

**On the circulation of the blood in acardiac foetuses, (with a wood-cut),
being a reply to a paper by Dr. Marshall Hall on this subject / by John
Houston, M.D.**

Contributors

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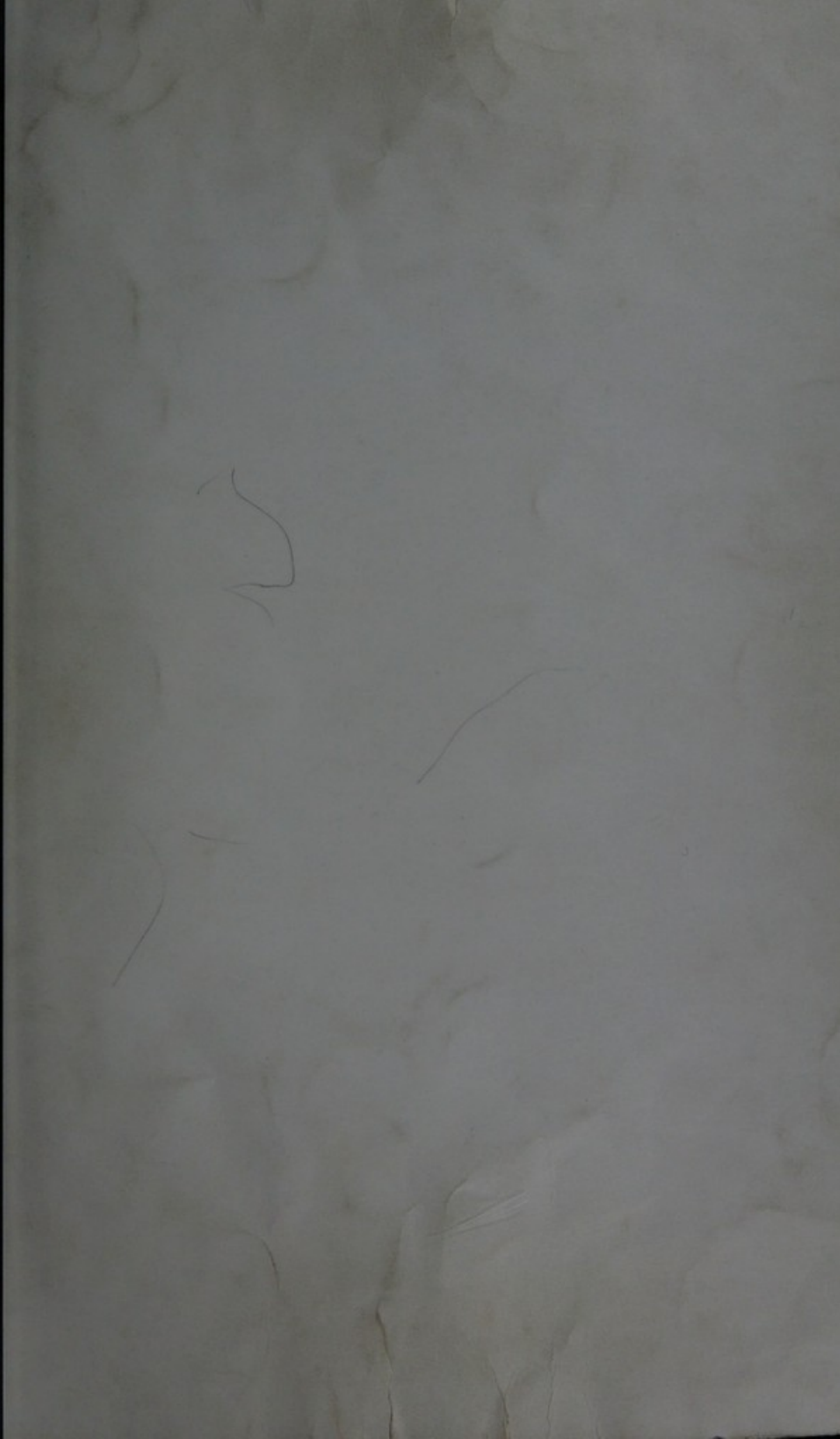
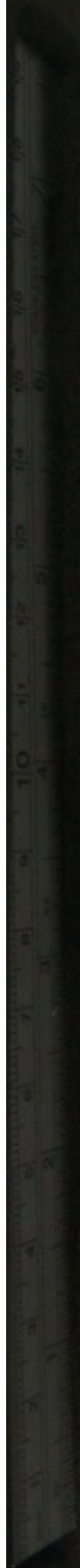
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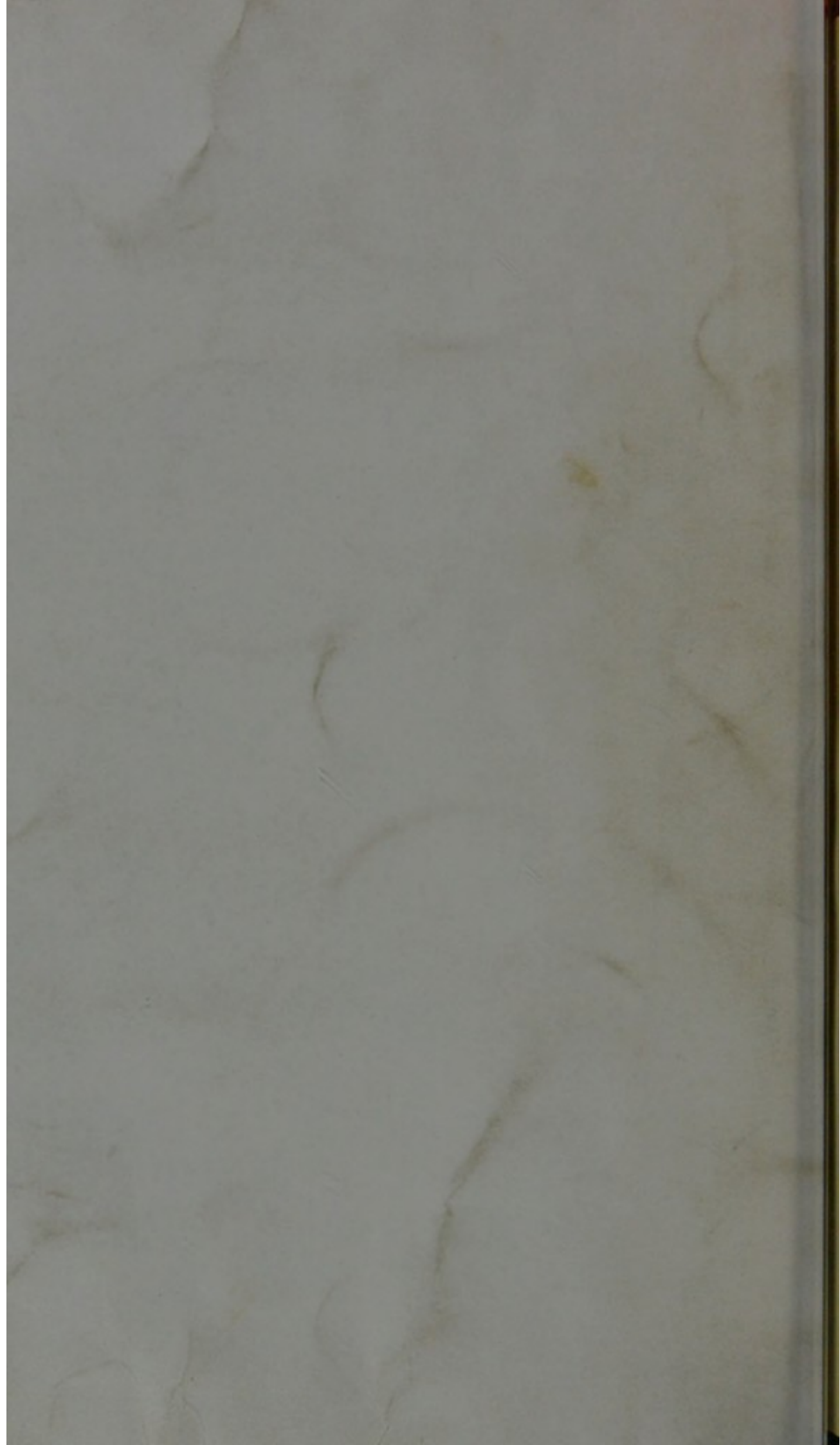
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*To Mr Hughes President of the
with Dr ON Anatomy
complement & kind regards*

THE CIRCULATION OF THE BLOOD

IN

ACARDIAC FOETUSES,

(WITH A WOOD-CUT),

BEING A REPLY TO A PAPER BY DR. MARSHALL HALL ON THIS SUBJECT.

BY

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honour of receiving my original statement on this head, I presume that I may calculate on a similar favour, now, that a defence of that statement has become necessary.

Dr. Marshall Hall's reasons for taking up the argument after such a long interval, may be best learned from his own words. "It is well known," he says, "that the late Dr. Young first suggested the most ingenious idea, that the circulation in the acardiac foetus is effected by the power and agency of the heart of the perfect foetus, by which the acardiac foetus is uniformly accompanied; that the late Sir Astley Cooper supposed that he had demonstrated this fact by his injection and dissection of the vascular system of the placenta or placentæ of the perfect and imperfect foetus in such cases; and that Dr. Houston of Dublin has called in question both the original views of Dr. Young and the *mode* of this circulation suggested by Sir Astley Cooper.

"My attention has been drawn to this subject by the recent able works of Dr. Carpenter and Dr. Graves. These gentlemen are of opinion that the views of Dr. Young and Sir Astley Cooper, regarding the circulation in the acardiac foetus, are erroneous, and they revert to the notion of Dr. Houston that the circulation is accomplished by the agency of the capillary vessels."

I may be permitted here to state, that Dr. Marshall Hall has been always a warm supporter of the theory, that in every instance "the heart affords the propelling force which circulates the blood through the capillary vessels," and very naturally combats any argument which would appear to militate against his long-cherished opinion: whereas, regarding myself, I did not, at the time of my original communication on this subject, nor do I, now, seek to make myself the champion of any theory. I merely reported at the time the inferences which I considered deducible from the dissection I had made; and I must state that even now, the "opinions advanced" by Dr. M.

Hall, "for they are nothing more," have not wrought any change in mine on the subject.

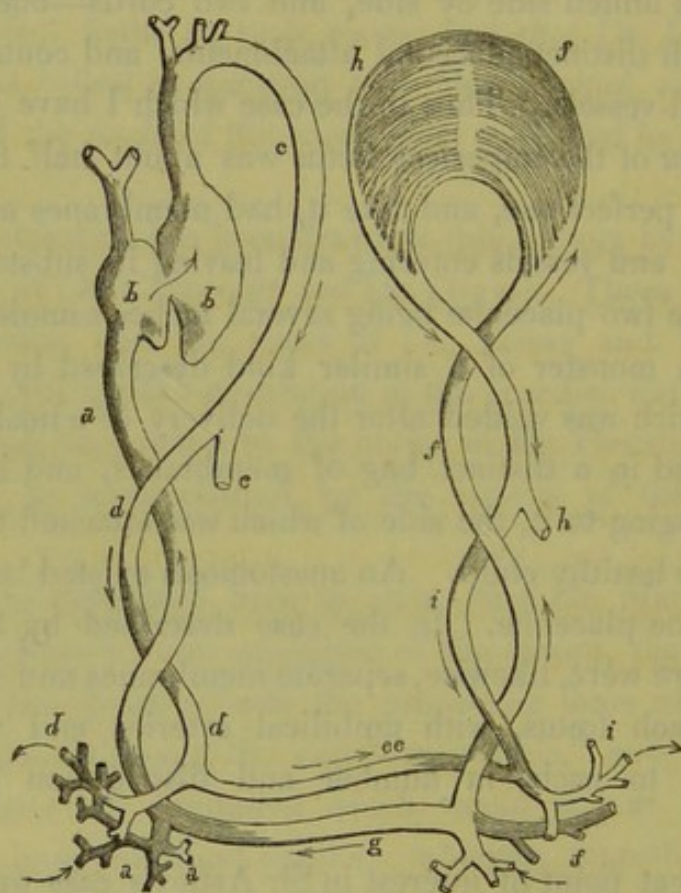
To make the matter at once intelligible, it will be right for me to state, that almost all the acardiac fœtuses hitherto described have been of twin birth, one of the infants being furnished with a heart. I say almost all; because Dr. M. Hall in his critique asks, has there ever been an exception to this rule? Two or three such have been recorded by Blandin, but if Dr. Hall chooses to take exception to their genuineness, I will not press the point, as it makes little part of my argument. In all these twin births there have been two placentæ, with two sets of membranes united side by side, and two cords—one for each fœtus—with distinct placental attachments, and containing the usual blood-vessels. Thus in the case which I have described, the placenta of the imperfect fœtus was about half the size of that of the perfect one, and like it, had membranes attached to its surface, and vessels entering and leaving its substance,—the cords of the two placentæ being several inches asunder.

A twin monster of a similar kind described by Dr. John Clarke, which was voided after the delivery of a healthy child, was enclosed in a distinct bag of membranes, and had a placenta belonging to it, the side of which was attached to the placenta of the healthy child. An anastomosis existed between the vessels of the placentæ. In the case described by Sir Astley Cooper there were, likewise, separate membranes and a separate funis for each fœtus, with umbilical arteries and veins corresponding to each, in number and distribution nearly as usual.

The great point of interest in Sir Astley's case was the discovery and demonstration by injection of the actual vessels by which the anastomoses between the cords of the two fœtuses had been carried on, and which, although known to exist, had not been fully made out by preceding experimenters. These anastomoses were both arterial and venous,—large branches of

the umbilical arteries of the perfect foetus running to join the umbilical artery in the chord of the imperfect foetus, and a still larger branch of the umbilical vein of the imperfect foetus uniting by open mouth with the umbilical vein in the chord of the perfect one, in such a manner that the blood of the two foetuses must have been capable of freely passing from the one foetus to the other, according as the determining influences in the one or the other might preponderate.

The annexed diagram I have sketched to convey an idea of the arrangement of the blood-vessels, and the course of the blood, in twin-foetuses of this kind.



- a. a. a.* The umbilical vein of the perfect foetus arising from its placenta, and running up to the heart.
- b. b.* The heart, represented as consisting of but a single auricle and ventricle, such as is, naturally, somewhat the condition of the organ at this period of life.

- c. c.* The thoracic aorta which may be looked upon, in the diagram, as having received the blood conveyed to it by both the aorta and pulmonary artery, from the foramen ovale and ductus arteriosus.
- d. d. d.* The umbilical artery arising from the aorta, and after a spiral course round the vein, dividing at the placenta into two branches,—one large, to be distributed in that organ, the other smaller, viz. :
- e. e.* The branch sent to anastomose with the umbilical artery of the acardiac foetus near the point of its entrance into the corresponding placenta.
- f. f. f.* The umbilical vein of the imperfect foetus arising from its placenta and running thence, to be distributed through all parts of its *acardiac* body, in capillaries, which are represented as being continuous with those constituting the origin of the aorta.
- g.* The branch of anastomosis between the umbilical vein of the imperfect and that of the perfect foetus, near the placentæ.
- h. h.* The aorta, represented as arising from the capillary terminations of the umbilical vein in the body of the acardiac foetus (see p. 351), and giving off, as in the other infant.
- i. i.* The umbilical artery, which after being joined by the branch (*e*) from the umbilical artery of the perfect foetus, terminates with it, in the ordinary manner, in the placenta of the acardiac foetus.

Now, it has been on this discovery of a vascular anastomosis between the vessels in the placentæ that Dr. M. Hall founds his theory of the influence of the heart of the remote foetus in conducting the circulation in its acardiac companion, and it is to this point in particular that I wish to address my observations.

Dr. M. Hall concurs with me in rejecting the explanation offered by Sir Astley Cooper, to the effect that the blood is propelled along the anastomosing branch of the umbilical artery directly to the imperfect foetus, because that would be contrary

to the ordinary course of the current in the arteries of that fœtus, and would involve an inversion of the circulation in the placenta. But, still wishing to retain for the heart the character of being the moving agent, he adopts another view of the course in which its energies may be supposed to be directed. He supposes that the stream of blood propelled by the heart through the anastomosing branch discovered by Sir Astley Cooper, meeting that coming along the umbilical artery of the acardiac fœtus, carries with it that languid stream by what he terms "a lateral action," forcing it, by the greater velocity of its current, into the capillaries of the placenta, and thence, again, still farther, through the umbilical vein into the body of the monster.*

No objection need be taken to Dr. M. Hall's theory, so far as the simple act of assisting to propel the blood into the placenta goes, farther than its insufficiency, of itself, to that end. But, beyond this point, the influence of even this moiety of the

* The following is Dr. Marshall Hall's description of this indirect "lateral action" of the heart of the perfect fœtus on the circulation in its acardiac twin companion :—

"There may appear to be some difficulty in conceiving how an anastomosis between the umbilical artery of the perfect fœtus with that of the imperfect one, can exist without arresting or impeding the flow of blood towards the placenta in the latter. The fact is to be explained, I believe, on the principle of *lateral action*. As a stream of air or of water, passing by other air or water, carries with it the adjacent particles of the latter; and as a stream of air or water passing rapidly along one tube immediately by the orifice of another tube containing a similar fluid, either at rest, or flowing with less rapidity in the same direction, draws the fluid from the latter; so the blood propelled with energy along the umbilical artery of the perfect fœtus immediately by a branch anastomosing with that of the imperfect one, will draw by lateral action, the blood contained in the latter into its own more rapid current. The blood in the artery of the imperfect fœtus [see diagram, i. i.] is thus drawn by the blood propelled in that of the perfect fœtus [d. d. e. e.] *towards and into the placenta*. This effect will also be proportionate to the greater velocity of the blood propelled by the heart of the perfect fœtus. Thus, then, in reality, and on two different principles, the blood is propelled to, and attracted from, the imperfect fœtus, by the power and action of the heart of the perfect one, and along the customary channels."

heart's power must cease to be directed in a manner calculated to complete the circulation in the imperfect fœtus, as suggested by Dr. Hall; for the blood-vessels of the latter come now to be out of the direct line of its influence. I wish here to observe, that my objection is not taken to the capability of the action of the heart of one of the fœtuses for driving the blood through the remote body of the other and back again,—for I do not consider that distance alone from the central force would nullify its influence in this respect, so long as the line of continuity of the tubes remains uninterrupted. The circulation in fish, in which there is only a pulmonary heart, and in which the blood goes the round of both the gills and the body from the same central impulse, is easy of comprehension on such a principle; and on this head, I am prepared to receive Dr. M. Hall's experiment on the vessels of the fin of the eel as conclusive. The circulation in the vena portæ, which many consider out of the reach of the heart's stroke, may, likewise, I admit, on the arrangement which I have stated, be promoted by such an influence. The line of the stream from trunks to capillaries, from capillaries to trunks again, and again from trunks to capillaries, and so on, goes round in succession, but it is in one unbroken series, until, arriving at length at the heart, the whole is received into the patulous, non-resisting chambers of that organ. In all these I can concur, even on pure hydraulic principles, but I am obliged to withhold my assent from the application of the same law to the case of the acardiac twin fœtus now before us; for, here, the line of vascular continuity is broken in the placenta, by the introduction of a new, diverting force, such as does not exist to interfere with the straightforward progress of the blood in either of the other instances.

It appears to have escaped the consideration of Dr. Hall that the artery of communication from the perfect fœtus, on which he lays so much stress, as being capable of propelling by "lateral action" the blood of the imperfect fœtus into its placenta, is accompanied by a corresponding vein of even more than propor-

tionate size, which, equally, on the same "principle of lateral action," must bring that blood back again in the same direction. The suction power of the heart,* no matter how feeble it be, will attract to itself the blood received into the capillaries of any veins within the range of its influence, rather than permit it to flow off in a new direction for the development and growth of another and distinct being, more especially if the blood-vessels of that being be not, as Dr. Hall's hypothesis teaches, endowed with any innate power of attraction for that fluid. The perfect foetus would thus, by its heart, take to itself, back again, all the disposable blood within its reach, and thereby become the instrument of depriving its acardiac twin companion of its supply, rather than of adding to its store.

The existence of this great vein, in such a situation, is fatal to Dr. Hall's theory. If it were not present then, indeed, there would be no other course for the blood arising out of the placenta, but that along the umbilical vein of the cord into the

* The following extract from Dr. Bayly's admirable Translation of Müller's Physiology, vol. i. p. 245, second edition, may serve as an illustration of what may, for want of a better name, be termed "the suction power" of the heart.

"During the dilatation of the auricles the distention of the veins diminishes. This was observed by Magendie and Wedemeyer, and I have myself witnessed it in the dog. A knowledge of this fact is necessary in forming an opinion on the following experiments:—Wedemeyer and Guenther, having tied the jugular vein in a horse, made an opening into it between the ligature and the heart, and introduced a catheter, to which a bent glass tube had been cemented. The longer descending branch of the tube (two feet in length) was placed in a glass filled with water. At first the inspirations and the contractions of the heart were nearly simultaneous and of the same frequency,—namely, thirty in a minute,—and the coloured water rose suddenly two or more inches in the tube at the moment of each inspiration and pulsation of the heart, and sank again each time to its former level. The inspirations gradually became twice as frequent as the pulsations of the heart; and Wedemeyer and Guenther now observed for a long period, that the rise of the fluid did not take place at each inspiration, but at every beat of the heart, and consequently simultaneously with each dilatation of the auricle. This experiment seems to prove beyond a doubt that the heart exerts a power of suction."

body of the acardiac fœtus, and the circulation would be, in such event, analogous to that in the vena portæ, or in the blood-vessels of the fin of the eel; but, whilst there, it must, on the hydraulic principles laid down by Dr. Hall, perform a function setting at nought the power of the distant heart over the blood circulating in the branches of the umbilical vein in the body of the acardiac fœtus. In fact, the existence of the circulation in this acardiac twin, in spite of such a drawback upon its fulfilment, appears suited more as an argument in favour of my theory of independent vascular action, than of that of Dr. Hall, which attributes the whole, *exclusively*, to remote cardiac influence.

Now, I wish it to be understood that this argument is founded on the supposition that the anastomosing branch, from the umbilical artery of the perfect fœtus, joins the *trunk* of that of the imperfect one *before* its subdivision into the branches which ramify in the lesser placenta, as the most favourable condition for the fulfilment of the circulation by the influence of the heart of the remote fœtus; for, if that anastomosing branch joined only one of its minor subdivisions (and it was against the possibility of the successful exertion of the remote heart on the circulation in the monster under the latter circumstances that I argued in my former communication, when I spoke of the improbability of its “driving the fractional surplus of its blood, with all the rest belonging to the placenta of the monster, not only into that monster, but out of it again”), I say, under such an arrangement, the probability that so important a function as that of supplying with blood the entire body of a human fœtus in the manner suggested by Dr. Hall would be infinitely lessened.

Dr. Hall's description of the manner in which he supposes that the heart of the perfect fœtus carries the blood through the anastomosing branch of the umbilical artery, and propels with it, “on the principle of lateral action,” the whole of the blood of the imperfect fœtus into the placenta, may, in his own clear

words,* be equally applied to its influence on that in the anastomosing branch of the vein. Let us see how his theory will then come out, substituting the word *vein* for *artery*, and tracing the blood *out of* the placenta of the abnormal foetus, instead of *into* that organ, as followed by him. "As a stream of air or water passing by other air or water carries with it the adjacent particles of the latter, and as a stream of air or water passing rapidly along one tube immediately by the orifice of another tube containing a similar fluid either at rest or flowing with less rapidity in the same direction, draws the fluid from the latter; so, the blood drawn with energy along the umbilical vein of the perfect foetus (see diagram, *a. a.*), immediately by a branch anastomosing with that of the imperfect one (*g.*) will draw by "lateral action" the blood contained in the latter, into its own more rapid current. The blood in the vein of the imperfect placenta (*f. f.*) is thus drawn by the blood attracted in that of the perfect foetus (*a. a.*) towards and into the heart. This effect will also be proportionate to the greater velocity of the blood attracted by the heart of the perfect foetus. Thus, then, in reality, and on two different principles, the blood of the placenta of the imperfect foetus will be attracted to the perfect foetus by the power and action of its heart and along the customary channels."

Now, this view of the case cannot be objected to even by Dr. Hall himself, for if the circulation be conducted on mechanical principles, the same laws which regulate it in one stage of its progress, as interpreted by him, must be equally applicable to it in another. Nor, perhaps, could a better exemplification be given of the insufficiency of pure hydraulics to the explanation of the phenomena of the circulation than the predicament in which such a line of argument places the question before us. For, if such were the rule here, the passive acardiac foetus would be absolutely drained of every drop of its blood by the

* See foot-note, p. 342.

mechanical power and action of the heart of its more highly favoured companion *in utero*.

As bearing out his views on this subject, by proving "that the action of the heart of one foetus does sometimes extend to the umbilical cord of a second foetus," Dr. Hall quotes a case from Lallemand of a *pulsating* hæmorrhage from the placental end of the cord of the first born of twin foetuses before the birth of the second. I may add, before commenting on this occurrence, that such instances are so far from being unusual, that the common practice of tying the placental end of the cord has been adopted, I believe, in anticipation of the possibility of hæmorrhage, should the birth turn out to be one of twins. Be this, however, as it may, I consider that this and similar cases, instead of confirming Dr. Hall's theory, rather weaken its foundation; inasmuch as the occasional occurrence of such anastomoses in natural twin cases—cases in which the foetuses, with their respective cords, placentæ, and hearts, attain full perfection, shows such communication between the vessels to be, of itself, a matter of very little moment, either one way or the other; and takes away half the argument for the supposed all-important value of the anastomosis in acardiac foetuses, by demonstrating its presence in cases where no such use for it can be supposed to exist.

Considerations such as these occurred to me when this very mode of accounting for the circulation suggested itself to my mind at the time of writing my former essay, and refuting the somewhat similar theory of Sir Astley Cooper on the subject. They are the same which led me to say, that "it must therefore appear evident that the *vis a tergo* imparted by the heart of the perfect twin cannot be the *sole* moving cause of the circulation in its abnormal companion;" and in another place, that "in thus questioning the power of the heart as being solely instrumental in accomplishing the transmission of the fluids through the body of the foetus, I am not prepared with any new expla-

nation likely to account for the phenomenon. The theory of 'vital attractions and repulsions,' although conveyed in terms which may be considered more as expressive of the facts, than as explanatory of them, appears to me to approximate more nearly to the true one than any which has been yet broached." Such were my conclusions formerly: they were more *negative* as to the heart, than *positive* as to the blood-vessels, and as such I must still leave them,—unweakened, I believe, by any arguments or facts adduced by Dr. Marshall Hall.

To a call on the part of Dr. M. Hall for "farther evidence" of acardiac circulation in "lower animals," I may reply that the currents of red blood in the arteries and veins of certain worms, such as the leech, earthworm, &c., in which they can even be seen with the naked eye; the well-arranged vascular apparatus of both the larva and perfect insect of certain neuropteræ, as the dragon fly; the almost equally simple arrangement of the arteries and veins of the arachnidæ; the fluid-conducting tubes of the diplozoon paradoxum; and, I may add, the perfect circulating systems of plants,—all carried on in the most systematic and efficient manner, without assistance from any heart-like agency whatsoever, afford examples of innate vital powers in the circulating vessels, disproving the accuracy of the assertion of Dr. Hall, "that we are destitute of all proof that these vessels themselves have any such power."

Moreover, phenomena present themselves daily to our view in the course of both physiological and pathological investigations, leading to the same conclusions.

The blood deserts the umbilical cord of the foetus as soon as the connexion between the placenta and the womb ceases, not because the heart of the foetus beats with less force after birth than before, for the contrary is the fact, and not because the heart's impulse in the direction of the lower part of the body is lessened, since the blood is well supplied to the inferior extremities: so little indeed of a mechanical nature is there in this

phenomenon, that if the cord be left untied and undivided for a little time after the separation of the placenta from the womb, the flow of the blood will become slower by degrees, and cease altogether in the end, and that even before the function of respiration has been established. The absence of hæmorrhage from the vessels of the umbilical cord in animals, which by instinct know this connecting link across on the instant of the birth of their offspring, is a beautiful illustration of this point.

When a large branch of an artery happens to be wounded near the point of its origin from another branch of equal magnitude, a portion of the blood still continues to flow into that which has escaped injury, and to be conveyed into the capillaries, beyond the seat of the wound,—a salutary phenomenon, due obviously, in part, at least, to the existence of a vital attraction between the remote part and the blood, and not exclusively to the force of the heart, the effect of which, under these circumstances, would be, on pure mechanical principles, to drive all the blood out of the wound thus made, rather than to propel it onwards through the limb, against the numerous collateral mechanical and vital resistances to which it must necessarily be there subjected. And, on the same principle, the application of a ligature on the main artery of a limb,—say on the femoral, for the cure of an aneurism of the popliteal artery,—instead of stopping the supply of blood by cutting off the direct influence of the heart, is followed by an unwonted and vigorous effort on the part of the capillaries to attract sufficient blood into the member to carry out the purposes of life and nutrition, as is evidenced by that feeling of tension and glow of heat, sufficient in many instances to call for artificial cooling to suppress it, which almost invariably, after a longer or shorter interval, develops itself.

As an illustration of a similar principle in operation even in the vegetable kingdom, may be mentioned the fact, that after the cutting off of a branch of a tree, the part projecting beyond

the last branch furnished by it dies and shrivels up, exhibiting a spontaneous arrest of circulation beyond the point where the attraction of vitality had ceased to invite the fluids.

But of all the illustrations of this matter, that of the sudden cessation of the circulation in the blood-vessels of the feet in mortification, while the vessels of the part continued free from coagula of blood or other mechanical obstruction, mentioned in my former essay, appears to me among the most conclusive.

The filling of the vessels of the cheek in the act of blushing, the enlargement of those of the uterus during pregnancy, and of those of the horns of the stag in their season of growth, are all likewise familiar illustrations of the powers possessed by the blood-vessels, in modifying, if not in conducting, an almost independent action of circulation.

The state of a part, in regard of temperature, influences too very considerably the degree of plenitude of the blood-vessels. When the hand is cold its blood-vessels are empty, and their pulsations feeble; but on exposure to heat these conditions undergo a complete change; the vessels fill up, and the pulse beats strongly, and that without receiving any new or additional impetus from the heart.

If the force of the heart alone drove the blood into those erectile and other tumours which bleed so profusely when touched or injured, one should be obliged to apply numerous ligatures after removing them with the knife; and yet every surgeon knows that, if the incisions be made in the sound parts at a little distance, the use even of the ordinary means of stopping the blood is scarcely called for.

And, lastly, I may allude to recent experiments and investigations on the subject of asphyxia from inhalation of noxious and poisonous gases, which have proved beyond all doubt that it is in a deranged action of the capillary vessels of the lungs that obstruction to the circulation in these cases commences,—an obstruction which the whole force of the heart is unable to over-

come, and which only gives way when the capillaries have been restored to their natural condition.

Dr. Hall marvels at my not being able to account for the phenomena of the placental soufflet in connexion with the circulation of the blood in that organ, and gives an extract from Barth and Roger explanatory of its nature,—making use of the circumstance, at the same time, as an argument against the general accuracy of my conclusions. To all this I need only say that there has long been much uncertainty regarding the cause of the placental soufflet, and that the work containing the extract alluded to was not written at the time of the publication of my essay.

Another point in my essay, from which Dr. M. Hall finds occasion for dissent, is one having reference to the *course* of the blood in the vessels of the acardiac foetus; and here I would observe *in limine*, and it is not a little strange, that his own theory on this head is not—what he supposes it to be—different from mine. He objects to my position that “the circulation in the vessels of the foetus is inverted,” viz. that the blood enters the body, and is distributed through its several parts by the umbilical vein and its branches, to be brought back again, therefrom, by the aorta, the origins of which are derived directly by inosculation from the capillary terminations of that vein, and yet he says that “the blood passes through the capillaries of the placenta into the umbilical vein, and through the umbilical vein and a series of capillaries (in the monster of course) to the aorta, and *not* according to the views of Doctor Houston, in an inverted direction.” Verily, this is a puzzle; a distinction without a difference; or, in Dr. M. Hall’s own words, “a most extraordinary statement.” For if the blood, no matter how propelled, passes, as agreed upon mutually between us, through the umbilical vein into the body of the acardiac foetus, and that it finds, there, no heart, and consequently no cross-channels, such as a *foramen ovale* and *ductus arteriosus*

would offer, by which to be transferred from the venous to the arterial side of the circulatory apparatus, it has no other course left for it but that "through the umbilical vein and a series of capillaries to the aorta," and therefore "*according* to the views of Dr. Houston, in an inverted direction." The possibility of this inversion I took some pains, in my former essay, to show that Nature had provided for, by leaving all the veins of the body without valves,—thereby removing the only difficulty which lay between Physiologists and the adoption of this view of the subject. I mentioned also a fact discovered in the examination of my case, which appeared to me to set the question as to the course of the blood in the umbilical vein at rest, namely, a remarkable dilatation of the placental end of that vein, the result of the presence of a tumour incidentally developed in the substance of the cord, and which indicated that the course of the blood had been in the direction of this tumour, and consequently from the placenta towards the foetus.

Dr. Hall further objects to the theory of the inversion of the circulation in the capillaries of the body of the foetus, and the consequent fulfilment by veins of a function usually performed by arteries, and *vice versa*, on account of its "improbability." But even of this we have an analogue in this very umbilical vein itself. Before birth it is, in all cases, the great artery (if I may so call it) of the liver, nourishing its substance, modelling its form, and imparting to it that superiority in size over all the organs in the body for which it is distinguished. By far the greater portion of the blood brought by this vein to the organ is distributed in its substance as if from an artery, for not more than a third of it passes directly on by the ductus venosus to the heart. Here then is a vein performing a discerning function in the fullest sense of the word; and the theory of the same vein, or a continuous substitute for it in the absence of the liver (for one of the great peculiarities of this foetus was the absence of this viscus), doing the same office, with the same

blood, for the other organs of the body to which its valveless ramifications are throughout distributed, is not to be rejected on account of its "improbability;" more especially as there is no alternative but to adopt it,—no other possible explanation by which the fact can be accounted for.

In reply to an objection urged by Dr. Hall to my using as an argument the well-known fact, that the blood-vessels of the early fœtus appear before the heart, on the ground "that of the *nisus formativus* and its modes of operation we literally know nothing," I may say, that while I admit the truth of the allegation, I must not concur in the inference which he draws, "that we cannot, therefore, reason from its phenomena." Because, although by such a mode of reasoning we may not always be able to ascertain what *are* the exact causes of certain phenomena, we may sometimes, nevertheless, acquire thereby such information, as will, at least, teach us what are *not*, and thereby advance a step towards a knowledge of the real causes. If one finds, for example, that during the development of the chick in ovo the "*nisus formativus*" constructs the blood-vessels before the heart, and that even before the appearance of this organ a movement of the blood is discernible in the vessels, the inference that the heart is *not* the cause of this movement, at this period of existence, is obvious and conclusive. And if one finds in an inquiry respecting the cause of the circulation in a twin acardiac fœtus that the action of a remote heart with a certain co-existing arrangement of vessels would, on pure hydraulic principles, tend rather to empty than to fill the vessels destined to carry the blood into the body of the imperfect fœtus, the legitimate inference is, that such heart cannot be the *sole* moving power in carrying on the circulation; and we are thereby relieved from the disadvantage of resting satisfied in error, and led to seek, if not for some new, at least for some additional cause of the phenomenon.

What this new or additional cause may be is, I think, the only question. Professor Alison has employed the terms "vital

attractions and repulsions" as expressive of the existence of some inscrutable principle, the attribute and effect of vitality in the capillaries, and perhaps, also, in the blood itself, by which that fluid is made to circulate in the body, and which he considers capable of effecting this object, under certain circumstances and certain conditions of existence, even independent of the action of a heart. Dr. Graves and Dr. Carpenter consider the case published by me, with the arguments deduced from it, as conclusive of such a power in the human being; but Dr. Marshall Hall, desirous of attributing all to the heart itself, persists in his original opinion, and censures these gentlemen for their credulity. "The facts," however, as deducible from cases such as these, and from the other considerations which I have detailed, "still remain, notwithstanding Dr. Hall's assertion to the contrary, that the heart is *not* the sole agent by which the blood is circulated through the body, and that we have good evidence for the belief that the blood-vessels themselves *are* possessed of a considerable, although hitherto unexplained power to that effect." The farther application of such views to explain the nature of inflammation cannot, therefore, as Dr. Hall says, in allusion to Dr. Graves's and Dr. Carpenter's use of my researches, be regarded "as a still farther deviation from true philosophy."

Before quitting this subject I beg to state that it is my intention not to engage in any farther controversy regarding it. What I have here written has been, solely, in defence of my original statements—to save them from that disrepute which a submission to the condemnation of so distinguished a Physiologist as Dr. Marshall Hall would necessarily throw them into. Dr. Hall's opinions and mine regarding the *course* of the currents of the blood in acardiac foetuses, it now appears, correspond; and I shall rejoice when the *final cause* of such circulation comes to be so well known and understood that on this head, likewise, there shall cease to be any difference between us.



