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To cite this article: John Spurgin M.D. (1827) XXXVI. Outlines of a philosophical inquiry into the nature and properties of the blood; being the substance of three lectures on that subject delivered at the Gresham Institution during Michaelmas term 1826, Philosophical Magazine Series 2, 2:9, 183-191, DOI: [10.1080/14786442708675646](https://doi.org/10.1080/14786442708675646)

To link to this article: <http://dx.doi.org/10.1080/14786442708675646>

Published online: 10 Jul 2009.

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XXXVI. *Outlines of a Philosophical Inquiry into the Nature and Properties of the Blood; being the Substance of three Lectures on that Subject delivered at the Gresham Institution during Michaelmas Term 1826. By JOHN SPURGIN, M.D. Fellow of the Royal College of Physicians of London, and of the Cambridge Philosophical Society.*

[Continued from vol. i. p. 426.]

FLUIDITY is a property of the blood which is next to vitality in importance; and indeed it may be regarded as the second essential of its nature, fitting or adapting it to fulfil the purposes of its first essential,—Vitality. From all that we have advanced upon the composition of the blood, it may be seen that this property is modified or affected by manifold circumstances; by none, however, more than by withdrawing it from its native vessel and keeping it at rest; when it soon enters upon another kind of existence, intermediate, as it were, between fluidity and solidity, assuming the form and state of a soft solid by accomplishing its tendency to coagulation. But in order to comprehend the great importance of this property of the blood, (viz. its fluidity,) we must first express the notion we entertain respecting the term Vitality. The coagulation of the blood has been regarded as the last effect of its vitality, and as the best proof of its possessing life, inasmuch as in this respect it approximates to the condition of the solids of the body, which are considered to be undeniably vital, by reason of their exhibiting the undoubted marks of life—*Contractility* and *Sensibility*. But if these be the only legitimate marks and signs of the presence of life,—the only phenomena that are essentially vital,—such a proof as the above is extremely defective, if not highly fallacious; for whilst the coagulating blood exhibits no marks whatever of sensibility, its properties agree in nothing with contractility. Coagulation and contraction are terms applicable to two different kinds of matter. Coagulation applies to the solidifying of fluids, Contraction to the diminished volume of solids: the coagulation of the blood, therefore, has nothing to do with the contraction of a muscle; nor the fibrillary structure of coagulated blood with muscular structure: in the former, moreover, the arrangement of the fibres is reticular or plexiform; in the latter, longitudinal only, and this most distinctly so; each fibre being kept separate from its neighbour by an investing sheath.

What are we to understand by the term Vitality? Is it a property of matter? of the blood for example; or is it something superadded to matter? to the blood, for example; or is it a term signifying

signifying nothing? or at best signifying but an imaginary existence? How many volumes have been written! how many hours have been spent! how many brains have been at work, to defend or to maintain each of these questions affirmatively, to the negation of the other! And, now, the task devolves upon us to express our assent to, or our dissent from, one or other of these sentiments; and we should unquestionably stand in a ridiculous dilemma indeed, were we to adhere to one of those views exclusively. We assent to the theory of life entertained by Hunter and many others, so far as it regards life as a distinct thing altogether from matter, a distinct somewhat; but we dissent therefrom, so far as it regards life as a mere principle of so abstract a nature and so indefinite a shape as to admit of being resolved into an imaginary somewhat, an ideal, inexplicable, and unintelligible phantom—a *materies vitæ diffusa*!

We assent to the theory that life is a property of matter, so far as it regards it as dependent upon matter for its manifestation in this material world; but we dissent therefrom, so far as it regards life as a product from the combinations of matter; because if it be merely a result of certain combinations of matter, we are bound to ask what brought about those combinations? combinations, indeed, that are at variance with the known natural affinities of matter, and which would prove matter to be inconsistent with itself, and would render death a strange anomaly; nay, an absolute impossibility. To say that these effects are owing to the combined actions, the healthful operations of parts and organs having a mutual and indefeasible connection one among another, the destruction or disturbance of which is followed by the phænomenon of death, is begging the question with a witness! The theory assumes what is absolutely denied and disproved by the conclusion. The theory assumes the necessity of combined actions, of healthful organic operations, for manifesting the various effects called vital, and yet concludes that these actions and these operations require nothing to combine them. The combination is a mere chance—the healthy actions and operations are a mere chance—the life, as the result of these, is a greater chance still! in short, it comes to be, according to this theory, as well as according to the preceding, an imaginary somewhat, a shadowy nothing. But in expressing our opinion of the views that have been entertained respecting life, it might at first sight appear as if we were desirous of detracting from the merits of those illustrious men who have espoused one or other of the theories just now adverted to, and had thence deprived ourselves of the authority and excellent reasoning which they afford. So far, however, from this being the case, we are supported both by their authority and

and by their reasoning; and above all, by their experimental labours, in maintaining that life is distinct from matter, but nevertheless dependent upon it for the manifestation of vital phænomena in this material world: consequently, when we assert that certain conditions are indispensable on the part of matter for the manifestation of vital phænomena, and that other laws are in operation for the bringing about, and preserving it in, such a condition; such laws, for instance, as by their operation evince a perfect knowledge of, and full power over, every law that pertains to material things, we are supported by both classes in employing the term, *Vitality*,—to express *that condition of matter which fits it for accomplishing and fulfilling some specific living purpose, some particular living design.*

But still the proof may be demanded of us of the blood being a vital fluid, even under the view which we have taken of vitality; such a proof for instance, as whilst it exhibits some peculiarity that is connected with the blood, and identifies itself at the same time with some striking peculiarity in the solids, will stand in the place of that which has been adduced by Mr. Hunter, viz. its spontaneous coagulation. We confess we can advance no other, than their undergoing the same process after death, *i. e.* Putrefaction. For we might as well look for signs of vitality in a dead body, as for the same signs in a fluid that is in an altered condition almost the instant it is withdrawn from its vessel; not to mention the mortal influence of venous blood itself, if injected, as such, into the arteries, without first undergoing aëration in the lungs.

Putrefaction, or the return of animal matter to its original state and natural combinations or affinities, is the inevitable doom of flesh and blood; and in this common peculiarity, the most inveterate reasoner against the blood's vitality is furnished with a no less sensible than suitable mark to turn him from his headstrong scepticism. For the proofs of vitality, we would go to the seat of life, the living body; but for the changes which have been wrought upon matter in order to its being rendered vital and living, we must avail ourselves of the researches of the chemical philosopher. For the manifestations of life, we must behold and admire the actions of the bodily parts severally, and the movements of the universally circulating fluid, the blood, generally.

Mr. Hunter's experiments on the effects of cold upon the blood and upon the fluids of the egg, most satisfactorily confirmed the presence in, and influence of some principle upon them, which enabled them to resist congelation for a considera-

New Series. Vol. 2. No. 9. Sept. 1827. 2 B ble

ble time ; but whether he could show with equal satisfaction that that principle was identical with life, or entitled to that appellation, without at the same time furnishing us with a definition of his term, must remain questionable, so long as science forbids indefinite terms to form a part of her vocabulary, or disowns indefinable notions as portions of her system.

To say that the blood enjoys vitality, or has a vital principle within it, in the same manner as the solids,—without defining what is meant by a vital principle,—is to leave the subject of the blood's vitality involved in as much mystery as if any other term, no matter how unintelligible, had been substituted in the place of vital principle, or vitality ! Indeed, we cannot avoid repeating a remark which we made in our introductory lecture ; that “ *whenever a subject is defined and determined by occult qualities, it remains as obscure and unintelligible as if no definition or description had ever been given.* ”

Not to incur the charge, therefore, of employing unknown principles as the basis of all our reasoning, we have attempted a definition of the term Vitality, which we hope one day to witness as the occasion of some discussion in the scientific world ; and this with a coolness of intellect and dispassionate unprejudiced state of mind which is best befitting so important a subject,—a definition which we well know to be quite novel in science, and which, therefore, we would not put forward as a theory, but rather as a question for examination.

We have endeavoured to express ourselves in as concise a manner as possible on the blood's vitality, and to define in what sense it may be regarded as a vital fluid. But as in considering its vitality we find that property inseparable from its fluidity, and thence connected with that condition which fits it for traversing every part of the frame, we must follow the course of this fluid, or accompany it to those its destinations where its life becomes more and more apparent, or where its vitality becomes more and more manifest. Contemplating then the blood as circulating through every part of the body ; as permeating the vessels from their largest calibre to their minutest capilli ; and as flowing, in short, through a whole body composed almost entirely of such minute capilli,—we shall immediately discern the ground and reason of the blood's fluidity ; this its property being, as we have before said, an essential in its nature secondary only in importance to its first essential, vitality. Much has been said on the cause of its fluidity, and many experiments have been instituted with the view to discover it : warmth or heat alone will not preserve it fluid ; for it coagulates when effused into any cavity or part of the warm
and

and living body*: in fact, no extraneous circumstance whatever can be regarded as a *cause* of this phænomenon, however greatly its tendency to coagulation may be retarded or influenced by any one extrinsic agent. The fluidity of water and other liquids is ascribed to the presence of caloric, and these may be rendered volatile by an increase of the heat: not so the blood; this increase would only tend to destroy it altogether as blood.

Can we say it is a vital heat or the animal heat which keeps it fluid? We think not; because the cold-blooded animals as they are called, have their blood equally fluid. Is the motion to which it is subjected; the constant agitation by the heart; the incessant straining as it were which it undergoes through the minute capilli,—sufficient to preserve it in a fluid state? or more, to cause it to be so? The action of the heart may be referred to several causes, so may the reaction of the capillary vessels upon the blood, and both ultimately to the presence of life in the body: but blood or living fluids existed before the heart that moves them, as in the first days of conception; they existed before any vessel was formed for them to circulate through: wherefore the first cause of the blood's fluidity must be sought for independently of the secondary or accessory causes just adverted to. And we may venture to assert, because our assertion is founded in fact, that the essential and primary cause of the blood's fluidity is its vitality: and this is consonant to that rule in philosophy, which teaches "that the cause of the cause is also the cause of the effect,"—*causa causans est causa effectus*†.

The fluidity of the blood must be regarded as a very extraordinary property indeed, and one which is eminently characteristic of some more active and energetic agent existing within it, which withholds it from yielding to its own natural tendency to coagulation. This agent some would identify with a vital principle at once, without considering the possibility that material elements may admit of such states or combinations as to render them highly active in their nature, extremely subtle in their form, and capable of imparting their own activity

* If we take a fish out of the sea, the heat of its body perhaps about 60°, and bring it into an atmosphere of 70°, the blood on being let out of the vessels will immediately coagulate. This was ascertained on board of a ship lying off Bellisle, in the summer of 1761: for immediately upon a fish being caught, I ascertained its heat; and letting out part of its blood, it immediately coagulated, although the blood discharged was become warmer than that remaining in the vessels of the fish; which, however, still continued fluid.—*Treatise on the Blood*, by J. Hunter, vol. i. p. 35.

† The blood, says Mr. Hunter, has the power of preserving its fluidity; or in other words, the living principle in the body has the power of preserving it in this state.—*Treatise on the Blood*, vol. i. p. 148.

and susceptibility to motion; or in other words, their own fluidity to crasser or grosser combinations of matter,—as in the case of the blood more especially; for we regard it as an axiom, that for every natural effect there must be a natural efficient cause.

Seeing then that in order to the blood's fulfilling certain purposes and designs,—for we fear not to say that the best purposes and the wisest designs are discernible in the formation and mode of existence of every living thing,—it must enjoy fluidity in a very eminent degree; it must admit of so subtle a division without a destruction of its nature, as will enable it to penetrate into those minute channels and secret recesses where the human eye-sight is eluded, and where those delicate manipulations and chemical operations are performed which no human skill can imitate nor art accomplish. Still the pathways to these recesses are open to our search; still may we trace the blood thither: in other words, its vessels are continued thither. And though we do not possess the means to accomplish, nor enjoy the skill to imitate, the various and wonderful works therein proceeding every the smallest moment, and though we may fall very short of ever arriving at the modes of operation therein resorted to;—yet it is all open to investigation; all prepared to stand the scrutinizing ingenuity and research of man; all is calculated to augment the store of his knowledge, to perfect him in reason, and to advance him in intelligence and wisdom.

It will be to our purpose if we avail ourselves of the testimony of one or more of the skilful and patient microscopic observers of the blood's circulation; for although they were constrained to visit the reptile race of the animal kingdom, as frogs and the like,—nay, a lower race still, as worms; yet from this quarter even have they raised up rich treasures of knowledge for our use and benefit. The celebrated Leeuwenhoeck was among the first to employ that potent instrument the microscope in facilitating our descent, or rather our ascent, into Nature's secrets; and his details of the wonders of the minute creation are interesting in the highest degree. But as we may have occasion to advert to this celebrated authority occasionally in our way; and as we are desirous of giving familiar illustrations as we proceed, we will now adduce some interesting testimony from the observations of Mr. Baker, who was a Fellow of the Royal Society of London, and who devoted much of his time to this kind of research.

On the subject of the current and circulation of the blood, he says, "The tail of a newt or water-lizard applied in a glass tube in the manner directed for the eel, affords an entertaining prospect

prospect of the circulation through numbers of small vessels. But nothing can show it finer than an exceeding small newt of this water-kind which sometimes may be found less than an inch long, and so transparent that the blood may be seen running in all directions, not only through the vessels of the tail, but throughout the whole body. In the fin-like processes situated just below the head the blood is seen coming along an artery to the extremity, and then immediately returning towards the heart again, through a vein that lies close and parallel thereto, and with which its communication is very apparent. This affords a charming sight, and may be viewed by the third or fourth magnifier; for the globules of the blood in *newts* are larger than in any other creature I have examined, and are fewer in proportion to the serum or water they float along in." To which he also adds, that the figure of them, as they are carried along the vessels, changes in a most surprising manner.

The recently produced tadpole being very transparent, is a good object for discerning the pulsations of the heart together with the circulation of the blood in every part of the body; the skin and transparent parts of muscles; the furthest joints of the hinder legs of little crabs; the legs and tails of shrimps; the transparent legs and head of several small spiders, and the current of the blood may be clearly discerned both in the veins and arteries. Mr. Leeuwenhoeck found the globules in various kinds of fish,—as the perch, trout, and salmon,—to be flat and of an oval figure, as also in some birds. The serous part of the blood in fish and aquatic animals is in greater proportion to the red particles than in animals or man, whilst the particles themselves are larger.

In viewing several of the above objects the blood may often be observed passing through vessels so minute, that its globules cannot glide along otherwise than single, and squeezed into oblong forms: yet a hundred of such globules, if placed close to one another in a row, would not equal the length of the diameter of a large grain of sand. Some experiments which were made by Mr. Baker, and his friend Dr. Alexander Stuart, physician to the queen consort of George the Second, with a solar microscope of a peculiar construction, we cannot omit to mention; though for accurate information we allow such a method as they adopted to be in many respects deficient; but as this deficiency does not affect the point under consideration, their experience may be regarded as extremely satisfactory. "Our object," says Mr. Baker, "was a frog, whose limbs being extended and fastened on the frame, we opened the skin of the belly from near the anus to the throat; then
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giving a little snip sideways, both at the top and bottom, by sticking a fish-hook in each corner of the skin, it was easily stretched out before the microscope, and presented on the screen a most beautiful picture of the veins and arteries in the skin, with the blood circulating through them. In the arteries we could plainly perceive the blood stopping, and as it were receding a little at each dilatation of the heart, and then immediately running forwards again at each contraction; whilst in the veins it rolled on in a continual current with inexpressible rapidity." To this Mr. Baker appends a note, wherein he says, "When the arteries were magnified very much, by removing the screen to a considerable distance, the alternate expansion and contraction of their sides were very visible and remarkable. After considering this" he proceeds; "as long as we thought needful, we opened the abdomen, and extending the muscles before the microscope, by the same means as we had done the skin, we had the pleasure of viewing their structure, which we found to consist of bundles of transparent strings or fibres, lying parallel to one another, and joined together by a common membrane. These strings or fibres appeared through their whole length made up of minute roundish vesicles; or, in other words, seemed like rushes divided the long way. We could not be certain of any circulation through the muscles, though sometimes we imagined we saw a very slow motion of some transparent fluid: but the object growing dry and rigid, we proceeded to our last experiment, which was to draw out gently a part of the frog's intestine, in order to apply the mesentery to the microscope: and herein we succeeded so happily, that I believe the circulation of the blood was never before seen in so distinct and fine a manner. No words can describe the wonderful scene that was presented before our eyes! We beheld the blood passing through numberless vessels at one and the same instant, in some one way, in others the direct contrary. Several of the vessels were magnified to above an inch in diameter, and the globules of the blood rolling through them seemed near as large as peppercorns; whilst in many of the minutest vessels only single globules were able to find a passage, and that too not without changing their figure into that of oblong spheroids. We saw likewise much better than we had done before, the pulsation and acceleration of the blood in the arteries, in the manner before described, and could clearly distinguish two or three vessels lying over one another, with currents running different ways. In short, it appeared like a beauteous landscape, where rivers, streams and rills of running water are every where dispersed.

During

“During this examination we took notice of a vessel extremely minute, issuing from the side of a larger, and turning backwards from it in a curve line. We perceived at unequal intervals sometimes one, sometimes two, and sometimes three colourless globules, dropt or squeezed out of the larger vessels into this minute one, and gliding through it singly and very slowly; which made the *Doctor* imagine it might be a *secretory duct*. We observed likewise, that as the animal grew languid, and near expiring, the blood in the arteries would stop on a sudden, seem as it were coagulating, and then run backwards for some time; after which it would again recover its natural course, with a great deal of rapidity.”

Mr. Leeuwenhoeck informs us that he saw, with great admiration, in the furthest extremities of a very minute fish's tail, how the larger arteries were there divided into the most fine and evanescent ones; and that many of the smallest veins returning from the said extremities, met together at last in some larger vein. There appeared also in some vessels such an agitation of that blood (which was protruded from the larger arteries towards the evanescent ones at the very extremity of the tail, and returned afterwards through many minute veins into a large one) as hardly can be conceived. In the larger arteries he could perceive a continual new protrusion or acceleration of the blood's course received from the heart; but in the smaller arteries the motion seemed equable without any such repeated propulsion: and though in the minutest vessels there appeared no colour, yet in the larger vein or artery, though near the end of the tail, the blood was plainly red. The communications of the arteries are sometimes direct with the veins, without their terminations becoming previously evanescent, and not to be traced. For the same curious observer tells us, that on each side of the little gristles, which give a stiffness to the tail of the fish, he could see a very open communication of the veins and arteries; the blood running towards the extremities through arteries, and returning back again through veins that were evidently a continuation of those arteries, and of the same diameter with them: and this he saw in thirty-four different places, in as many arteries and as many veins. The length of the whole fish was not half an inch; yet in the tail the circulation was notwithstanding visible in thirty-four places, and the current of it in sixty-eight vessels; and yet these vessels were very far from being the most minute of all. How inconceivable then must be the number of circulations in the human body! nor need we wonder to behold it issuing forth at every puncture of a pin or needle.

[To be continued.]

XXXVII. *Reply*