the larger vessels may be endowed with a peculiar degree of contractility. In most of the lower animals, where a distinct heart is wanting, the vessels or some parts of them contract systematically, and in a few of the simpler animals where contractility has not been observed, dilating action or external compression appears to be the most probable cause of the progressive motion of the nutritive fluids.

In a case of this kind, the fetus "in utero" may grow and thrive as well as any other, but once born, as the connection with the mother is stopped, the child must die, as the blood circu-
no direct propelling force to force it to the lungs, thus to undergo the necessary changes for animal life.

The most abnormal condition is the complete obliteration or partial closure of the Pulmonary artery. This is amongst the most serious disorders of the Fetal Heart. A feature in this condition, as in the former case, may attain its proper size and look quite healthy so long as it is connected with the mother, all the blood passing through the foramen ovale to the left side of the heart, and from there by the Aorta to the different parts of the body, but as soon as this condition is ended or when the child is born, if there be complete obliteration of the Pulmonary artery, so that no blood is forced to the lungs, the child immediately turns black in the face, and after a few convulsive struggles, dies; but if the Pulmonary artery allows a small portion of the blood to force to the lungs, the child may struggle
on for a few days, but as it is impossible for a child to live without a due oxidation of its blood, and as the pulmonary artery does not admit of sufficient quantity to the lungs, the child dies after a few days of extreme suffering, generally labouring all the time under increasing conditions; the blood on rather blue colour before mentioned soon leaving the body, but always getting worse.

Another, although rather uncommon abnormality, is when the lecitoa arrives from both ventricles; but only one half of the blood which ought to be sent to the lungs, from the right ventricle, goes in that direction, the other half always making its escape by this false opening into the lecitoa; besides this, the lecitoa arrives from both ventricles it must necessarily en-croach upon the opening of the pulmonary artery, and thereby lessen its diameter, so that this also prevents the necessary supply of blood being sent to the lungs.
As case of this kind at birth, as in the former cases, exhibits all the symptoms of an undue circulation of the blood, while the child may live and struggle on through infancy and its attendant diseases, but kind experience has taught me, that it is vain to hope for a mitigation of its sufferings, and that the child must sooner or later fall a victim to this disease.

Another rather curious case of abnormality in the foetus, came under my own observation lately.

Having professed a foetus, which seemed to be about the ninth month, and which on external examination, presented nothing peculiar with regard to form, colour, &c., I had it injected by the umbilical veins. On examining the chest, I found the following arrangement of its blood-vessels. The ascending aorta is small, passes straight up, and after a course of about three-quarters of an inch, terminates in three branches of equal size, which are the right
Subclavian, and the right and left common carotid arteries. The Pulmonary artery is very large, measuring about half an inch in diameter, being nearly twice that of the ascending aorta, the diameter of which is one quarter of an inch. After a course of half an inch, the Pulmonary artery gives off the branches which go to the lungs, these arising from its back part and almost by a common trunk. A quarter of an inch further on, the Pulmonary artery (or ductus arteriosus) gives off from its anterior and left side the Left Subclavian. The pulmonary artery, without diminished in size, now contracts rapidly to half its former size, and is continued on as the descending aorta. There is thus no communication between the ascending and descending aorta. The right and left subclavian arteries offer of equal diameter. The vena cava and pulmonary vena are normal as to course and size.
On opening the ventricles, they are seen to communicate by a large aperture, arising from a deficiency in the left ventricular root at its upper part. The right ventricle is twice the size of the left, though its walls are at least not thicker than those of the latter. The pulmonary artery arises normally from the upper and anterior part of the right ventricle. The aorta arises exactly above the communication between the two ventricles, its mouth being equally visible from either cavity. The aperture of communication is of a rounded form, measuring one-third of an inch in diameter, bounded below and on each side by a smooth thick edge, and above by the opening of the aorta. The semilunar valves of the aorta and pulmonary artery are well-developed and normal. The tricuspid orifice is three times the size of the mitral orifice. The right auricle appears to be dilated, whilst the left is about one-third the size of the right, and a little larger.
these its corresponding ventricles. The Foramen Ovale is normal, and its value is fully formed; but the free edge remaining between the upper end of the Foramen and the free border of the valve, appears to be considerably smaller than that which is usually seen in the full grown subject.

As far as I am aware, no case has yet been recorded in which the above remarkable abnormalities were combined. In the third volume of the "Library of Medicine," article "Malformation of the Heart," reference is made to two cases somewhat analogous. In the one related by Sir C. Darwin, the pulmonary artery arose from both ventricles and furnished the descending aorta, the ascending aorta originating normally. In this second, related by Mr. Peachcat, the left subclavian arose directly from the pulmonary artery, in the above case. Moreover, both of these conditions are combined. And the malformation has been confined to the bloodvessels alone,
Interesting inferences might have been drawn with regard to the fetal circulation. There was no communication between the ascending and descending aorta, and this corresponds to the views commonly entertained, that the finer blood of the ascending aorta is distributed by the vessels which arise from the aorta, whilst the descending aorta is filled with the less fine blood from the pulmonary artery. Again, it will be observed that the two superior extremities were supplied with blood from different sources, which in the normal state of the heart, would have been of different qualities, whilst in no perfect was there any difference in degree of development between the superior extremities. The additional complication, however, of such a large aperture between the ventricles, must have established complete admixture of the blood of the two sides of the heart, before it was sent into the aorta and pulmonary artery, so that, independent of subsequent
Abnormalities of the vessels, all parts of the body would be supplied with blood of the same quality.
These are the principal, although by some means all the abnormalities which have been noticed by writers on this subject, but I will refrain from entering upon any of these, as they are in general modifications of those I have described.
This slight account of the abnormalities of the heart and vessels, brings to a close my sketches of the cutaneous circulation.

If I have given a plain and correct description of my subject, I have succeeded in all I attempted; but if on the contrary I have been unsuitable anatomist, I have cut through skin and all, you must pardon a rude hand and an unsuitable knife, knowing that the best way sometimes is—

Aliquando bona dormit at Homerus.