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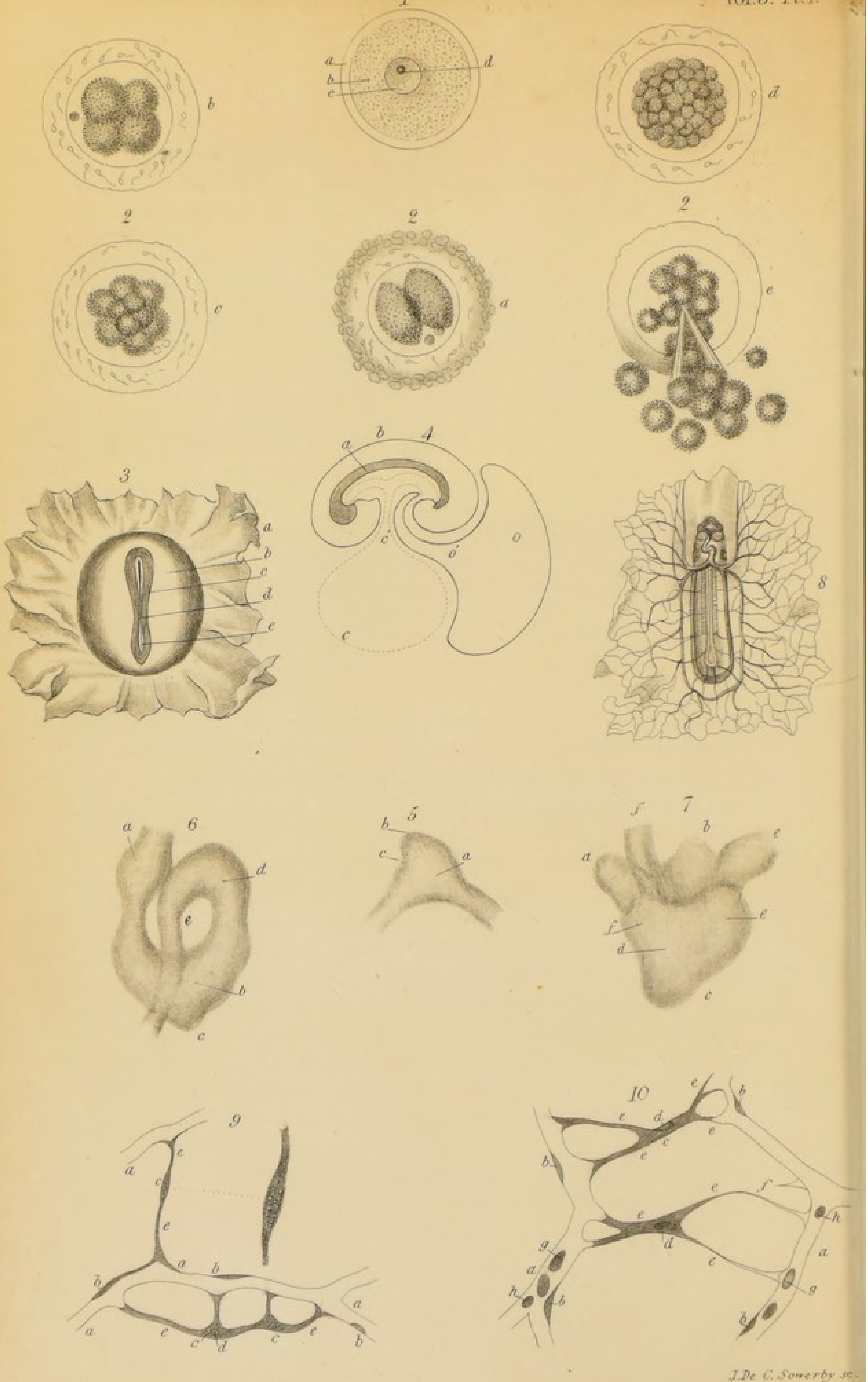

J. De C. Sowerby sc.

THE

VITALITY OF THE BLOOD

PROVED BY

PHYSIOLOGICAL EXPERIMENT, AND ITS APPLICATION TO VETERINARY PATHOLOGY DEMONSTRATED.

By J. S. Gamgee, *Student, Royal Veterinary College, London.*

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WITH the intention of proving by inductive reasoning, founded on physiological experiment, the truth of the doctrine first advocated by Hunter, that "the blood is a living fluid," and for the purpose of establishing thereon principles applicable to veterinary pathology, one important question first requires solution,—What is the nature of the attribute life? which we affirm to be an inherent endowment of the blood.

To account for the infinitely varied and beautiful phenomena presented by living bodies, many physiologists have exercised their ingenuous minds from the very earliest periods; and, launching into ideal regions of mystery and fancy, have too often been satisfied with the adoption of chimerical hypotheses, rather than adhere to undeniable facts.

Aristotle referred the organization of the numerous individuals constituting the animal and vegetable kingdoms to "a series of animating principles;" whereas Hunter conceived "the materia vitæ diffusa" to be the main cause of the constant activity manifested by an organism in the processes of development, decay, and repair.

These theories have been successively combatted by those of Müller and Prout, who, consonantly with prevalent notions, were desirous of attributing the functional activity of the animal economy, and even the existence of organized bodies, to a distinct vital principle, or an organic force.

Similar views are by many entertained up to the present period, on the plea that all the phenomena presented by living beings cannot be accounted for on the principles, whether physical or chemical, which science has hitherto established; and, therefore, they allege the necessity of framing an imaginary theory to compensate for that which cannot be rationally interpreted.

The argument "that, because we cannot account for many of the actions of which a living body is the incessant scene, we are to assume the existence of a vital principle," is not valid; because, if it were, equally should we be justified in imagining that many of the marvellous and inexplicable occurrences in inorganic nature are dependent on a similar abstract agency, rather than refer them to the one great and only source of all mystery and wonder, THE OMNIPOTENT CREATOR.

The alleged necessity of supposing that "vitality" is the ruling agent of organized beings, is refutable for the following reasons:—1st, Because the march of science has developed facts which collectively prove the dependence of many phenomena presented by living bodies on the ordinary laws of nature. Thus, it is now a well-known fact, that venous blood is rendered fit to maintain the functional activity of animal textures in virtue of a chemical change; also, that general absorption is due to the property of permeability, which alike pertains to organic and inorganic substances; and that many of the changes to which the alimentary matters are subjected previous to assimilation are explicable by and in accordance with chemical laws.

These notable advances in the pursuit of truth diminish the evidence in favour of the notion that organization is dependent upon an imaginary principle or force; consequently we cannot admit an hypothesis, which, while it envelops in clouds of mystery important facts, does not aid in the solution of any of the pending obstacles in the study of nature, and which, in the absence of doing good, must necessarily be prejudicial.

2dly. In the supposition that vitality governs organic bodies, are we to suppose, with Aristotle, that each animal and plant has a separate and distinct vital principle? If so, whence is it derived? Where does it resort when organization is extinct?

The impossibility of surmounting these objections urges the necessity of abandoning the theory which gives origin to them.

3dly. Experimental evidence corroborates our views. If an animal be destroyed, and its component parts severed from one another, each, in greater or less degree, evinces vital properties. The blood, even if placed in several receivers, coagulates spontaneously; and on applying galvanism to the nerves which supply the various extremities, the head and other parts, muscular contractions are induced. These are all indubitable signs of vital attributes, which cannot depend on "a vital principle," because, as single, it could not be participated by a plurality of tissues, when these are no longer in apposition so as to constitute one grand whole.

If the animal textures afford proofs of vital endowments even when subdivided, these properties must be referred to the indivisible organic atoms; consequently the phenomena of life are not referrible to "one distinct organic force," but to "one series of organic laws," with which organic matter must have been impressed at the creation of the universe; and we consider the reproduction of organisms from pre-existing parents, and the subsequent exercise of their functions, as the necessary consequence of the transmission of organic particles endowed with the powers of assimilation and development; just as inorganic matter presents varieties of forms by virtue of the co-existent laws which govern it.

In accordance with these premises, in our endeavours to prove that the blood is a living fluid, we shall simply have in view to demonstrate that, as a whole, it is subject to the same laws as all living bodies are, and that its constituent molecules possess organic properties, viz. development, assimilation, growth, and decay.

In the pursuit of this object, we shall, first, adduce the physiological and chemical proofs of the blood's life; secondly, the pathological evidence of the same fact, or, in other terms, the study of those deviations which the blood presents in its composition and function from the normal standard, and the operation of those pathognomic states on the animal economy.

In tracing the development of the blood from its origin to its perfect elaboration in the animal organism, we shall pass in review the most striking changes presented in the evolution of the mammalian embryo, more particularly elucidating those which relate to the vascular system.

That the existence of the ovarian ovum in mammalia is essential to the propagation of their species was first maintained by De Graaf in 1690; but subsequently opposed by the ingenuous Haller, who prevailed over the Dutch physician in the opinion that the ovum was first formed in the Fallopian tube out of a substance emitted from the ovary. Sixty years since, Cruikshank ineffectually attempted to revive De Graaf's theory, which, however, remained in abeyance until 1827; when Von Baer discovered the mammalian ovulum in the ovary, erroneously considering it as analogous to the germinal vesicle of oviparous animals. This statement was contradicted by Coste and Wharton Jones, who clearly demonstrated that the ova of mammalia, like those of birds, contain a germinal vesicle perfectly distinct but proportionately smaller.

The ova in the ovary are contained in Graafian vesicles, lined by the membrana granulosa, which is composed of granules arranged in linear series: each ovum consists, first, of an external, thick, but transparent envelope, the zona pellucida; secondly, the yolk; thirdly, the germinal or Purkinjean vesicle; fourthly, the germinal spot or macula germinativa, first observed by Wagner. [*See Fig.* 1, *Pl.* 1.]

In harmony with the researches of Purkinje in birds, Dr. Martin Barry has shewn that, in mammiferous animals, the germinal vesicle (consisting of a structureless membrane, distended with an albuminous fluid, and having attached to its walls a Granular germinal spot) is the first formed element of the ovum. Bischoff, on the other hand, accords the priority of formation to the Graafian vesicle; but, comparing the experiments from which these inferences were drawn, we are inclined to favour the opinion of the English embryologist. By aggregation of oil-like globules and granules, the yolk surrounds the germinal vesicle, and acquires a vitelline membrane or zona pellucida.

The production of ova is said to commence, in the cow and sow, at an early period of intra-uterine life, but not until birth in the human species, dog, and rabbit.

The position of the several parts of the ovum varies in attaining maturity. By the traction of retinacula or granular cords attached to the membrana granulosa, the ovum is conveyed from the centre to the surface of the Graafian follicle; the Purkinjean vesicle and macula germinativa being subjected to a similar translocation from their central situation to the superficies.

Bischoff (in a memoir communicated to the Academy of Natural Sciences at Paris) relates a series of experiments which have enabled him to infer the important law, that in all mammalia (not excluding the human species) the ova are subject to periodical maturity; and that, independent of the influence of the male seminal secretion, they are discharged and conveyed along the Fallopian tube into the uterus, where they disappear if not fecundated.

But although ova are perfected in the higher mammalia independent of conception, nevertheless their expulsion is not constant during an animal's life. At the period of heat or rut changes are operating more or less generally on the system, but especially on the generative apparatus, preparatory to the reproduction of the species.

The vessels supplying the ovaries carry an increased quantity of blood, in consequence of which those structures present a turgid aspect; the inner vascular tunic of De Graaf's follicles thickens at its inferior part, so as to press against the base of the ovum, which, aided by the retinacula, escapes from its envelope into the Fallopian tube; and the solution of continuity thus inflicted on the Graafian coats is filled up by a yellow body, "the corpus luteum," which is indispensably formed after the expulsion of ova, even independent of fecundation.

Zwicky, who has investigated the structure of the corpus luteum in the cow and sow, attributes its formation to the fibrous arrangement acquired by the cells constituting the inner layer of the Graafian follicle, which enlarge and present various nucleoli destined to become centres of secondary cells: these elongate and assume the character of fibres, thus adding continually to the internal stratum of the theca, which is finally converted into a perfect corpus luteum.

The ovum having escaped into the Fallopian tube, it is here, according to Pouchet, invariably fecundated; whereas Bischoff believes that in some cases conception may occur previous to the rupture of the Graafian coats.

Contact is obviously the leading phenomenon in the fecundative process, and it is effected between the maternal ovulum and the male seminal secretion, containing spermatozoids, which have been considered by Valentin and Henle as organized animalcules. Wagner having lately contradicted his statement that strychnine and other narcotics arrest the movements of those filaments, and Köelliker having proved that their structure is homogeneous, we conclude that the spermatozoids are but parts of an organism, being themselves destitute of independent life, but by means of cilia they are enabled to propel themselves to the uterine cornua as elaborators, and probably carriers, of the seminal fluid.

Soon after fecundation, the mammalian ovum becomes the seat of infinitely varied changes, for a knowledge of which we are principally indebted to Bischoff and Dr. Barry in their respective researches on the bitch and rabbit.

The most striking feature in the first stage of embryonic development is the disappearance of the germinal vesicle: the ovum, in its subsequent passage along the Fallopian tube, is surrounded by a thin membranous production separated from the pellucid zone by the interposition of a fluid which imparts to it a gelatinous appearance. Vesicles speedily become manifest on that membrane, "the future chorion," and, by aggregation into tufts, constitute its villi.

Midway the length of the oviduct, a clear area is perceived between the yolk and the zona pellucida, in consequence of the former having shrunk from the inner surface of the latter. In a similar manner to the cleaving process witnessed by Vogt, Dr. Sharpey, and others, in the ova of fishes, amphibia, and parasitic worms, the mammalian yolk cleaves into two masses, and each of these repeatedly subdivides, until the whole vitelline substance presents a mulberry aspect, which gradually vanishes by a continuance of the cleavage, so that, when the ovum reaches the uterus, its yolk resembles a mass of granules arranged in spherical partitions; and in each of these is a central vesicle non-invested by a membranous envelope, but which is soon added to every one of the globular segments of the vitellus, transforming it into a congeries of cells, whose nuclei are the central vesicles previously alluded to. [*See Fig.* 2, *Pl.* 1.]

The most external cells coalesce at the periphery of the yolk in a membranous layer, " the vesicula blastodermica," or germinal membrane, which increases in thickness by the increment of cells developed in the interior of the vitellus. Soon after its appearance the germinal membrane divides into two strata: the outer or serous one is the basis of the osseous, muscular, and tegumentary structures, whereas from the inner or mucous layer the viscera originate. Between these strata numerous granules accumulate to produce the " area vasculosa;" and on the vesicula blastodermica the germinal area is discerned as a dark spot, composed of cells and granules, the central part of which, being clear and transparent, is named the area pellucida.

In the last-mentioned space the first trace of the embryo, or nota primitiva, appears in form of a hollow groove, beneath which is laid the foundation of the vertebral column by a mass of cells, " the chorda dorsalis." [*See Fig.* 3, *Pl.* 1.]

While the nota primitiva acquires a pear-shaped figure, the contiguous cells, ascending in convergent ridges, form the laminæ dorsales; these coalesce, converting the groove into a canal, which is perfectly closed, except at its anterior part, where three projecting vesicles represent the future cerebrum. The extreme ends of the embryo now become inverted, and the oblong blastoderma gradually separates from the evolving intestinal tube as the umbilical vesicle. From each side of the dorsal laminæ two laminæ viscerales take a direction forwards and inwards, mutually aiding each other in forming the anterior walls of the trunk.

Having thus briefly sketched the earlier stages of embryonic development, some of the more important points deserve further consideration. During the first twenty-four hours, from the first appearance of the nota primitiva, projections from the external layer of the germinal membrane form anteriorly the involucrum capitis, posteriorly the involucrum caudæ, and laterally the laminæ laterales: these unite in a visible cicatrix over the lumbar region, enclosing the embryo in a complete sac, designated the amnion.

From the caudal extremity of the embryo, the allantois first protrudes as a mass of cells. In carnivora this membrane extends entirely around the young animal; in ruminants it is bicornuated; and in the solidungulata an albuminous deposit separates its vascular layer from the mucous.

So soon as the Wollfian bodies and the kidneys appear, they are placed in direct communication with the allantoid sac, through the medium of the sinus uro-genitalis; and by the closure of the visceral arches the allantois is divided into a superior small portion, "the urinary bladder;" and a central canal, "the urachus," leading into the inferior and larger compartment external to the body. [*See Fig.* 4, *Pl.* 1.]

Throughout the earlier period of these changes the ovum is perfectly free in the uterine cavity; but, concurrently with the growth of the embryo, the vessels supplying the uterus increase in caliber; the coats of that viscus acquire a greater degree of thickness, and an exudation from the tubular follicles of its mucous membrane produces the decidua. This, in the generality of mammalia, consists of epithelial cells and bloodvessels united by an albuminous deposit, in which the villosities of the chorion shoot and grow, so as to form one common fœtal covering, "the placenta;" which exists in all mammiferous animals, with the only exceptions of the marsupalia and the monotremata.

It is a fact worthy of notice, that the villi of the chorion assume various modes of distribution in different classes of animals. In the pachydermata, the camel, and the lama, they stud the membrane throughout its whole extent; but in the cow, sheep, goat, and their congenera, those villi are collected into cotyledons at different parts of the chorion, corresponding to uterine cotyledons, where the fœtal blood undergoes the necessary changes for its adaptation to the functions of nutrition and growth.

Important changes in the early epoch of embryonic life have already been narrated; and we have endeavoured to explain the process of cellular development, from the original cleaving of the yolk into two masses: we have likewise described the appearance of the true germ on the germinal membrane, which is produced by vesicular arrangement of the vitelline contents; and, finally, we have alluded to the foundation of the nervous system by a part of the embryo cells.

The vascular apparatus in progress of development now remains to be considered; and, since we have undoubted proof that the primary formation of organs in the chick does not materially differ from other vertebrata, we shall give an account of that process in the bird's egg, this being much easier obtained for examination than are the ova of mammalia.

In the egg of the fowl, twenty-two hours after incubation, a congeries of vesicles is all that can be seen of the future organism; shortly afterwards the vertebral elements are laid, and at twenty-six hours the first vestige of the heart appears as a mass of embryo cells, resembling a cylinder in form, but not closed at either extremity.

By multiplication of cells, and their adjustment in a linear series, projections advance from the rudimentary heart to join a net-work of bloodvessels formed in the vascular layer of the germinal membrane. A few of the primitive vesicles in the interior of the heart become free, and float among the nuclei and granules of others, which liquefy, and aid in the formation of the blood. In this state all is motionless; a few minutes elapse, and by a kind of peristaltic action the vesicular heart effects movements, which, at first irregular and slow, gradually become rythmical, and display to our view the apparatus of circulation in functional activity.

The cells originally composing the heart do not define its contour; but they subsequently acquire a closer relation to each other, and unite superiorly, transforming the previous cylinder into a cone.

Preparatory to the first oscillatory movements the ventricle is separated from the auricle, whose appearance soon becomes bi-lobed; and by transverse cellular partition the septum auriculorum is completed.

The bulbus arteriosus, formed at an early period of embryonic life, suffers considerable decrease during the division of the heart into cavities; and at forty-eight hours, the pericardium, pulmonary arteries, and venous trunks, complete the foundation of the central circulatory system. [*See Fig.* 5, 6, 7, *Pl.* 1.]

Ere we describe the manner in which the blood and its conduits are perfected, a marked proof of economy and design presented by the embryo chick, between the second and third day of its evolution, deserves notice. Although a vascular system is required at this early stage, still a less perfect form of it suffices to fulfil the wants which are as yet comparatively limited;

and Nature, who never expends too great a share of complexity to attain perfection in any of her works, but only just so much as is compatible with the invariability of her laws, so arranges the heart and two arteriæ omphalo-mesentericæ, as to convey blood into the sinus terminalis, whence two venous trunks return it to the central organ. [*See Fig*. 8, *Pl.* 1.]

This provision soon becomes too restricted to fulfil the demands of the growing textures, and the vascular net-work is extended into numerous inosculations, by the union of offshoots from the previously existing vessels, with radiating cells at the extreme end of the dorsal chord.

In the formation of the bloodvessels, two distinct plans present themselves. The larger trunks are derived from rows of embryonic cells whose external envelopes coalesce: while their interior is liquefied, and admits of the free movement of the granules and nuclei, and also of the elementary blood propelled into them by the heart.

Köelliker has ascertained that in the young tadpole's tail the capillaries are derived from cells placed at some distance from each other; and they acquire a radiate appearance, sending out processes which reciprocally meet. The meshes of the vascular network thus formed increase in density, either by the radiation of intermediate cells, or by projections from other capillaries whose calibre is in progress of perforation for the reception of the circulating blood. [*See Fig*. 9, 10, *Pl.* 1.]

These metamorphoses are nearly completed, and still the heart and bloodvessels have a granulo-vesicular appearance. It is only at the ninety-fifth hour of incubation that their constituent cells are converted into a fibrous tissue.

We have previously mentioned that the blood owes its origin to embryo-cells, moving to and fro in the interior of the rudimentary heart, and of the vessels in the germinal membrane. The dim outline of those cells becomes translucent, and their nuclei beset with nucleoli are more clearly visible, in consequence of the liquefaction of interposing granules. Between the nucleus and the envelope, colouring matter is deposited, and perfects the transition from pale vesicles to red blood discs.

The best authorities concur in the statement, that even in the mammalian embryo, the primitive blood corpuscles are nucleated, and multiply in one of two ways; either by the formation of infant cells within older ones which ultimately dissolve, or by the division of the nucleus and cell-wall of a previous red disc, so that two or more perfect cells are derived from the materials of one.

When the lymph corpuscles are added to the circulating fluid, it is from them that red blood discs are reproduced by dissolution of granular matter, and addition of colouring constituents. At that period, in the mammifera the multiplication of the primitive nucleated blood discs ceases; and these are substituted by a new set of red corpuscles destitute of nuclei.

From a variety of facts established in the preceding paragraphs, we deduce the inference, that the blood is a living fluid.

The cells which originally compose the embryo present uniform characters; some of them are the elements of the nervous system, others lay the foundation for the blood and its conduits. That life pervades the nervous centres has never been doubted; and if the blood is derived from the same materials as they are, the identity of its vital properties is an inevitable consequence.

From the fact that a few hours after the dorsal chord is evolved, provision is made for the circulation of the blood, and that before any organs or definite structures exist, it may be safely argued, that the blood is more essential in the production of vital actions than the solid tissues of the animal frame are.

So long as the rudimentary nervous centres existed alone, the embryo presented no signs of functional activity; but when the bloodvessels and blood were formed, motion became apparent in various parts of the young animal. The nervous system was not of itself adequate to maintain that marked feature of life, viz. development and rapid growth, but it required the co-operation of the vascular apparatus. Hence we conclude, that in the first manifestations of life, the blood is concerned as pre-eminently as the nervous centres.

Having explained how the blood increases in quantity and perfects its composition, independent of the influence of organs, what more demonstrative proof of its life can be required, when it is borne in mind that living objects alone are capable of reproducing their species, and of self elaboration?

The embryonic cells having been totally expended in the formation of the blood, the muscular, cartilaginous, osseous, and other textures must necessarily be derived from it; and the various degrees of vital properties with which they are endowed must likewise pre-exist in this fluid in the acme of perfection.

That the blood is not simply a carrier of nutriment for the repair of decaying textures, but is intimately connected with the functional activity of the most vital organs, is proved by a mere cursory glance over the comparative morphology of the vascular system in the several classes of organized beings.

In vegetables, fluids ascend from the roots to the leaves, through the medium of cells, leaving the matters which have been taken up from the earth in the body of the plant, while the solvent fluid evaporates. This circulation is carried on without the aid of any propelling organ, and is similar to that met with in the lower classes of animals, such as polyps, entozoa, &c.

In the animal kingdom, two principal varieties of vascular system prevail. First, in the invertebrata a colourless fluid circulates; secondly, in the vertebrate class, red blood is propelled by a heart through a double system of vessels.

From the fact, that in all animals, fluid plasma containing pale corpuscles circulates, it is evident that it is essential to the reparation and growth of tissues; accordingly, it is found in the mollusca as well as in man. Nutrition being the chief function in activity for the maintenance of the former animals, they are endowed with a fluid simple in composition, but adequate to the support of a machine whose uses are so limited, and whose phenomena of vital actions are so few.

In ascending to the reptile tribe (many of which are no larger than some of the mollusca, but perform a greater variety of movements, and have a more acute instinct) we find that their nervous system is more complex; and to the pale nutrient fluid is superadded a set of nucleated corpuscles, chemically combined with hæmatosine; a heart is likewise provided, with double auricle and single ventricle.

In the higher classes of vertebrata, and more particularly man, the physical powers are not more developed than in many huge serpents, or even minute insects, whose agile movements and consequent decay of tissue and demand for nutriment by far exceed in proportion the activity of those functions in the higher mammalia, in whom the distinctive characters are, a capability to perform a great variety of actions, and the gradual ascendancy of reasoning faculties over the instinctive.

The structure of the brain, and distribution of the nerves, acquire complexity in the more elevated classes of animals, in proportion as their vital functions are more numerous; and in the same ratio the composition of the blood progresses, its red corpuscles being destitute of a nucleus. The nucleated cell is generally considered the most complete; but in the red blood discs the absence of the nucleus obviously denotes perfection of organic structure, because the red non-nucleated corpuscles are substituted in embryo for a primitive set having a central macula.

If, in proportion as the blood acquires more perfect forms, its use as a nutrient fluid be not adequately increased, but, on the contrary, that ascendancy in the scale of organization keeps pace with the more numerous manifestations of life, we necessarily conclude that the blood in circulation must be alive, because it would be subversive to all sound physiological doctrine to suppose that a dead fluid became the source of vital functions; or, in other terms, that dead matter could be an "origo vitæ."

Having dedicated the preceding observations to a description of the blood's development in embryo, it now behoves us to elucidate the process by which the constant loss sustained by the blood in the renovation of adult animal structures is repaired.

That organized materials alone can serve as food to animals, and hence that the chyle is an organic fluid, are well-known facts. The means by which the alimentary substances are triturated in the mouth, there subjected to the action of saliva, and subsequently to the joint influence of pepsine and gastric juice in the stomach, are not appropriate changes for consideration in these pages; neither shall we stop to detail the processes by virtue of which the pancreatic and biliary secretions tend to separate the nutrient from the excrementitious matters, but shall commence by an examination of the chyle.

The chyle, procured from its appropriate conduits near the intestinal canal a few hours after the animal has been fed, is a white milky fluid containing water, salts, albumen, and numerous corpuscles, of which four kinds have been distinguished. First, a molecular base, containing very minute and numerous particles of a fatty nature ; secondly, a quantity of oil globules, varying in size ; thirdly, spherules, which are not acted upon by ether, but are probably of an albuminous composition ; fourthly, proper chyle corpuscles. In its onward course through the mesenteric glands, the chyle is susceptible of spontaneous coagulation, which proves the gradual increase of fibrin. It is a question of much interest, Whence is this fibrin derived ? Most probably it is by a conversion of albumen, which in chemical composition is very similar to it, but differs in its physical properties. Still, how fibrin is derived from albumen, cannot be precisely explained. According to some chemists, the change consists in an oxidation of the latter substance, while others view the chyle corpuscles as cells destined to elaborate the plastic material.

The proper chyle corpuscles become more numerous as the chyle advances onwards in its conduits ; and it is evident that they are all formed within the lacteals, because their size would impede their introduction from the intestine. Henle was of opinion that two or three fat molecules united to form a nucleus, over which a cell wall was developed, so as to perfect the chyle globule. Professor Goodsir, of Edinburgh, alleges that the epithelium lining the lymphatic glands is the source of the chyle corpuscles ; but, notwithstanding the merits of both these observers, we cannot decide the point until further investigations corroborate the views of the one or of the other.

When the chyle reaches the thoracic duct it receives, in addition, a colourless fluid named lymph ; which has been said by many physiologists to be composed of the *effête* materials of the body. Thus another obstacle is opposed to the doctrine that the blood is a living fluid ; because, if it be true that lymph is *effête*, viz. disorganized and useless matter, it is contrary to reason to suppose that it would be allowed to deteriorate the vital properties of the blood.

But I do not agree with the theory which inculcates lymph to be composed of the refuse materials of the organism. I contend that it contains the superabundance of nutriment conveyed to parts ; or, in other terms, that the tissues not appropriating the whole of the nutritious material which exudes from the capillaries, the excess is returned by the lymphatic vessels in the circulatory system, for the purpose of supplying, at some future period, the animal wants- In support of this opinion the following observations are offered :—

First. Lymph consists of a fluid with granules and white particles, similar to, if not identical with, the pale corpuscles of the blood. If the prevalent notion be correct, that the white particles are mainly concerned in nutrition, they must exist in the lymph, because not appropriated after their separation from the blood; for it is not possible that decaying tissue should resume the aspect and properties of those elements which were destined for its formation.

Secondly. Lymph being coagulable, no doubt can be entertained as to the existence of fibrin in it. From the fact that, in a state of health, the excretions are destitute of the fibrinous element, the idea suggests itself that lymph containing fibrin to a considerable amount cannot be *effête,* viz. destined to be thrown off as refuse.

Lastly. From a knowledge that all useless materials are rapidly separated from the body by appropriate excretory organs, whereas lymph flows into the great veins, whence it is conveyed throughout the whole course of the circulation, we infer that the lymph, in taking so circuitous a route, must be adapted to perform the functions of the circulating fluid; viz. to repair the loss of the animal tissues. Lymph cannot, therefore, be *effête,* but is obviously susceptible of organization.

This conclusion was arrived at by *à priori* reasoning upon the phenomena presented by the lymphatic system ; and it is satisfactory to add, that, since the above views were committed to paper, I have had occasion to test their truthfulness by a careful study of the most modern authors on physiology, who unexceptionally refute the supposition that lymph contains the *effête* materials derived from the organic textures.

In proportion as the fibrin of the chyle increases in amount, its albumen and oil particles diminish; and, simultaneously with the greater development of chyle corpuscles, the milky fluid acquires a reddish tint. This has generally been attributed to the production of red particles in the lacteal system; but, according to the researches of Mr. Lane, it depends upon the adventitious mixture of red particles in the operation performed for the obtainment of the chyle. Leaving this point, as yet somewhat undecided, we may remark, that no doubt can exist as to the eventual conversion of chyle corpuscles into red discs, in the mode already described when treating of the blood's development in embryo.

Abundant proof has thus been afforded of the blood's renovation by elaboration of the chyle constituents ; this change mainly consisting in the formation of organizable principles from solved and plastic materials, through the medium of repeated sets of corpuscles or nucleated cells. Since, therefore, it can no longer be questioned that the blood is endowed with the power of assimilation and self-reproduction, its vital properties are satisfactorily proved in accordance with the general law, that living objects alone are capable of reproducing their own species.

One of the most palpable and instructive differences between living and inorganic substances results from their comparative chemical analysis ; and we are accordingly informed that the striking feature of inorganic compounds is the simple ratio in which their elements unite ; whereas organic bodies are remarkable for the high proportions of their elementary combination. The qualitative analysis of Liebig, Mülder, and other chemists, demonstrates the fact, that the organization of a body, and hence its manifestations of life, are in direct ratio, nay, in inseparable relation, with the nature of its elements. Thus, while carbon, hydrogen, and oxygen are the constituents of vegetables, nitrogen is indispensable for the formation of animal tissues, and the exercise of their respective functions.

Based on these principles, one or two reflections suggest themselves on the chemical constitution of the blood, in search of additional testimony of its high organization and life.

When the primordial chyle is analyzed, it is found to contain binary, or at the utmost ternary compounds. Tracing it from its absorption into the lacteals (which is partly effected by endosmose, and through the intervention of cells in the intestinal villi) until its constituents are converted into cytoblasts and corpuscles, we have ample evidence of a quaternary and quinternary composition. If the cytoblast or nucleus be followed from its highest point of life in the more perfect tissues, through the successive stages of deterioration, unto its chemical aud organic dissolution, the retrograde steps are marked to the re-assumption of a binary combination of its elements. If, then, the blood gradually progresses in chemical constitution from its origin in the chyle to the accomplishment of its use in the repair of structures, the contemporaneous ascent of its vital attribute is a necessary result.

By the works which have emanated from the Giessen school, gelatine has been proved to occupy the lowest place in the scale of animal proximate principles; hence it must be admitted that tissues which contain gelatine are inferior in organization to those from which it is absent; and, insomuch as the blood affords no traces of gelatine, it is more highly organized, and, therefore, more truly vital than all those solids of the body into the formation of which gelatine enters as a necessary ingredient, and that in variable proportions.

The subject which now remains for examination is the coagulation of the blood, and its independent power of incipient organization into a fibrous structure.

When blood is abstracted from the vessels of a living animal, it gradually loses its fluidity, and forms a coagulum or clot, whence the serum is expressed. This change is so generally known, that it would be superfluous to expatiate on its stages; but it is the sum total of the causes which in any degree influence or prevent coagulation of healthy blood, and the peculiar arrangement of the clot, that demand our investigation.

That rest is not the only cause of the coagulation of the blood, is proved by agitating with a bundle of small sticks this fluid, when contained in an appropriate recipient; when, notwithstanding the constant movement, the fibrin solidifies in elongated strings. Neither is it by the influence of cold, or, more correctly, diminution of heat, that the clot is separated from the serum; since blood frozen immediately after its obtainment from the body coagulates as usual when thawed; and a clot is likewise formed, if the temperature of the blood after its withdrawal be kept up to its original standard.

Some chemists allege that heat and carbonic acid are evolved during coagulation. This statement needs confirmation, because the first-named is opposed by the negative results of Mr. John Hunter's experiments on the blood of the turtle; and, although it is certain that carbonic acid may be extricated from blood by chemical processes, still the question is doubtful whether that phenomenon occurs during ordinary coagulation.

Exposure to air is favourable to coagulation; but that even this is not the only cause is evident from the fact that an imperfect clot is formed *in vacuo,* and blood solidifies under oil, which precludes atmospheric influence.

The physical character of the blood is certainly modified by the contact of dead or living tissues; these do not, however, either prevent or cause its coagulation: clotted blood being occasionally met with in the cavities and even the bloodvessels of living animals, while it is not uncommon to find fluid blood in bodies whose life is extinct.

In our former remarks, decay and renovation have been alluded to as the prominent features of living bodies; and how admirably they are provided for by the circulation of a fluid conveying nutriment, has been demonstrated in reviewing the morphology of the vascular system from plants to the highest mammalian animals; and we have also proved that upon the circulation of the blood depend the first symptoms of life, for the support of which that fluid is required to preserve a definite form and quantity. When the demand made on the blood's function (as a source of nutriment or as a stimulus to vital actions) ceases, either by its being withdrawn from the body or by the influence of other circumstances operating on the system, it is but natural that the blood should no longer preserve that form of fluidity which was indispensable for the exercise of those functions, but which is no longer called for when they had ceased. Hence it is that fibrin, a solid in reality, and only a fluid "*pro tem,*" abandons its liquid state when no longer required to circulate in all parts of the body for its renovation and support, and assumes its own physical state as a solid concretion.

Moreover, the very act of coagulation, so often adduced as proof of the blood's degeneration, is the precise evidence of its independent power of organization. The assertion that in coagulating blood dies, namely, that the separation into clot and serum is the act of death, is as untenable on the part of those who admit the blood to be a living fluid, as it is on the part of the others who entertain the opinion that the circulating fluid is dependent for its homogeneity on the solids of the body; because the phenomenon of coagulation is not a mere cessation of one state and transition into another, as death is to life the instant of extinction, but a process with marked stages, gradually presenting, for a period of forty or fifty hours, a more beautiful aspect and a higher degree of organization, from a granulo-corpuscular mass to an intricate interlacement of fibres. The blood being, therefore, capable of self-organization, it is undoubtedly alive; insomuch as we have no example of a dead material being capable of assuming an independent organic form.

Having thus fulfilled our primitive intention of proving the blood's life upon physiological principles, we recapitulate in brief terms the evidence upon which that conclusion is based.

First. Blood is capable of self-development in embryo from primitive cells; in the adult, from the elements of chyle. It being a generally admitted principle, that living objects alone reproduce their own species, the former established facts prove that the blood is a living fluid.

Secondly. From an examination of the vascular system in various classes of animals, and the result obtained having demonstrated that the blood does not acquire a more complex composition in proportion as the demand for its nutriment increases, but in direct ratio to the ascent of the vital functions, we infer that the blood is alive, otherwise it could never be a source of vital actions.

Thirdly. The notable organic properties of the blood have been ascertained by a glance at its chemical composition; its life is, therefore, proved in accordance with the physiological axiom, that ascent in organic form implies activity of vital powers.

Fourthly. We conclude that life is a pre-eminent endowment of the blood from its capability to assume the character of an elementary fibrous structure, independent of the contact of dead or living tissues.

That death is the ultimate destiny of all beings which are endowed with life, and that in the performance of the varied functions for the maintenance of their complex constitution living bodies are liable to disease, or, in other words, they afford evidence of deviation from a state of health, are truths impressed on the mind of the most casual observer of animated nature. In addition, therefore, to the physiological statements already advanced to prove that blood, being a living fluid, likewise dies, we now have to demonstrate by facts, what, *à priori*, cannot be denied,—that, if life be an attribute of the blood, it must occasionally betoken symptoms of disease.

Acknowledging analytical research to be the safest, and therefore the most profitable, mode by which scientific truths can be established, we shall pursue that method of inquiry in the hope that the disease of the blood (as a whole) may be made more clearly intelligible, when we shall have endeavoured rationally to investigate the pathological results of alteration in the quantity or perversion in the quality of the blood's constituents.

The vivifying influence which the blood exerts on the system is in a great measure due to its red particles; this being proved by the fact that, when these are absent from the nutritient fluid of animals, they become torpid, and their functions are comparatively inactive; *vice versâ*, vigour of body and functional activity are invariable sequelæ of an abundance of red blood discs: it is, therefore, obvious that, if the blood contain an undue amount of red particles, its stimulating influence on the organism will be increased, and thus will be laid the foundation or predisposition to disease of an exciting character. In animals this excess is betokened by the red colour of the conjunctiva and caruncula lachrymalis, which is the concomitant of general systemic plethora; and experience corroborates what theoretical reasoning would have led us to suppose, that by lowering the amount of red particles, and thus impoverishing the blood, fatal maladies may be averted.

To the veterinary practitioner, and likewise to the farmer, it is well known that, when young cattle are "thriving fast," certain precautionary measures require to be adopted for the prevention of a devastating malady designated "Black Quarter," or "Quarter Evil." The means employed are, blood-letting, aperients, and the use of counter-irritants, such as the insertion of a piece of hellebore root or a seton in the dewlap. The *modus operandi* of these curative measures, and their efficacy in preventing the malady, throw light on its pathological nature.

One of the most prominent results of venesection is a diminution in the ratio of red particles; because, by decreasing the total bulk of the circulating fluid, we favour endosmosis from the interstices of the tissues into the vessels. Now, if we bear in mind that the red particles are reproduced with greater difficulty than any other constituent of the blood, it is clear that, as the loss of the watery element is compensated for by absorption, the red discs must relatively decrease in amount, because not proportionately regenerated.

The diminution in the proportion of fibrin in the blood, when the formation of pus is induced in any part of the system, is explicable in accordance with the chemical composition of these fluids, the latter product being derived from the excessive oxygenation of the former proximate principle ; but how the purulent discharge should more especially waste the red particles, is not so easily accounted for ; nevertheless, it is a fact unquestionably confirmed by the pallidity which follows excessive suppuration both in man and other animals.

When the prophylactic means before alluded to are neglected, it frequently occurs that among many of the most thriving beasts of a herd "black quarter" rapidly spreads. This malady, regarded by Youatt as inflammatory, by others as gangrenous fever, I attribute to a diseased state of the blood, and that for several reasons :—1st, It may be prevented by the adoption of measures which directly exert their influence on the blood. 2dly, Prominent symptoms during life are local heat and interstitial effusion into parts which rapidly die. This cessation of life may rationally be referred to the diseased state of the circulating fluid, since the parts do not exhibit signs of disease until their increase in heat or bulk betokens the sanguineous congestion and subsequent extravasation. 3dly, The principal pathognomonic change witnessed in cadaveric inspection of animals which have fallen victims to the affection, is general congestion of viscera and tissues, with effusion into the various cavities, and a great tendency to speedy decomposition.

That these changes are not the result of inflammation we infer from the rapidity with which the malady runs its course, and the great prostration of the vital powers evinced soon after its commencement. To the term "gangrenous fever" we object ; because, although the febrile symptoms are accompanied by a great proneness to mortification of the tissues, yet, neither the fever nor the local gangrene being the primary elements of disease, we cannot adopt a name which might deceive as to the pathology of the affection without, at the same time, indicating the principles on which it can be treated. For the previously adduced reasons, we are of opinion that black-quarter owes its origin to a superabundance of the plastic element and red particles of the blood, which, for want of adequate expenditure in the function of nutrition, and of purification by the secretory and respiratory apparatus, accumulates within the body and becomes deteriorated in quality. To this explanation an apparent obstacle may be the local seat of the disease at its onset, viz., swelling, heat, and pain in the hind quarters and lumbar region, or occasionally in the muscular substance of the fore extremity. These symptoms are referrible to the inability of the heart to propel the current of blood, and its consequent accumulation among immense masses of muscles through which so large an amount of this impure fluid circulates.

The principles for the treatment of black-quarter, according to the preceding views of its pathological nature, may be classed under four heads:—1st, Removal of the impure blood. 2dly, Artificial support to the system to compensate for the defect of a nourishing and vivifying blood. 3dly, Attendance to the local effects of extravasation and menacing death. 4thly, The adoption of such measures as will ensure the reproduction of a pure vital fluid while the bad is being eliminated.

The first object may be effected in a twofold manner; by venesection (which is to be had recourse to sparingly on account of the supervening debility), and the use of evacuants, which tend to purify the blood by increasing the various secretions. Stimulants, such as the spirit of nitric æther or liquor ammoniæ acetatis, are indicated under the second head with the view to maintain in vigour the nervous system, whose prostration, in consequence of a want of pure arterial blood, may be regarded as the immediate cause of the rapid death of the tissues, and, in fine, of the extinction of animal life. So soon as local extravasations occur, it will be prudent to evacuate the fluid by free incisions, and to employ disinfectant agents followed by friction, in order to promote the local circulation; and lastly, when the urgent symptoms are abated, the reproduction of pure blood may be facilitated by keeping the animals in well-ventilated and light stables, and administering nutritious food, or on dry pastures, where luxurious herbage does not immoderately abound, attending particularly to the state of the secretions. As adjuvants to this system of hygiène, chalybeates should be daily administered, on account of their well-known efficacy in favouring the reproduction of the red particles of the blood.

In pursuance of our adopted plan, having considered the effects of an increase of the red blood discs, we shall now advert to the consequences of their deficiency. Such defect is a proximate cause of diseases of a debilitating or asthenic character, and therefore requires to be counteracted by those means which may promote the formation of red particles by maintaining the functional activity of the internal organs. But as the notable effects of that deficiency are most obvious when the blood is also poor in fibrin, we shall defer their consideration until we examine the alteration in the character and proportion of the fibrinous element.

Under ordinary circumstances the proportion of fibrin contained in the blood varies from 2 to 4 parts in 1000. The fact that arterial blood is somewhat richer in fibrin than venous, denotes the rapidity of the process of fibrinous formation, and adds support to Mülder's theory of the composition of fibrin; namely, that it is an oxy-protein, or rather, a deutoxide of protein, formed by the oxygenation of albumen in the lungs.

The characteristic property of fibrin being that of spontaneous coagulation, we might at once predict that, when it exists in the blood withdrawn from an animal in excess, the clot will be compact, and assume a more organized form than usual. Accordingly we find that the process of coagulation is very marked in inflammatory blood, which always contains an undue proportion of fibrin. Excess of this principle is unboubtedly a predisposing cause to inflammation, which may frequently be prevented by moderating a plethoric condition of the system. But even when excess of fibrin in the blood is not the direct cause of inflammatory disease (and therefore our success in preventing the latter does not depend upon impoverishing the former), still the rapid formation and accumulation of fibrin in the blood, when once inflammatory action has originated in any one part of the system, is a means by which the diseased condition is prolonged, and its consequences aggravated; because the circulation of a vital fluid, whose nutritious element is in excess, is a source of undue excitement to the functions generally, but more especially to that of nutrition; the abnormal exaltation of which is the fruitful origin of the ravages of inflammation, as indicated by depositions of lymph, which according to its quality, whether plastic or aplastic, becomes converted into adhesive bands or membranes, abscesses or other morbid products.

Although inflammation may not owe its origin to any change in the composition of the blood, nevertheless it must be evident, for the reasons adduced in the preceding paragraph, that, as a too rapid production and accumulation of fibrin are immediate consequences of an inflammatory attack, and proximate causes of its unfavourable terminations, so must remedies be directed to the modification of the constitution of the blood, if, as rational pathologists, we are desirous of mitigating the cause as the most certain means of averting the effect.

If, as a general principle in the treatment of inflammation, the superabundance of fibrin in the blood is to be moderated, let us inquire into the causes of that excessive production of the plastic element. Adopting Dr. Williams' definition of inflammation, that "it consists in the existence of too much blood in an organ or tissue, with motion partially increased and partly diminished," expressing the same sentiments in more explicit because more familiar terms, we may say, that while the vessels in the centre of an inflamed part are congested, nay perfectly blocked up, the collateral circulation is preternaturally accelerated. The vital fluid, whose motion is arrested in the centre, is exposed to the influence of blood which in the adjacent vessels circulates with unusual rapidity. Congestion—arrest of the blood's flow—implies suspension of its main function,—that of nutrition; consequently the albumen in the obstructed vessels remains unexpended. Whether we adopt the original view of Liebig that the red particles are the carriers of the oxygen in the blood, or his more modern theory, which attributes that function to the tribasic phosphate of soda; or finally, if we adopt Mülder's notion, that the oxygen in the blood is in combination with the protein, without committing ourselves to any one of these views in particular, by the common consent of all, it is clear that, as an excessive amount of blood circulates through an inflamed part, so must an undue proportion of oxygen be carried through it; and thus the albumen contained in the obstructed vessels in the centre being exposed to incessant oxygenation, is converted into fibrin, and this, becoming diffused by the circulating blood, adds considerably to the normal amount of the fibrinous constituent.

But, in addition to this local formation of fibrin in an inflamed part, its accumulation in the blood may be explained on two other principles. 1st. One great condition to the performance of the nutritive function being the slow movement of the blood in the systemic capillaries, taking into consideration the rapidity with which the whole mass of blood flows during inflammation, we perceive that its fibrin cannot be expended in the nourishment of the textures, and therefore superabounds in the blood. 2dly. It is a fact cognizant to all those who have even superficially glanced at the various symptoms of disease, that as a concomitant of inflammation the respiratory function becomes excited: this implies the absorption of more oxygen than usual in the lungs, and therefore the general process of fibrinous formation or the oxygenation of protein will be exalted.

In accordance with this explanation of the causes to which the excess of fibrin in inflammatory blood is attributable, we are now prepared for the investigation of the remedies by which it can be counteracted. Experience, in support of common reason, teaches us that this object is attainable by two great means; 1st, by venesection, which absolutely lowers the amount of fibrin in the system; 2dly, by withholding the supplies of nutriment whence fibrin may be obtained.

But are there no means by which that excessive oxygenation in the vessels may be counteracted? A definite and satisfactory reply cannot here be offered; but we are disposed to attribute the beneficial effect of the compounds of antimony in reducing inflammatory diathesis to their depriving the circulating fluid of its excess of oxygen. Medical men in England, as well as on the continent, have for a long time ranked antimonial compounds among the most valuable antiphlogistics, and we would suggest that their administration in small and frequently-repeated doses be more generally adopted in veterinary practice.

As one of the various means by which the blood of a patient labouring under inflammation may be impoverished, counter-irritation may, doubtlessly, be had recourse to with considerable benefit, and particularly when those agents are employed which tend to a speedy formation of pus. But while we recognize counter-irritants to be potent means in mitigating an inflammatory attack existing in an internal organ, we must advance an objection to their employment in the acute stage of the disease; and when sufficient time has not been allowed to transpire for the general febrile excitement to be reduced by antiphlogistic remedies, of which blood-letting is certainly the most potent.

When a counter-irritant is applied to any one of the patients that come under the care of the veterinary surgeon, several hours must elapse before a discharge of pus can be procured. In this interval local inflammation is set up around the spot where the blister or seton has been applied; and according to the theory previously established by us, that wherever local inflammatory action exists there oxidation of protein and the formation of fibrin progresses, it follows, that the counter-inflammatory action artificially induced will be a means of augmenting still more the proportion of fibrin in the blood, thus increasing the primarily existing inflammation and febrile excitement before any benefit is derivable from the purulent discharge. For the same reasons rubefacients are objectionable when it is desired to counteract inflammation in an important organ, because the revulsive effect which they induce is but slight, and they afford no relief by promoting suppuration; but, on the contrary, in virtue of the irritation which they set up, add to the state of general excitement by accelerating the local circulation, and thus favouring the production of fibrin.

If counter-irritation be had recourse to after the acute inflammatory attack has been partially subdued, we may reasonably expect beneficial results from the discharge induced, without any fear of aggravation of the previous disease, or the too rapid extinction of life, by the high state of inflammatory fever which is kept up by the increased supply of blood (containing fibrin in excess) sent to the nervous centres.

The superabundance of fibrin in the blood during inflammation is one of the prominent causes in the maintenance of that diseased action when it is once set up; and, therefore, such remedies as we have already alluded to must be employed in order to restore the vital fluid to its normal composition. In many instances, however, it behoves us to take into account the various terminations of inflammation, for the purpose of guarding against those which endanger the integrity of important organs before time is allowed for the gradual mitigation of the disease. Of these terminations the most dangerous is, perhaps, that of an effusion of plasma, the fibrin of which coagulates and interferes with functions whose exercise is indispensable to animal life. It follows that, to prevent this untoward result occurring, the prevention of the effusion, but more especially of the coagulation of fibrin, are important objects to be attained. Both mercury and opium have been long advocated, and are much extolled by practitioners of human medicine as medicaments of the greatest service in preventing extravasation taking place; and we are, therefore, warranted in giving a more impartial and general trial to this plan of treatment than has hitherto been awarded to it by veterinarians as a body.

In search of agents which may prevent the consolidation of fibrin, let us first inquire if that process can be in any way retarded out of the body. Alkaline carbonates in general, but particularly the nitrate and carbonate of potass, effectually prevent the clotting of blood if mingled with it immediately after its withdrawal; and, by the testimony of both continental and English physicians, we know the great good which is derived from the use of saline compounds in the treatment of inflammation. Basing our opinion on the foregoing explanation of the *modus operandi* of those agents, we recommend their employment, in frequently repeated doses, in those diseases generally where the consolidation of fibrin is to be dreaded; and especially in such an affection as pleuro-pneumonia in cattle, the most fearful result of which is the destruction of the structure of the lung, and consequent annihilation of its function by fibrinous deposition.

In the ulterior prosecution of our object, i. e., that of rationally investigating the signs, effects, and mode of treatment of perversion in quality and quantity of the blood's constituents, it is necessary to bear in mind the all-important physiological principle, that the health of the animal frame depends on the activity of the secreting organs in removing superfluous or impure matters from the vital fluid. Torpidity of any one of the secreting functions necessarily implies a redundance of noxious material within the blood, or the occurrence of serious consequences to the whole body, as sequelæ of the suspension or arrest of the uses which those secretions were subsequently destined to perform. In the former instance positive injury is done to the nervous system, and life impaired by the *éffête* material which the blood contains; an example of such evil resulting is the comatose state that follows upon the accumulation of urea in the system when the urinary apparatus is suffering under acute functional or organic disease. The suppression of the respiratory function, by preventing the conversion of venous into arterial blood, likewise precludes the possibility of life being prolonged beyond a very short period. These changes in the quality of the blood have long engaged the attention of medical inquirers of all classes, on account of the suddenness of their occurrence, and the intelligible manner in which they are the source of such imminent disasters. But it is to the more gradual perversion of the blood, or, rather, to the protracted imperfection of its purification by the secerning organs, that I am now desirous of alluding, in order to demonstrate the importance of taking minute cognizance of the effects of external agents and internal functions on the quality of the blood, so as to establish a sound and profitable, because scientific and well-based, system of veterinary pathology.

In the category of diseases to which the ovine race is subject "Rot" has long held a prominent place. The post-mortem appearances presented by animals which fall victims to it being effusion into the cavities, and an organic disease of the liver, undivided attention has been paid to these pathognomonic changes as constituting the real essence of the malady.

Subscribing to a prevalent opinion that the organ originally diseased in "rot" is the liver; protesting, however, against Mr. Youatt's statement, that the affection primarily assumes an inflammatory type, it is necessary to inquire how derangement of the function of that organ can produce such effects on the animal economy, and then to deduce principles applicable to medical treatment.

When a farmer or shepherd examines sheep for purchase he is accustomed to look at the inner canthus of the eyes. If the parts there existing are of a florid red colour (in the absence of all other signs of disease), the animals are pronounced sound; if, on the contrary, a pale or yellowish tinge is presented by the caruncula lachrymalis and conjunctival membrane generally, the sheep are condemned as being tainted with the "rot."

Another well-known incident is, that sheep thus betokening an incipient attack of the rot, for a short time rapidly accumulate fat; and so well was Bakewell aware of this fact, that, with a love of lucre which overcame his regard for honourable dealing, he was in the habit of placing his improved sheep on land which was favourable to the production of this disease, in order that the animals might accumulate flesh, and yet be unfit for breeding purposes when disposed of in the market.

Connecting these two important facts, additional proof is derived in support of the belief that the liver is primarily affected. The pale colour of the conjunctiva may either depend upon a retention of the biliary constituents in the blood, or upon the diminished number of red particles, the results of imperfect chylification and sanguification, when bile is no longer secreted, or, at least, imperfectly so; whereas the accumulation of adipose matter is referrible to a non-elimination of hydro-carbon from the system by the liver, and its consequent accumulation in the form of fat. A moment's reflection will suffice to shew that, even in this early stage, the composition of the blood is impaired. The inability of the liver to perform its normal function, and the resulting retention of hydro-carbon, implies its accumulation in the blood; and although we have no proof that choleic acid exists in the vital fluid, yet it is certain that if the liver does not separate and elaborate its elements they must remain in the circulation and alter the qualities of the blood.

That these explanations are not merely theoretical, but based upon fact, is demonstrable by tracing the cause of the functional derangement of the liver. It is on low rich pastures that rot mostly prevails, and especially after a wet summer and autumn, when the herbage is unusually forced and of a succulent character. The grass having rapidly sprung up contains less of the really nutritious principles of the vegetable, but from its succulent character abounds in the elements of saccharine matter, the chief of which are carbon and hydrogen. To the liver pertains the duty of eliminating these elements from the system; and it is no wonder that, when so large an amount of labour is thrown upon this gland, that its secreting powers should become exhausted, and functional derangement ensue. We thus dispense with the gratuitous hypothesis of those who attribute rot to "miasm," or to "peculiarity of climate," and we recognize as its cause the quality of the herbage operating in an intelligible manner on the liver.

The uses of the bile in the digestive process are no longer fulfilled when its secretion is imperfectly performed, and hence in the progress of rot the animals become emaciated from an improper preparation of the material whence new blood is to be formed. It is, moreover, a point worthy of remark, that one of the prominent features assumed by the animal secretions when the function of the liver is arrested, is an acid reaction ; and in a case of dropsy, accompanied with organic disease of the liver, I have been able to ascertain the acidity of the effused fluid.

Consequent upon this improper formation and purification of the blood, its albuminoid constituent becomes deficient, i. e. the vital fluid acquires a watery character at the expense of its normal viscidity. It is an admitted fact, that a certain thickness is favourable to the circulation of the blood in its conduits ; and we can, therefore, explain the effusion into the various cavities, as a sequela of the superabundance of the watery element, with a deficiency of albumen, which prevents the equable diffusion of the vital fluid throughout the numerous meshes of the vascular network.

Briefly condensing our opinions as to the pathology of rot, we admit, in the first place, that it owes its origin to functional derangement of the liver ; secondly, we view the effects of the ailment of that organ as threefold :—1st, A non-elimination of hydrocarbon causes an accumulation of fat in various parts of the system. 2dly, In consequence of the blood being improperly purified, the secretions acquire a decidedly acid character ; and, lastly, the process of sanguification being interfered with by interruption to the flow of the bile, the composition of the blood becomes so altered as to be unfit for the support of the organism ; and, as the result of the watery character of the vital fluid thus induced, it does not flow uniformly in the vessels, but has a tendency to extravasate through their coats.

The principles which are to be our guide in the treatment of rot, simply resolve themselves into the restoration of the function of the liver, and the removal of those effects which exist as the sequel of diseased action; first, however, removing the animals from the pasturage where they have become affected, and allowing them to graze on well-drained land. As a cholagogue purgative, calomel may be of service in the early stage; but when the functional derangement of the liver has become chronic, useless attempts to restore that gland to health by the adoption of active measures are to be avoided, and we are rather to aim at the attainment of that object by purifying the blood through other means. The use of diuretics is certainly advisable, and based on the fact, that the secretions have an acid reaction when the liver is functionally deranged, alkaline agents, such as the carbonate of potass should be administered, in order to afford an additional quantity of base which may unite with the excess of acid in the system, and thus facilitate the elimination of the *éffète* material. The chloride of sodium has also been long recognized as a valuable medicament in the treatmeat of rot. Its beneficial agency may be explained by its tonic effect on the digestive organs; or (when administered in large quantities) by its causing exosmose from the intestinal vessels, thus diminishing the amount of the watery element in the circulation.

To counteract the debility which supervenes as rot progresses, a tonic plan of treatment should be had recourse to; and with this view we advise the administration of diluted nitric acid in the proportion of from twenty to thirty drops of acid to six ounces of water. Nitric acid is certainly an invaluable tonic, and its efficacy in promoting the formation of firm flesh may probably depend on the large amount of oxygen it contains in loose combination, and which it yields up in aid of the respiratory function, for the combustion of hydro-carbonaceous matters, and the oxidation of protein, so as to form the more elevated proximate principles that enter into the composition of the animal textures.

Having already exceeded the limits within which it was intended to confine this Essay, I cannot abstain, in conclusion, from advancing a few reflections, which may attract the attention of some members of the profession to the importance of the subject here discussed, and to the baneful effects which must inevitably follow if the veterinary surgeon be not acquainted with the uses and diseases of the fluids as well as of the solids of the body; and how abortive must be all endeavours to found a scientific system of horse and cattle pathology, unless the normal and abnorma' states of the blood, as well as of the organic tissues, be made the theme of persevering study, the subject of profound consideration.

For a long time did humoural pathology exercise an unrivalled sway over the minds of the followers of Æsculapius ; but its errors were too numerous to bear up against the attacks of enlightened men of modern times. No sooner were some of the humouralist's theories justly discarded, than medical men at once overthrew all that ages had believed, and the doctrines of solidism totally supplanted the assailed opinions, these being admitted as true, to the exclusion of all others. But here was the error. Extremes are always prejudicial. Such, however, are the exhilarating effects of novelty to man's mind, that newly conceived and even extravagant notions often suffice to annihilate the work of ages, before mature judgment regains dominion over transitory hypothesis or too sanguine expectations. Such was the case at this period of medical science. From humourism to the theory of solidism was a precipitous step, and one which could not fail to lead to inductions partially true but too hastily established. As science has progressed, it has accordingly been proved that, although disease in the fluids is frequently the result of pathognomonic changes in the tissues, yet occasionally it is independent of any such cause, and that many of the affections to which the animal organism is subject are consequent on a vitiated state of the blood, either in its physical properties or chemical relations.

Veterinary science having been for the first time cultivated in England, with any marked degree of success, about sixty years since, precisely at the period when the dispute was rife between the olden theory of humoural disease and the modern one of solidism, the result has been, that the followers of our common art having gradually adopted those innovations. no one has ever sought to investigate their truth or repudiate their error. True it is, that in some treatises on horse pathology, and by an early and distinguished teacher of veterinary science, Professor Coleman, some forms of disease were attributed to the blood, but such surmises (for in reality they were nothing more) have eventually fallen into oblivion with the decease of their propagators, who merely alluded in ambiguous terms to " a poisoned condition of the blood," without demonstrating the nature of such perversion, or the mode of counteracting it.

We have already alluded to the fact, that on the quality and quantity of the blood the animal organism depends for its maintenance in health; it is, therefore of the greatest importance to afford the necessary conditions for the blood's elaboration and support, in order that, while animals advance in health and perfection adequate to the services required from them, those diseases may be averted which depend upon excess, defect, or perversion of any of the constituents of this fluid. For this purpose, not only must the atmosphere be pure from the deteriorating effects of respiration and ammoniacal exhalations, but such food must be supplied as will afford the greatest quantity of nitrogenized principles, whence pure blood for the composition of the tissues may be elaborated; and the least of those materials, which from their physical or chemical properties, may deteriorate the quality of the vital fluid; and here is a topic of high importance to the veterinary surgeon, not only as a mitigator of disease, but as a scientific economist in busy towns or agrarian districts.

It is futile to say that the veterinary surgeon does not require a profound knowledge of agricultural botany, of the precise quantity of animal food which various plants supply, and of the properties of the soil whence they are produced; that to him, hygiène, agricultural chemistry, and the fundamental principles of rural economy are superfluous. Should some one assert that the pursuit of these studies would be lowering the grade of the vocation of the veterinarian, I would reply, as his aim and object is that of curing disease, will it not be one great step obtained to prevent it? And as it is the duty of the veterinary surgeon to diagnose and to treat disease, will he not be more likely to succeed in his endeavours if he can strike at the root of the malady by removing its cause, and aid in repairing the losses, not only of the tissues but also of the blood, which is so frequently the original seat of disease? And if it be the veterinary surgeon's desire to fill an honourable station in the scientific world, and to be acknowledged as a useful member of society, will he not enhance the fulfilment of that noble endeavour by adding to his achievements as the fortunate conqueror of maladies, his conscientious claim as the safe adviser of means to avert them?

However much I may have been desirous of demonstrating that the blood, being a living fluid, and consequently subject to death, is likewise liable to disease, yet to complete such a task by a first attempt 'tis in vain to hope. The VITALITY OF THE BLOOD being admitted, its susceptibility to disease cannot for a moment be doubted ; and notwithstanding the imperfect manner in which the important truths connected therewith may have been here expounded, still let it be remembered, that this humble tribute to veterinary pathology is dedicated by a veterinary student—by one who is desirous of promoting the establishment of a rational and scientific system of veterinary pathology in accordance with physiological principles ; and he sincerely trusts, that in refuting any errors with which these pages—in common with all human productions—may be imbued, and substituting more correct positions, the older and more distinguished members of the profession will not be unmindful of this, while their acknowledgment of his endeavours will repay the author's most sanguine expectations.

EXPLANATIONS TO PLATE I, VOL. V.

Fig. 1. Ovum from a rat at the period of œstrum, magnified 280 diameters.

a. zona pellucida. *b.* very pale yolk. *c.* germinal vesicle. *d.* germinal spot, seen by very strongly refracting light, after Bischoff *(Annales des Sciences Naturelles,* 1846.)

Fig. 2. A. Ovum of a bitch from the Fallopian tube, half an inch from its opening into the uterus, shewing the zona pellucida with adherent spermatozoids; the yolk divided into its first two segments, and two small granules or vesicles contained with the yolk in the cavity of the zona. B. Ovum of a bitch from the lower extremity of the Fallopian tube: the cells of the tunica granulosa have disappeared: the yolk is divided into four segments. C. Ovum of a bitch from the lower extremity of the Fallopian tube, in a later stage of the division of the yolk. D. an ovum from the uterus: it is large, the zona thicker, and the segments of the yolk are very numerous. E. Ovum from the lower extremity of the Fallopian tube, burst by compression; the segments of the yolk have escaped, and in each of them a bright spot or vesicle is visible. After Baly *(Supplement to Müller's Physiology.)*

Fig. 3. Portion of the germinal membrane of a bitch's ovum with the area pellucida and rudiments of the embryo, magnified ten diameters.

A. germinal membrane B. area vasculosa. C. area pellucida. D. laminæ dorsales. E. primitive groove, bounded by the pale pellucid substance of which the central nervous system is composed. After Bischoff *(Entwickelungs-geschichte des Hurde-eies.)*

Fig. 4. *a.* represents the dorsal structure of the embryo. *b.* the amnion. *c.* the yolk sac. *e.* the vitelline duct. *o.* the urachus. After Müller *(Elements of Physiology, Vol. II.)*

Fig. 5. Heart of an embryo chick, 32 hours after incubation.

a. the cavity of the organ. *b.* is the spot where the two sides of the heart appear to join. *c.* line of demarcation between the auricle and ventricle. After Prévost and Lébert *(Annales des Sciences Naturelles,* 1844.)

Fig. 6. Heart of an embryo chick of 48 hours.

a. is the bilobed auricle. *b.* ventricle. *c.* apex of the heart. *d.* bulbus arteriosus. *e.* commencement of the aorta. After Prévost and Lébert *(ibid.)*

Fig. 7. Anterior view of the heart of a chick 140 hours after incubation.

a and *b.* the auricles. *c.* the left ventricle. *d.* the right ventricle. *e, e.* the aorta. *f, f.* the pulmonary artery. After Prévost and Lébert *(ibid.)*

Fig. 8. Embryo of a bitch at the 23d or 24th day, magnified two diameters. It shews the network of bloodvessels in the vascular lamina of the germinal membrane, and the trunks of the omphalo-mesenteric veins entering the lower part of the S shaped heart. The first part of the aorta is also seen. After Bischoff *(ibid.)*

Fig. 9 *and* 10. Capillaries in process of formation in the larva of the frog.

a. capillaries permeable to blood. *b.* nuclei attached to the inner surface of the membrane. *c.* bodies of the radiating cells. *d.* nuclei of these cells uniting with offshoots from vessels already permeable to blood. *f.* offshoot from a capillary. *g.* red corpuscles. *h.* pale corpuscles of the blood. After Koelliker *(Annales des Sciences Naturelles,* 1846.)