AN

INQUIRY

INTO

THE NATURE AND CAUSES

OF

ANIMAL HEAT

AND

INFLAMMATION,

BY

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PART I.

When we contemplate the influence of caloric, over all bodies, animate and inanimate; and the impossibility of exhibiting any substance independant and unconnected with it; we feel the necessity of admitting, that the varied changes induced by its subtile and extensive agency, are real, and not unsubstantial, or exaggerated ideas of an imaginary power. By it the ponderous element of water is made buoyant in air; and, wafted by the winds, seeking, as it were, those places where its presence is most required; its onward course becomes suddenly arrested by an acquisition of caloric from some part of the earth barren from drought; by which, its buoyancy being increased, straight, it seeks the more elevated regions of the atmosphere, "where eternal cold prevails," to whose condensing power it yields its wings; and again assuming its original form, it descends in grateful showers, restoring to life and health the drooping tribes of vegetables which hung fainting over the feverish and sapless bosom of the earth. Through every stage of animal existance, from its commencement to the period of its close, we have an opportunity of observing, how inseparable

from action, how closely interwoven and identified it is with the springs of life and animation. By its presence or absence, increase or diminution, is the action of the punctum saliens, (the nuncleus from whence life emanates in the chick) regulated; by it, all its parts are in due time developed, and made perfect. On it, not only the existence of the fœtus in utero depends, but, by its operation, the gradual expansion or growth of the embryo is promoted; till at length complete in all the parts requisite to support the functions of life, it is detached from its parent connection, and ushered into a new medium, where new wants arise, to supply which, new actions are indispensible. Now it is that the genial warmth which imparted life, and supported organic action, first fails: and now it is, that the lungs (hitherto unnecessary) first contribute their aid in support of Animal Heat, without which life had ceased e'er it had well begun.

To sustain the living actions, imparted by the steady and uniformly high temperature of the womb, some independant source of caloric, sufficient to meet the vicissitudes of heat and cold, to which all animals are more or less exposed, became necessary. Accordingly we find, that all beings possessing life, and action, are furnished with organs capable of procuring them that portion of heat which best suits their several necessities: some are dependant on one set of organs, frequently varying in structure and locality; but constant and uniform in the production of the effect required: while others composing the tribe of hot blooded Animals, derive their high temperature from a double source, respiration and vascular action. The first of which claiming a precedence from the universality of its application, comes here more properly under consideration.

The necessity for atmospheric air to all animals provided with lungs, has been long known, and admitted. But later experience has proved, that all the inferior classes of animals equally stand in need of an atmosphere of which oxygen constitutes a proportion; on which they are found to produce changes, similar to those effected by respiration in the upper classes.

Experience has also taught, that animals, immersed in air not containing oxygen, produce no change on such air; nor can respiration be supported by it. The muscles whose office it is to guard the approach to the lungs, steady to their trust, resist its admission; nor are they to be influenced by the weight of the gas, as generally supposed, for the lungs are found equally collapsed from the presence of hydrogen, nitrogen, or carbonic acid; the two former of which are lighter, the latter heavier than atmospheric air.

The changes produced on oxygen gas, by an animal confined in a given portion of it for a sufficient length of time, are ascertained, by the experiments of Spalanzani, Voquelin, and others, to be as follows: 1st Its qualities are altered, 2nd Its bulk is diminished; that is, the oxygen disappears, and its place is found to be occupied by carbonic acid. A train of accurate experiments instituted by Ellis, have established, that this change is effected by a chemical union of the oxygen with the carbon: which he has satisfactorily proved to be furnished, not only by the lungs of animals, the gills of fishes, the breathing pores of insects, and the surface of every portion of living matter; but also by any dead animal substance if moistened.*

* See Ellis's enquiry into vegetation and respiration.

The next object was, to ascertain if any of the oxygen which had disappeared in the experiment, was absorbed: the probability of which was suggested by the bulk of the air having been diminished.

Bichat states (from experiment) that air thrown into the blood-vessels, induces agitation and convulsions, succeeded by death. Doctor Girtanner having injected oxygen gas into the jugular vein of a dog, saw him expire, after labouring for a few minutes under evident bodily torture and hurried respiration. If air be forced with a syringe through the wind-pipe into the lungs, and made to enter the blood-vessels; agitation and unusual uneasiness are produced in the animal; and if an artery be opened, even in a distant part, blood mixed with froth and air springs out *. From these experiments, and indeed the anatomy of the parts themselves, we may fairly conclude, that air does not enter the blood-vessels, while the natural course of action continues uninterrupted

On the supposition of an absorption of oxygen, therefore, the loss in bulk sustained by the gradual conversion of that gas into the carbonic acid in respiration, cannot be accounted for. But if we consider what it is that gives greater volume to one gas, than another; if we consider that caloric is in a state of chemical combination in the gases, and that a chemical decomposition has taken place when oxygen combines with carbon to form the residual gas in respiration, which gas is more dense than oxygen; we can have no hesitation in deciding, that it is to the loss of caloric, and not to the absorption of either gas, that the diminution in bulk is really attributable.

* Bichat sur la vie et la mort.

We have seen, from experiments of the celebrated Characters before mentioned, the introduction of any gas into the blood-vessels, followed by such a train of symptoms, as renders the idea, that air constitutes any part of the contents of the vascular system, totally inadmissible. But, there can be no difficulty in conceiving the transmission of caloric through the membranes and coats of the vessels placed between the inspired air, and the blood. In this way only can the difference in the bulk of the residual gas, caused by the loss of a portion of caloric, which is set free by the decomposition of oxygen and subsequent formation of carbonic acid, which is specifically heavier, and measures less, be satisfactorily or scientifically explained.

Proceeding to examine the effects of the caloric thus disengaged in respiration; we find, that the blood returned to the heart by the venæ cavæ, undergoes a remarkable alteration in its passage through the lungs where it exchanges its dark colour for the bright red of arterial blood, as it is usually but perhaps improperly called; for, this florid colour is not peculiar to the arteries; since, under the influence of some circumstances, of which we will take notice in their proper place; it is found florid in the veins, and dark in the arteries. A change similar to that, which the blood experiences in the lungs, is produced by exposing dark blood, out of the body, to oxygen gas, nitrous oxyd, or atmospheric air: from all of which, a portion of oxygen disappears, and is converted into carbonic acid.

But, blood, exposed to nitrogen gas, remains unchanged, as well as the gas, which is unaltered in quantity and quality. The same is also ascertained to be the case with every other gas. A change of

colour similar to that which the blood undergoes by exposure to oxygen, will take place, if it be covered with a moistened bladder, serum or albumen; all of which are proved, by the experiments of Ellis, to furnish carbon, as well as the blood. But, if blood be covered by a thin stratum of water, no alteration will be produced on its dark colour. The water itself does not furnish carbon; and the small proportion of atmospheric air contained in the quantity of water employed in the experiment made by Ellis, is not sufficient to produce the change. The frequent and rapid movements of fishes, together with the almost constant action of the gills on the water, brings them in contact with a quantity of atmospheric air, sufficient to produce the usual change of colour in the blood, which is not effected by a thin stratum of water.

The experiments of Ellis, not only prove the conversion of oxygen into carbonic acid in respiration, but, they are also conclusive in demonstrating, that the entire of the oxygen employed, is converted into carbonic acid; provided, the animal lives sufficiently long. Now, as the entire of the oxygen (except a portion of its caloric, the loss of which is just sufficient to explain the difference in density between the gases) is converted into carbonic acid; the blood absorbs no oxygen from the air; nor, can it receive any thing, but caloric; since nothing else is lost in the experiment. Therefore, we may fairly conclude that the alteration in colour, which the blood experiences in the lungs, is produced not by oxygen, but by the absorption of caloric.

We are not at a loss to adduce many facts demonstrative of a similar change of colour, produced on different substances by caloric at its different points of combination with them. 1st Latent caloric

is colourless in iron; but, when by the operation of hammering, it is forced out as sensible heat, it assumes a bright red- 2nd The shells of many of the testacea, naturally dark, change to a florid colour, on being exposed for a sufficient time to the heat of boiling water. 3d The colour of some of those metallic oxyds, called per oxyds, seems to be produced by some peculiar fixation of caloric in them, rather than by oxygen; since by exposure to fire, the black oxyd of iron will be converted into the red, which could not be the case, if the red colour depended on oxygen, which, as well as the other gases, is expelled from substances containing it, by the action of fire. Besides, some of those substances, which yield the largest proportions of oxygen by heat, are of opposite colours; for instance, the black oxyd of manganese, and the hyperoxymuriate of kali.* To these instances, I shall only add the following (perhaps not irrelative) observation. If iron be exposed to atmospheric air and moisture, part of its carbon combines with oxygen, and the iron assumes a florid colour. But when from long exposure, the carbon supplied by the surface of the iron becomes exhausted; the decomposition of oxygen ceases, and the florid colour is lost in the darker hue of the carbonate of iron. †

It does not belong to our present object to enter into any discussion relative to the preparation of iron

* Living vegetables while exposed to light (either natural or artificial) give out oxygen, and have their colours deepened: but if kept in darkness they retain oxygen, and lose all colour; whence it would appear that the presence or absence of oxygen is equally immaterial to colour.

† Fourqnoy states, that on exposing venous blood to oxygen gas, it immediately acquired the scarlet colour, but after some time, although it was still exposed to its action, it again became purple. Ann. de chim. t. vii. p. 148.

held to be contained in the blood. It is sufficient for our purpose, that the existence of iron in that fluid has been demonstrated ; now as it is on the globules of the blood, that the influence of the caloric absorbed at each respiration, is porticularly manifested, and as there is a strong coincidence and similarity between the florid colour, which iron is found to assume, from exposure to heat or atmospheric air and moisture, and that, which the blood experiences in passing through the lungs ; which florid colour is (as will hereafter be shewn) converted to a dark one, in blood as well as iron, by the loss of a portion of their caloric ; and as we also, by washing away the colouring matter from the globules, deprive them of the iron which they contain, we are, I conceive, justified in concluding that the change of colour, which the globular part of the blood experiences from the absorption of caloric, is induced by a union of the caloric with the ferruginous portion of the globules. If then, the radiation of caloric be maintained to flow from the iron contained in the blood ; it may naturally be asked ; Why its operation is confined to the diffusion of caloric, in a degree so low as that which constitutes Animal Heat? To which I confess myself unable to give a more satisfactory reply, than, that the peculiar qualities of the medium, in which the iron is suspended, must necessarily be regarded as the causes of the effect in question. We know that there are substances, which if applied to the tenderest surfaces of the body, will preserve them harmless, when brought into contact with iron at a red heat. Nor is it more difficult to conceive, that the other component principles of the blood should temper the action of iron and render it different from that which it displays (per se) at a high temperature ; than the fact, that water, which contains 85 parts of oxygen in the 100, should be mild ; while a mineral acid, which contains

only 70 parts of oxygen in the 100, should be highly corrosive.

From artificial respiration in the dead subject, as well as the natural exercise of that function, the same results are, to a certain extent, obtained ; that is, the dark colour of the pulmonary blood is converted into a florid one, in consequence of which the action of the heart is renewed. Whence we derive additional testimony in favour of our opinion, that the florid colour of the blood is produced by caloric : for, the action of the heart and arteries is, in all cases, regulated by the degree of heat present. 1st The heart moves quicker in hot than cold blooded animals in whom, the blood of the general circulation is dark. 2nd The bat, which is naturally a hot animal, becomes during the winter, cold as the ambient medium, its heart perfectly quiescent, and arterial blood dark as the venous. 3rd The actual heat of the hedge-hog is considerably lowered during the languid motion of the heart in its torpid state. 4th The heart of a frog, reduced to torpor, by cold, admits a revival of its living action, by the application of a proper degree of heat.

To demonstrate that caloric possesses the same influence over the animal and vital functions of the higher classes, we are not reduced to the necessity of having recourse to any hypothesis, it is fully and unequivocally established by the fact, that in febrile cases, a diminished state of watchfulness, and a calmer action of the heart and arteries, are the invariable results of the abstraction of superabundant caloric from the body : while, an augmented energy of the nervous and vascular systems uniformly succeeds is preternatural or morbid accumulation.

I would not, however, be understood to state, that no other cause of nervous and vascular excitement exists in fever, when it has run its course for some days: on the contrary, I am well aware, that febrile excitement has, particularly in an early stage, a joint dependance on the presence of other stimuli; amongst which, that, arising from enteric congestion will often be found the most active. But, I feel that we are fully warranted in affirming, that caloric possesses a direct influence over the nervous and vascular actions; since we have it in our power to increase those actions by confining and preventing its escape from the body; or, to reduce them, by its abstraction. produced by any of the means usually employed for that purpose, for instance, the application of cold water, technically termed "cold dashing," exposure of the body to a cool atmosphere, lessening its covering, or by copious draughts of cold liquids; and this notwithstanding the presence of other stimuli, which remain uninfluenced by such means.

Since then, artificial respiration succeeds in restoring the colouring matter to the blood, and that, that restoration, is followed by a certain degree of vascular action, which must be the consequence of a previous nervous excitement, which again, in the absence of artificial stimuli, depends on the quantity of caloric present; we may conclude, that the vasoular action, in whatever degree it may take place, is produced by the stimulus of caloric, imparted to the nervous system by the colouring matter of the blood.

In the works of Bichat, we find the following passages * "The black blood which penetrates the "organs, as soon as the chemical functions of the

* Gold's Translation of Bichat on Life and Death, page 223 & 234.

" lungs have ceased, will not maintain them in a " state of life and activity. To determine what the " influence of the black blood is upon the organs, I " shall first remark, that the property of the red " blood is to stimulate them, and keep up their vital " actions. This will be proved by the following " observations: 1st Compare phlegmon, erysipelas, " and inflammatory tumours (to the formation of " which the red blood is essentially requisite) with " scorbutic spots, and petechiæ, produced by the " black blood. The first will be found connected " with the exaltation of the vital powers, the second " with their depression. 3d The greater number of " gangrenes in old men, begin with a lividity in the " part, a lividity which is evidently the index of the " absence or diminution of the arterial blood in the " part. 4th The redness of the branchiæ of fish is " always the sign by which their vigour may be re- " cognized."

Again we find, * " All the inward organs then, die " nearly as they do in asphyxia; that is to say— " 1st Because they are penetrated by the black blood. " 2nd Because the circulation ceases to communicate " that motion, which is essential to their life, never- " theless, there are many differences between death " from asphyxia, and death from lesion of the brain. " 1st The animal life in the latter sort of death, is " generally interrupted at the very instant of the " shock or blow. In the former it is terminated only " in proportion as the black blood penetrates the sub- " stance of the brain. 2nd In the greater number of " the asphyxiæ, the circulation does not immediately " cease, the blood is only gradually blackened, and

* Page 275, ibid.

" continues for some time to be moved onwards by " the agitation of such parts as are still under the " influence of the brain ".

From the foregoing extracts it is evident that Bichat was well aware of the superior exciting power of the red blood. The following, however, will show, that he did not even suspect the existence of a connexion between caloric and the colouring matter of the blood.

* " I am ignorant of the manner in which the red " blood excites and keeps up the life of the parts, " perhaps the principles by which it is coloured be- " come combined with the different organs to which " it is distributed. In fact, there is a considerable " difference between the phenomena of the general " and those of the capillary system."

" In the first, the blood in changing its colour, " leaves behind it the principles which made it red; " in the second, the elements to which its blackness " is owing, are rejected by respiration and exhalation. " Now, this union of the colouring principles of the " arterial blood, may probably constitute a material " part of the excitement which is necessary to the " action of the organs.—If such be the case, the " black blood as it does not contain the materials of " such union, cannot act as an exciting cause."

We find a similar admission, in Ellis's ingenious work; conveyed in the following terms.† " From " whatever cause, therefore, the red colour of the " blood may proceed, we may safely conclude, that " it cannot arise from the combination of oxygen. " It forms no part of our present intention to inquire

* Page 224.

† Ellis's farther enquiries into vegetation and respiration. p. 300.

" further into the cause of this redness of the blood ; " it is sufficient, for our present purpose, to have " shewn that it cannot proceed from its oxygenation."

Having examined those circumstances which mark the connexion between the florid colour of the blood, and the absorption of caloric ; we shall now proceed to show, that the abstraction of caloric from the blood is attended by a corresponding loss of its florid colour.

Dr. Crawford, in the course of his experiments on the blood, having immersed a dog in water, at a high temperature, found that the venous blood drawn in half an hour after, was nearly as florid as the arterial. In another experiment, with a view to ascertain the effects of cold on venous blood, he immersed a dog, whose temperature was at 100°, in water at 45°, which, he states, to have caused a darker hue in the venous blood than he had ever seen before. Without adverterting to his conclusions, it may be remarked, that, in the first of these experiments, the caloric acquired by the blood in respiration, and afterwards maintained by arterial action, (in the manner to be explained in the second part of this work) from which, the blood derived its florid colour, was not abstracted by the medium ; in consequence of its high temperature : it was therefore carried onward with the blood in its passage through the veins.*

In the latter experiment, to which we have alluded, the venous blood became unusually dark from the rapid abstraction of caloric, produced by the low temperature of the water in which the dog was immersed.

* The venous blood of persons labouring under inflammatory fever, where caloric is confined from want of perspiration to absorb, and carry it off, is also found to present a similar phenomenon.

Mr. Hunter, having tied the carotid artery of a dog, found the blood to assume a dark colour; which certainly cannot be explained by any supposed reflux of venous blood; the interposed valves forbid any such conclusion. It has been also observed. that the first blood which issues from the arteries, when a tourniquet has been applied round a limb previous to amputation, is dark as venous blood. The blood thus confined, and at the same time unaffected by arterial action, in a short time is exhausted of the caloric, on which its florid colour depended; it then possesses the same inferiority of temperature, with respect to arterial blood, that venous blood is known to do; and presents the same darkness of colour.* Bichat states, "There is always black blood in the red blooded "system, when death begins by the brain or lungs. "When the functions of the heart are suddenly "suspended, the arterial system contains a portion of "red blood only."†

When mortification takes place, the circulation ceases in the dead parts; which of course, lose their vital heat; the point at which the circulation stops, acting as a ligature on the adjoining vessels of the living part. The inferior temperature of the mortified part, presently, abstracts a portion of caloric from the blood contained in the extremities of the vessels

* The colour and temperature of blood belonging to a healthy phelgmon, notwithstanding its detention in the local vessels by which its passage through the lungs is prevented, continue while the vigorous action peculiar to that species of inflammation is maintained, higher than that of the general mass, which is moderately acted on, and regularly transmitted through the lungs. The causes of these phenomena cannot, with propriety, be further entered on in the present stage of our enquiry; they will, however, be readily comprehended when we come to speak of the consequences of compression of the blood.

† Gold's Translation of Bichat on Life and Death. page 276.

contiguous to it; this deepens the colour of the arterial blood,* until it becomes nearly as dark as the livid mass with which it is in contact: the abstraction of caloric still proceeding, a coagulum is formed, constituting one af the most material steps which nature takes to prevent hemorrhage, on a separation of the dead parts. In amputation, a coagulum is also formed within the ligatures; but, its formation is not so extensive or perfect, in consequence of the caloric being retained, by the protection from atmospheric cold which is afforded by the flap. †

Physiologists have endeavoured to give a solution of the dark colour of venous blood, by maintaining that it arises from the presence of a greater quantity of carbon. But, the fallacy of that doctrine is fully demonstrated by the experiments of Ellis, which prove that arterial and venous blood, equally furnish carbon; and are eqnally capable of converting a given portion of oxygen into carbonic acid. They also prove, that not only the blood, but all the other solids and fluids, which are of various colours, will, under similar circumstances, produce a similar phenomenon. Hence it is evident, that there can be no reason whatever for concluding, that the carbon which is furnished by the lungs in respiration, proceeds either

* Cold, however applied, will produce this effect on the blood; in the torpid state of animals (the result of cold) the arterial blood is as dark as the venous.

† I am well aware that many respectable writers deprecate the idea that coagulation of the blood is, at all, influenced or promoted by cold, yet we find them, in direct contradiction of what they would inculcate, recommending, when topical bleeding is performed, the subsequent application of warm fomentations "to continue the flow of blood" or, in other words, to prevent coagulation of the blood, which we know would, otherwise speedily take place.

directly, or solely, from the blood.*

Although the colour of the various parts of the body, in proportion as it inclines to the florid or dark, denotes with a good deal of accuracy the higher or lower temperature of the part, (instances of which we see in phlegmon; in the florid colour of the cheeks after exercise, or their darker hue from exposure to atmospheric cold joined with inaction) yet, we find that man, and the higher classes of animals, whose circulating systems are similarly constructed, not only enjoy a temperature of blood nearly equable, under the opposite extremes of heat and cold, but, are enabled to resist the inroads of either excess, which would be alike destructive of animal mechanism and alike subversive of that harmony which is thus protected and prolonged to the close of the vital functions.

Attracted by the beauty of this arrangement (which alone, would be sufficient to overturn all the arguments of the self deluding sophist, who would refer all that is sublime in nature to a fortuitous combination of cause and effect) I have endeavoured to analize those circumstances whose operation seemed likely to contribute to its production; in the hope of being able to trace the means by which this nice, this essential balance was preserved. Such observations as I have been able to make, I submit with the less reserve, for this reason; that, perfectly concurring in the justice and propriety of those few inferences which

* M. Hassenfratza, filled a number of glass tubes with arterial blood, and sealed them hermetically; after some time the blood became purple and acquired the venous appearance. Here it cannot be conceived that the change of colour could proceed from any thing acquired, or from a loss of any of the component principles of the blood: the well known subtility of caloric which enables it to permeate the densest bodies, together with its tendency to become latent, are facts which stand single in offering a solution of the phenomenon.

are found accompanying the detail of experiments directed to the same object; I cannot possibly take from, if I should not add to the fund of knowledge already acquired on that head.

The analogy subsisting between respiration and combustion, and the nearly equal consumption of a given portion of oxygen by either process led me to consider what control atmospheres of different temperatures might exercise over Animal Heat; or how far, such irregularities might assist in explaining an effect nearly uniform and unvarying.

When the temperature of the atmosphere is low, the principles of which it is composed, approximate in proportion to the loss of caloric. Consequently the air received into the lungs at each respiration will, bulk for bulk, contain more oxygen than a warmer atmosphere, wherein the principles are more expanded by caloric. Now, the effects resulting from a respiration of pure oxygen gas, or an atmosphere containing a large proportion of it, are an increased energy in all the vital functions in consequence of a more extensive decomposition of oxygen, attended by a corresponding acquisition of caloric, or colouring matter by the blood. The influence of an atmosphere condensed by cold (and consequently containing a larger proportion of oxygen) over the process of combustion, is sufficiently evident, from the more brilliant and rapid ignition of combustible bodies, in cold than in warm weather. For in combustion, as in respiration, it is to the caloric chemically combined with oxygen, and subsequently set free by its decomposition, that the effect is to be ascribed, and not to the free caloric contained in the atmosphere, whose presence is casual, and does not promote combustion or Animal Heat in respiration: as

we find exemplified by the experiments of Sir C. Blagden, Sir Joseph Banks, and Doctor Solander, who remained for several minutes in rooms heated to 212°. They describe the feeling communicated by the air as unpleasant, but easily borne, respiration was little affected, and differed only in the want of that refreshing coolness communicated by the inspiration of cool air. At each inspiration, the nostrils felt scorched by the heated air; while each expiration cooled them again; and, if they breathed on the thermometer, it fell several degrees. The body touched by the fingers, felt cold as a corpse, while the actual heat of the skin and under the tongue was 98°.

When the cloathes were stripped off, the air was more disagreeable for a few minutes, but a profuse sweat breaking out gave instant relief.

In this experiment, the excess of caloric contained in the heated air, was absorbed by the perspiration, and its influence over the body arrested. In respiration, exactly the same process was carried on, with this exception, that the pulmonary exhalation, corresponding to the bodily perspiration, must have been from the commencement; since its presence is constantly necessary to enable the carbon to effect the necessary decomposition of oxygen. The difference of temperature between air inspired and that expired (as shewn by the thermometer) indicated the quantity of caloric absorbed by the pulmonary exhalation, which was converted into vapour, and communicated at each expiration, a sense of coolness resembling that imparted to the body by perspiration. Under such circumstances, the caloric of the heated air simply gives expansion to the cutaneous and pulmonary exhalations which thus become as it were a

barrier between the body and the destructive influence of caloric.

In fine, the small quantity of oxygen contained in an atmosphere so expanded by caloric, together with the absorption of that caloric by the double perspiration of the body and lungs, can alone account for the non-increase of temperature. While the greater proportion of oxygen contained in a colder and more condensed atmosphere, joined with the absence of perspiration, affords the only clue to unravel this fiat of divine wisdom, which enables man, who is naturally the most unprotected of the warm blooded tribe, to meet and resist the varied contingencies, which he is destined to encounter through life's precarious course.

END OF THE FIRST PART

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PART II.

In the preceding part of this enquiry, I have endeavoured to give a general view of the most material facts connected with the consideration of that source of animal temperature, which, from the diffuseness of its application, I have distinguished as the first or general source: a source in which it will be found that all animated beings participate in a greater or less degree, and, however difficult of detection, even an organic structure in some may be, still the existence of a power, by which they are enabled to effect the necessary decomposition of atmospheric air, is abundantly testified by the most accurate and conclusive experiments. This source of caloric is equally essential to all while the vital functions are regularly exercised. Fish will not live in water deprived of air by boiling. Reptiles, as well as man and the intermediate classes, perish when deprived of atmospheric air, or confined in air of which oxygen does not form a part. If then this source of caloric be maintained to be the only one, from whence animal temperature is derived; we must look for an explanation of the

difference of temperature between animals, in the extent and power of decomposing atmospheric air vested in the organs performing that function; but as this power depends on the quantity of carbon furnished by the animal structure; the caloric acquired by the decomposition of oxygen, must bear a determinate and uniform relation to the quantity of carbon the animal is enabled to supply; which again, must depend on the extent or number of organs destined for that purpose: but no such superiority, either in extent or power, appears, from comparative anatomy, to reside in the respiratory organs of the warm blooded animal over those of the cold-blooded; on the contrary, many of the cold-blooded tribe, as the frog and lizard, possess a greater extent of lungs than some of the warm-blooded tribe of equal size: while many of the reptile class have a greater number of organs (breathing pores) all of which are capable of furnishing carbon and decomposing oxygen.*

Moreover, natural history reveals to us, that warm and cold-blooded animals inhabit the same medium: therefore the medium does not influence the distinction: in both, the oxygenous portion of the atmosphere is converted into carbonic acid; therefore this

* In the Phylosophical Transactions for 1811, we find the detail of some experiments by Mr. Brodie, of which the following is the substance. Two Rabbits were deprived of life in a similar manner: In one, artificial respiration was performed; while the other, on which it was not performed, remained in the same medium and temperature. On comparing the bodily heat of the two Rabbits at equal intervals for several hours, he found the temperature of the one on which artificial respiration was practised, to decline faster than that of the other: the same result attending overy repetition of the experiment. Although these experiments throw no light upon the causes of Animal Heat, they at least point out, in a clear and convincing manner, that respiration is not the cause of it—since artificial respiration (apparently attended with all the effects which it does or can produce when performed naturally) not only failed to maintain it when generated, but had the direct effect of even removing it from the body faster than it otherwise would have been.

power of decomposing oxygen, being in common, cannot possibly explain the difference in temperature, nor can we find in the nerves any rational solution of the difficulty; for they are also possessed in common, and have their structure and uses as nearly similar as the peculiarities of each could be supposed to permit. Thus far then their circumstances correspond; but, in the vascular structure of each, a marked difference is to be noted. Beginning with that which is more simple; we find in cold-blooded fish a single heart, from which proceeds a single artery; (whose diameter equals the ventricle) transmitting the blood direct to the gills, by means of numerous small arteries terminating in corresponding veins, which shortly after unite to form a vessel called aorta decendens, but which in reality, is only a venous trunk, by which the rest of the body is supplied with blood, which is again returned to the heart by other veins. In the more complex structure of the warm-blooded tribe, whether of the aquatic or land species, is found a double heart, furnishing the body to its remotest limits with an arterial circulation. *

Bearing in mind this general line of demarcation between warm and cold-blooded animals, if we pass from the consideration of such circumstances as appertain merely to the healthy state of each, to some of the morbid affections peculiar to the former; we shall find reasons, still more cogent, for concluding that the highest degrees of temperature generated in

* Although a general arterial circulation is *invariably* possessed by warm blooded animals, the opposite or venous one is not, in every instance, associated with the cold: but notwithstanding that vascular structures, apparently arterial, occasionally present in the latter, such deviations will still be found, on due consideration, incapable of producing effects materially differing from those which will be shewn to result from a circulation purely venous.

the animal frame are the result of causes perfectly distinct, foreign and unconnected with any influence which the pulmonary function under other circumstances might perhaps be supposed to possess. In general inflammation (which will be shewn to be only a higher degree of Animal Heat, excited by a preternatural activity of the same causes which, under ordinary action, give rise to Animal Heat) although we have reason to believe that accelerated respiration does not increase the temperature of the body, but rather that it produces a contrary effect, since, according to Mr. Brodie's experiments, artificial respiration causes the dead body to cool faster—and that in the living one, respiration, performed quicker than the decomposition of the oxygenous portion of the inhaled atmospheric air can take place, certainly produces a refrigerant effect, as may be readily ascertained by making a few full inspirations in quick succession: still these facts (unquestionably strong in themselves and tending in no inconsiderable degree, to establish the point under discussion) by no means afford that clear and undeniable evidence with which we find the phenomena of topical inflammation replete. Thus for instance, when the extreme parts of the body become inflamed, even in a limited extent, an intense degree of heat will be found to occupy those parts, while the remainder of the body retains its usual temperature only and the lungs their usual action.* Again, in the other cases, where the exciting

* It is evident that if the lungs were the only source of Animal Heat; the temperature of the extreme part of the body could never have equalled, much less surpassed, that of the lungs or the adjacent parts. Because the quantity of caloric must necessarily have been greatest in the lungs, where the supply was first received, from whence as it proceeded through the different parts of the frame (all of which are known to be conductors of caloric) the quantity must have been diminished as the distance was increased: which is not conformable with the phenomena of Animal Heat; and is in manifest opposition to those of topical inflammation.

cause has been violent, the local inflammation will be followed by general inflammation or symptomatic fever and laborious respiration, which, being (as well as the general inflammation) subsequent to the local inflammation, is obviously not the cause of it; nor can it, in any possible way, be connected with the increased temperature, except as a contingent result or consecutive effect, apparently intended by nature as a means of moderating febrile or excessive bodily temperature. These are facts, concerning whose truth or admissibility we can have no hesitation—and therefore they must be admitted as testimony full and conclusive, that the caloric furnished to the blood, from a source, common to all animals, or the difference in quantity, supplied by the greater extent or number of organs, by which the oxygenous portion of the atmosphere is converted into carbonic acid; are causes totally inadequate to explain that difference in temperature, which gave rise to the natural, and comprehensive distinction of animals, into warm and cold.

Doctor Crawford, aware of the insufficiency of the theory of Animal Heat, as set forth by the justly celebrated Doctor Black, attempted to remove the objections arrayed against it, by supposing that the heat, liberated by the decomposition of oxygen in the lungs; passed into the blood in a latent form, in consequence of which its temperature was not raised, and that this heat was, by other chemical changes, given out in a sensible form during its circulation. By this hypothesis, he certainly removed some difficulties; but in doing so, he has substituted others of equal magnitude. For there is no inconsiderable difficulty in conceiving what those chemical changes were, which, it would seem, he himself found more easy to imagine than describe, since he has failed to bring forward a single fact or argument in support of the very subject,

which should naturally form the leading object in any research to discover the causes of Animal Heat.

In stating, thus freely, our opinion of Doctor Crawford's theory of Animal Heat, we disclaim all intention of detracting from the credit to which it is, in many other respects, justly entitled. We have been led to notice it so far, in order to show how little that theory (which has for years past maintained, and still continues to hold, the first place in general estimation) has, in reality, contributed towards the elucidation of the proposed subject, a subject too, which, in point of importance to the Physician and Surgeon, yields to none within the whole range of physiology: but here we stop; for we feel that to proceed with its discussion would be but to trifle with our readers, exceed our prescribed limits, and alter the design of our work, without any countervailing promotion of its views. We shall therefore, without occupying further time in preliminary observations, proceed to the specific object of our enquiry, that is, the source of Animal Heat and Inflammation: the existence of which we shall endeavour to demonstrate as dependant on the union of the following causes—

1*st Arterial action exerted on the blood throughout the general circulation.*

2*nd A conoidal or arborescent structure of the arterial tubes.**

3*rd A course of the blood directed from the trunks*

* The arterial tubes are not strictly conoidal, but consist of a series of cylinders whose diameters are constantly decreasing in a direction from the heart. This peculiarity of structure, while it insures, as will be seen hereafter, advantages of the utmost importance to life, is, with respect to the effect with which we are at present concerned, the same thing: therefore and in order to contrast in any easy way the very different effects resulting from a conoidal structure and one of an equal diameter through its entire extent, we have preferred the word conoidal to the more prolix definition just given.

of the arteries towards their branches—comprising, in their assemblage, *the proximate cause.*

4th Nervous influence—constituting *the remote cause;* on which the foregoing immediately depends.

If the structure of the vessels belonging to the general circulation had been such as to have excluded the first of these causes, the circulations of hot and cold-blooded animals would have been virtually the same; and as no difference can be detected in the blood itself, we may conclude that the effects, produced by both circulations, would have been similar. If again, the form of the arterial tubes had been cylindrical, not conical, the production of caloric would have been equally unprovided for, no heat having ever been ascertained to result from the most rapid movement of a fluid through a cylinder. Lastly, if the third cause had been reversed, the vis a tergo could not have existed in that powerful degree, requisite (as will hereafter appear) for the evolution of Animal Heat.

With respect to the remote cause, it will be sufficient for the present to state, that the heart and arteries are abundantly supplied with nerves, to whose influence their actions are absolutely and immediately subservient.

To aid recollection, and prevent the embarrassment created by a want of methodical arrangement, I have endeavoured to bring within the limits of three general heads, such principles, experiments and facts as seemed most condusive to the object of each. In their selection, I have preferred those which belong to original and acknowledged authorities, as likely

to afford more satisfaction, and entitle me to more confidence than I could claim, from the introduction of any thing new, as a ground of support for those conclusions to which I have been led myself, and to which I hope to conduct others.

The object of the first of these heads is, to prove, That, *compression, made on the blood, would be a cause competent to the extrication of heat from it.* That of the second, to establish the fact, "*that such compression naturally obtains.*" The third to demonstrate, *that where no compression is effected on the blood, no evolution of caloric will take place.*

In support of the point, first to be established, I shall briefly enumerate a few general principles, illustrated by experiments, which no one, acquainted with chemical science, will hesitate to recognize or admit. All bodies contain two portions of caloric; the one more intimately combined, termed latent caloric; the other sensible or free. All bodies owe their state of solidity or fluidity, hardness or softness, to the quantity of caloric they contain. If caloric be added to any body solid or fluid; the immediate consequence of such addition is an expansion of all parts of such body, as the caloric pervades. Since bodies are expanded by the acquisition of caloric; before they can be again condensed, they must give out that portion of caloric which gave them their more expanded form. Therefore, when we say a body suffers compression, and is condensed; we understand, that such body whether solid, fluid or gaseous, has actually given out heat. A certain degree of compression will so far disengage latent heat, as to make a portion of it become sensible; but a much less efficient cause will suffice for the transmission of a portion of sensible heat from a body which

oontains it, to any other substance capable of conducting it if placed in contact.

That solids are expanded into fluids, and fluids into gases, by the addition of caloric, will (as a general rule) be readily granted. The converse of this, viz. "That the more dense bodies become, the less caloric "they contain," is proved by the following experiments—1st If muriatic acid gas be passed through water, it will be condensed, and the temperature of the water will be found increased in proportion to the condensation. 2nd Compression is capable of condensing a mixture of oxygen and hydrogen gases so as to form water. In this experiment the quantity of heat thrown out is sufficient to inflame the gases, independent of the electric spark. 3d. Add one measure of water to four of sulphuric acid, and the temperature will rise to 300°, (88° above boiling water) the mixture now occupies less space; therefore it has become more dense than the medium of the two seperate liquors. 4th The red heat produced by striking a cold hammer on cold iron is the result of condensation: (produced by the strokes of the hammer,) which forces out the latent heat and causes it to become sensible.

Water at its temperature of fluidity, cannot be made the subject of experiment, in the present case, at least it is an unfit one to select in order to give a full representation of the effects of compression on a fluid body: water being nearly at its maximum density at that point. But should it acquire even a slight addition of temperature from the atmosphere, or any other casual source it will be expanded; and may be

1 Thompson's Chemistry.
2 Biot's Experiment.
3 Parke's Chemistry.

forced to give out the additional caloric by compression. Accordingly we find that Mr. Canton, succeeded in compressing water, at the usual temperature, in a small degree, by increasing the pressure of the atmosphere already on it, by means of a condenser. But, water whose volume is much increased by heat, will readily give out the caloric which caused its greater expansion, when subjected to compression. Thus, if a bottle with a long neck, filled with boiling water and closely corked, be put standing in a basin of cold water, the caloric which expands the water contained in the bottle, being abstracted by the cold of the water in the basin, the water will sink in the neck of the bottle; marking the loss of caloric and condensation consequent on it. A vacuum being now formed in the neck of the bottle; the water will boil, and again fill the bottle, in consequence of the expansive force of caloric, which is no longer resisted by its antagonist force, compression, if the cork be now drawn, and the pressure of the atmosphere suffered to operate on the water, it will sink under its compressing power: an escape of caloric will take place, and on trying the temperature of the water, it will be found to have lost several degrees; it will scarcely feel warm.*

Some of these experiments, no doubt, do not afford instances of the production of caloric by mechanical compression; but the effect of compression is condensation, and the effect of condensation, is the escape of a portion of caloric, whether the cause be chemical or mechanical. An experiment on the blood itself (as far as it regards the present head) would perhaps be more satisfactory and more ad rem. but, I trust, the arguments which the subsequent part

* Parkes's Chemistry. (Notes)

of this work will place before the reader, will be deemed sufficiently valid and convincing to supercede the necessity for an experiment which is rendered not only difficult but impracticable, from the following causes, viz. Its quick coagulation. The greater or less conducting power of the vessel in which the blood might be compressed. The tendency of its caloric to escape. The impossibility of determining whether the loss of caloric be not produced as much by the abstracting power of the appatus or the surrounding medium, as by the compression employed. Nor is this difficulty to be removed by increasing the temperature of the surrounding medium: since, if their temperatures be made equal, the caloric could not pass off from the blood into the medium; from which, if its temperature were higher than that of the blood, it must receive caloric instead of imparting any. Different modes of compressing blood removed from the body, have been suggested to me, but all have been liable to some one of the above objections, any of which would be sufficient to render the experiment inaccurate, in its representation of the collateral circumstances attending the compression of the blood in the body, and therefore could only lead to conclusions more or less fallacious.

If then it be admitted, that compression made on any body, whether solid, fluid or gaseous, will cause the body so compressed, to part with some of its caloric: it follows as an imperative admission also, that if the blood suffer compression, it will, in obedience to the same law, present the same result.

In the commencement of the second part of this work, when speaking of the arterial tubes, we have remarked that their construction was not strictly

conical, but consisted of a series of cylinders whose sections were constantly decreasing in a direction from the heart towards the extreme and superficial parts of the body. Each ramification, being cylindrical, has its capacity equal throughout its extent, but less than that of the branches between it and the source according to the number of branches which precede it or its distance from the heart which forms the center of the circulation. Now it is evident, although but little resistance is given to the motion of a fluid through any single cylinder, that, the extent of each of those cylinders being very limitted, and the ramifications which immediately succeed more contracted, each of them will have the effect of opposing and retarding the free motion of the blood as it advances; and that this opposition will be still augmented and consequently the transmission of the coloured and thicker parts of the blood rendered more and more difficult, until at length the ultimate cylinders of the series will be impervious, except to the thinner parts of the blood which are colourless.

From such an arrangement it is obvious that a resistance to the advance of the blood must take place, equal if not greater than that which a conoidal structure would have afforded. This then constitutes one of the circumstances necessary to produce compression of the blood—Another consists in the propelling power of the heart and arteries; a power which is in direct opposition to the resisting one to which the form of the arterial tubes gives rise, but superior to it in order to insure a regular circulation of the blood through the frame, and obviate any remora to its progress beyond that which is requisite to assist in effecting a certain degree of compression of the blood, on which the elimination of heat from it will be shewn to depend. This power of propelling the blood, or

the vis a tergo, commences in the left ventricle of the heart, which from its great muscularity and the peculiar course observed by the fibres composing it, is manifestly capable of exerting a prodigious contractile force over its contents, in consequence of which they are driven with an impetuous motion through the aorta the only opening of the ventricle where the exit of the blood is unopposed by valves. The quantity of blood, thus expelled by each contraction of the ventricle, being supplied during its relaxation by the blood of the pulmonary veins, produces those reiterated contractions of the heart, which, in the generality of cold blooded animals, is, with the exception of the pulmonary artery, the sole power on which the circulation depends; but in the warm blooded, although a primary and essential cause, is yet by no means the only one, for every portion of the arterial system is endowed with a power of propelling and acting on its contents perfectly independent of and distinct from the first impulse communicated to the blood by the action of the heart.*

Now it is evident that when these opposite powers, viz The resisting and propelling act together in any part of the vessels, that the blood must then and there, be in a state of compression. But as the vis a

* If a ligature be placed round all the vessels proceeding from the heart, the motion of the blood will continue for some time in the smaller vessels after death.—Doctor Wilson Phillips on the Vital Functions and Internal Diseases p. 207 —But we have still clearer proofs of the action of the arteries being the result of their own powers independently of the heart. 1st In the local increase of their action which takes place in topical inflammation without any corresponding increase of action in the heart or the vessels intermediate between it and the affected part—And 2ndly in the converse of this, viz. The diminished energy of the circulation in paralytic limbs, while the vigour of the heart continues unimpaired, and its action unaltered: neither of which cases could, possibly, have existed, if, as some Physiologists have maintained, the circulation depended on the heart solely, and the arteries were merely inert or passive tubes.

tergo or propelling power commences at the heart, and is extended through and inherent in every part of the arterial circulation, and as its antagonist or the resisting power is extended in like manner through the same system, and only ceases at the extremities of the capillaries, where the veins commence; the entire of the arterial tree must be distended by a column of blood in a constant state of compression. Nor is it less evident, that when the pulse (which marks the period of arterial contraction) is superadded to this, a considerable augmentation of compression must then be produced.* Should this conclusion, however, notwithstanding its being so strongly borne out by the anatomy and physiology of the arterial system, be deemed to rest on evidence of too theoretic a nature to be entitled to our full and unqualified assent, we can no longer withhold it, when we find that the projection of blood which takes place from a punctured artery must necessarily be the result of compression made by the artery on the blood, since (as a little consideration will soon convince us) compression will fully and satisfactorily account for that phenomenon, while, on no other principle whatever, can it be, fairly or at all, explained. For we know that a fluid may fill any vessel compleatly, yet no escape or projection of the fluid shall take place, while the vessel remains unaltered in capacity and undisturbed as to position: but if the capacity of the vessel (supposing it composed of yielding materials) be contracted by an approximation of its parietes, a displacement or escape of the fluid corresponding to the degree of

* The blood thus compressed, must suffer condensation and consequently (in conformity with the general law) must give out a portion of the caloric which it contained previous to its being condensed. This conclusion it must be admitted, holds good in theory; but it is not our intention to rest satisfied on such visionary evidence as an unsubstantiated theory would afford, we shall show, in the subsequent part of this work, that it holds equally good in practice.

compression, that is, feeble or strong, slow or rapid, in proportion to the action of whatever agent or power may have been employed to diminish the capacity of the vessel, must necessarily be produced. If, for instance, we fill a bladder with a fluid, place it between our hands, make pressure on it, and puncture it, a projection of the fluid (in like manner as blood is projected from a wounded artery) will be immediately produced.

In this simple experimental illustration, we can have no doubt, that the projection of the fluid is the immediate result of the compression affecting it, because the projection is increased or diminished, as we, at pleasure, increase or relax in our exertion which produces the compression. We also find that by imitating arterial action, that is, by alternate relaxation and compression, we are enabled to project the fluid per saltum, as the arteries do by their systole and diastole, or, by an unvarying pressure, to make it flow in a uniform stream, as blood does from a punctured vein in which the return has been arrested by ligature.* We also further perceive, that if either hand (one of which may be considered as representing the active, that is the compressing and propelling force of the arteries, the other, their quiescent or resisting power) cease its exertion, or be withdrawn, compression cannot and projection does not take place.† In short, the analogy between the two cases is so apparent, and the similarity so striking, that we cannot

* A common syringe will serve to exemplify all this equally well.

† When an artery has been wounded, if fainting take place, the projection of blood will cease, in consequence of the uncompressed state of the blood which necessarily follows the suspension of arterial action.

for a moment hesitate to recognize the operation of the same causes, in the production of effects, identified in principle and in no way dissimilar, save in the mechanical power they depend on, which is obviously unimportant.

The arterial blood, therefore, of warm animals is evidently subjected, at all times of animation, to compression; but as the extent, to which it is carried, cannot in every instance, or at all times be the same, being subject necessarily to such variation as may occasionally affect the causes proximate or remote on which it depends, it naturally follows, that the temperature of the body, if it depend (as we alledge it does) on compression of the blood, must be subject also to vary with the degrees of compression arising from the more or less strennous exertion of the causes by which it is produced; which we shall now demonstrate to be the case invariably *.

In the natural or healthy condition of the body, wherein the nerves, that is to say, the immediate cause of arterial action.† and remote cause of Animal Heat,

* It is evident that the florid colour and high temperature of inflamed parts, depend on the degree of compression affecting the blood, and not on the afflux or presence of a greater quantity of blood simply: because in phlegmonous inflammation, attended with a vigorous or healthy action, the colour and temperature of the blood are always high, but in erysipelas and other inflammations, where the vascular action is weak, the temperature is low, the colour dark; and still lower and darker in ecchymoses, &c. &c. where the blood is entirely uncompressed. Nor are these differences attributable to the blood being out of circulation, and not having its florid colour renewed in the lungs, since the most florid blood, contained in the vessels of a phlegmon, is equally out of the circulation, and therefore equally unaffected by the pulmonary function, and different in no respect, from the dark blood belonging to low inflammations and extravasations except in the degree of compression affecting it.

† It is evident that the nerves are the immediate cause of the action of the heart, from the languor of it, which succeeds tying the eighth pair of nerves, or its quicker motion by irritating them (Haller) In the same manner, they may be shewn to be the immediate cause of arterial action also.

are free from any preternatural excitement, the pulse, or stroke of the arteries is performed with a certain degree of strength and length of interval, which experience shows to be a true indication of the presence of that state; from such an exertion of vascular action, the blood suffers a certain degree of compression which we find attended by the diffusion of that quantity of caloric through the frame, which gives rise to the natural temperature of body called Animal Heat, a temperature which is never exceeded while that species of vascular action continues. This, being the natural state of action, is of course, unattended by any sensation of pain. But when the nerves are aroused from that calm and natural state, by any sufficient stimulus, the increase of nervous influence (always marked by sensations more or less troublesome, or painful, according to the nature or intensity of the stimulus applied to them) produces a proportionate increase or acceleration of the pulse, attended by an elevation of bodily temperature, not only commensurate with the strength and rapidity of arterial action, but corresponding with it also in extent and duration.*

If the nervous excitement be general, the increase of vascular action is found also to be general, the consequences of it, general inflammation or fever If on the other hand, the nervous excitement be limited to any particular part, the vascular action of that part only will be increased, and (the morbid temperature arising from it being equally limited) local

* Richerand, in his Elements of Physiology, says, It is, doubtless to the great activity of the assimilating powers in infancy, that a more elevated temperature is habitual. For this, however, we would account differently, and say, according to the principles of this theory, that such a temperature is the natural consequence of the greater rapidity of arterial action in the infantile than the adult state.

inflammation only will be produced.*

This compressing power of the arteries, being exerted through every portion of that system containing red blood, (as testified by the pulse) points out the extent of the seat of Animal Heat; and shows that it is not, as Bichat gratuitously states, peculiar or confined to the capillary system, but diffused throughout the entire.

It must, however, be admitted, that, notwithstanding its being so perfectly demonstrable, not only from

* The sense of pain and subsequent increase of vascular action, produced by the application of blisters, acrid substances or mechanical irritation, to any part of the body, strongly corroborate this explanation of the proximate and remote causes of local inflammation, of which, the attendant phenomena appear to take place in the following order. 1st A sense of pain. 2nd An increased action of the local vessels. 3rd An elevation of local temperature. 4th Tumefaction. 5th Effusion, attended with an increase of local swelling. The two first having been already spoken of as remote and proximate causes, it remains only that we should say something concerning the two last. First then, with respect to tumefaction, we conceive the following to be a fair and satisfactory mode of accounting for it—The caloric generated by the increased strength and rapidity of arterial action is immediately absorbed by all the fluids and solids composing the part; by this, their volume (like that of every other substance in nature) is augmented—next effusion takes place, from the colourless part of the blood having been forced, by the increased action of the red blooded arteries, through the minute cylinders, in a quantity more copious than the absorbents are capable of removing. This, of course, adds to the local tumefaction by its presence; but it adds doubly, in consequence of having its volume also increased by the absorption of a portion of the excess of caloric generated by the morbid action of the vessels.

To demonstrate this to be the true explanation of that tumefaction of the soft parts which takes place in phlegmonous inflammation (for in other species of topical inflammation, where the vascular action and temperature are low, the swelling is always inconsiderable) and that it is not dependant on effusion alone; it will be only necessary to direct the reader's attention to the swelling of the hands and feet, which follows any unusual or severe degree of exercise, by which the local arterial action and temperature are much increased, or, what will perhaps exemplify the principle still better, the cold and hot stages of a paroxysm of intermittent fever; in the first of which, the bulk of all the soft parts is remarkably diminished, but in the latter, in which the action of the arteries is violent, a tumefaction of these parts, equally remarkable, is produced, and removed, with a subsidence of the arterial action and morbid temperature

the extent of arterial pulsation, but the phenomena of Animal Heat and general Inflammation, unattended by topical inflammation marked as such, that the power of generating Animal Heat is not restricted to any particular portion of the arterial circulation; it was not without some appearance of reason, that many were deceived into a belief, similar to that which Bichat entertained. For, seeing that the phenomena of local inflammation, in which the vessels of the capillary system are eminently engaged, assume a character so much more strongly marked than those of general inflammation, in which the larger arteries are principally concerned, and finding that general inflammation frequently followed an inordinate action excited in the capillary system, it is not to be wondered at, that men, who were totally ignorant of the causes of Animal Heat and Inflammation, and, of course, incapable of reasoning systematically on the subject, should have been led to form erroneous opinions from circumstances apparently so strong and consequential. But to the Physiologist who traces the proximate and remote causes of Animal Heat to the same source that we have, the causes of the superior temperature, arising from the action of the vessels composing the capillary system, readily unveil themselves.

When he comes to examine these vessels, anatomically, he finds that although they possess less of the elastic property than the larger arteries, their structure is stronger in proportion as their capacities become less; and consequently, that their powers of compressing the blood, which is more firmly opposed to arterial action in the small than larger sized vessels, must be, in more than the same proportion, greater—far, as to the proximate cause, the result of his

examination proves satisfactory. With respect to the remote cause, the same line of examination shows them also to be furnished with a much greater proportion of nerves than the large arteries, and hence he gleans such further information as enables him to compleat his explanation of the superior energy of those vessels when engaged in the inflammatory action, as well as their more vivid susceptibility of that action from slight causes. Extending his research, he sees that the cylindrical ramifications, in proportion to their diameters, either admit or resist the entrance of the red blood, and that as they become still more minute, the circulation of the red blood is checked, and finally put a stop to compleatly * He finds that these vessels (colourless in consequence of their minuteness) effectually resist, during the moderate or healthy action of the vessels with which they are connected, the entrance of red blood; but that when once the larger vessels of the part are preternaturally excited, the strength of the circulation is such, that the natural resistance, opposed by those vessels to the entrance of red blood, in consequence of their minute capacities, is overcome, they are suddenly injected and distended with florid blood, which being prevented from circulating further by the progressive minuteness of the ulterior cylinders, or from returning into the larger ones, by the vis a tergo, is detained in intimate contact with their parities, communicating to their nerves an unusual and powerful stimulus, which quickly involves them in the inflammatory mischief, thus, at once, aggravating and extending the primary affection.

* In speaking of the motion of the blood in the smaller arteries, Mr. Hunter says, "being there viewed with microscopes, the red globules are seen moving with different velocities in different parts, and taking retrograde or lateral motions, according as mechanical obstructions, or those arising from contractions in the vessels, may happen to retard or change their motion. Hunter on the Blood, 4to. p. 43.

That such are the true consequences, resulting from the minute branches of the arterial system being forcibly occupied by red blood, we infer, not from the highly stimulating properties of florid blood merely, but because all the symptoms of inflammation viz. An acute sense of pain, throbbing, burning heat, etc. invariably arise with its introduction, continue with its detention, and subside with its removal from these vessels, which, in their natural state, that is while the red blood is excluded from them, have no pulsation, and are no more capable of generating Animal Heat or Inflammation, than the vessels of insects whose blood is colourless,*

Taking this view of the matter, the Physiologist is, at once, enabled to comprehend the reason, why the arterial system consists of a series of decreasing cylinders, instead of being exactly conical. In the cylindrical construction of the vessels, the commencement of each arterial branch or cylinder is of the same diameter as its termination; therefore, whatever part of the blood enters easily, will pass onward to the entrance of the next cylinder without obstruction. By this contrivance, nothing short of a morbid increase of action will force the red blood into the minute cylinders where their progress would be either impeded or arrested. But if their structure had been strictly conoidal, the entrance or

* We estimate the value of any remedial application in inflammation, Ophthalmia for instance, by its effects, in restoring the minute vessels to their naturally colourless appearance, and unloading them of the red blood, which while present, keeps up a sense of pain and consequent inflammation, which experience tells us, is not to be subdued while the red globules remain; we find also that the dilation which these vessels have suffered by the red globules having been forced into them, favors the recurrence of inflammation, or, in other words, their re-admission into these vessels, this we endeavour to guard against by astringent applications, which have the effect of contracting these vessels to their natural capacities, in consequence of which they are again enabled to resist the entrance of the red blood, and so rescued from a permanent state of inflammation.

commencement of each ramification being (according to the nature of a cone) more capacious than the remainder of the branch, would evidently have given admission to globules, which would necessarily have become wedged in some part of it, even from an impulse or impetus of the blood, not exceeding that communicated to it by the healthy or ordinary action of the heart and arteries.

If such then had been the structure of the arteries, in place of that which the protecting hand of an unerring and bountiful Creator has been pleased to bestow, it is evident, from our experience of the consequences uniformly resulting from the presence and detention of red blood in the minute branches of the arterial system, that instead of our passing through life, without perhaps a single visitation of disease, an hourly, nay a permanent state of inflammation would have been maintained in every part of the frame where the vessels became too minute to suffer the red blood to pass through them; and consequently, the most vigorous constitution must have fallen the earliest victim to a spontaneous and irremediable species of combustion.

In the discussion of the preceding head we have endeavoured to demonstrate in a clear and convincing manner, that the result of arterial action, such as takes place in warm blooded animals, must be a compressed state of the blood. And, proceeding to apply this principle to the varied temperatures of health and disease, we have shewn, by an appeal to experience, that in whatever degree the pulse became altered in in strength and rapidity, either locally or generally, in the same proportion was the temperature of the body, either local or general, raised or depressed. We shall now, however, point out a remarkable and

important exception to that general rule, by means of which we shall be enabled to shew, that from whatsoever cause or causes, compression of the blood is either diminished or suspended, from that moment the evolution of Animal Heat will be diminished, or will cease to take place, and consequently, that a compressed state of the blood must be the actual and immediate source from whence Animal Heat flows.

When engaged in the consideration of the circumstances on which compression of the arterial blood depends, we saw, as a preliminary step to the blood's being compressed by arterial contraction, that a resisting and propelling power were essentially necessary to fix and steady the blood. If such powers had not existed, the contractile force of the arteries must obviously have failed of any compressing effect on the blood; for no principle in nature can be more evident and undeniable, than that a fluid body, if it be totally unconfined, will yield to any force applied to it and of course completely escape being compressed, let the magnitude of the compressing power be what it may: or, if it be confined, in proportion as it is more or less so, in the same proportion must it resist any force, and be compressed or uncompressed.

On this simple and obvious principle then, it is plain that if the quantity of blood, contained in the arterial system or the vascular system in general, (which amounts to the same thing since, venesection and and arteriotomy equally take from the general mass of blood in the circulation) be so diminished that it shall not sufficiently distend the artery, (a circumstance which we can easily ascertain by the pulse) it will be less confined and consequently will in propor-

portion escape being compressed * The fact may be thus proved—take a portion of an artery, or any other tube with yielding parietes, six or eight inches in length, distend it with any fluid, securing it, at either end of the tube, by ligature. Pressure made on any portion of the tube will now show that the fluid is capable of giving a resistance to it, so effectual, that if the force applied be sufficient, it must be compressed; inasmuch as it can neither give way or elude the compressing power to which it is subjected. Let one third of the fluid escape, and it will be directly found that it does not present the same general resistance that it did, when the quantity was undiminished; but if, instead of one, two thirds be removed, partial pressure, either lateral or circular, will no longer be resisted; the fluid will yield wherever force is applied to it, and cannot be compressed, unless the quantity be again augmented, or that which remains be collected in a portion of the tube which it is yet capable of distending.

This, I believe, will serve to convey a sufficiently clear idea of the necessity for quantity as well as pressure, in order to a fluid's being compressed. We shall therefore, relinquishing theory, proceed to demonstrate that the degree of compression which the blood undergoes in the arteries, depends on the quantity of blood in the system, not less than on arterial action itself, and that the temperature of the body declines in proportion as compression is diminished by lessening the quantity of blood, notwithstanding the indisputable fact, that arterial action may be, at the same time, accelerated instead of retarded.

* The capability of a fluid to distend any vessel may evidently be diminished in two ways, either by increasing the capacity of the vessel, or lessening the quantity of the fluid, the capacity of the vessel remaining the same.

When an artery has received a punctured wound, the strength of the blood's projection is such, at first, that it is scarcely possible to restrain it: but if either the quantity of blood in the vessels be lessened, or arterial action (the effects of which we have already shewn to be compression on the blood) be reduced, the strength of the blood's projection will be alike diminished in either case. If, for instance, the quantity of blood be considerably lessened by the uninterupted progress of hemorrhage, the projection of the blood, which strictly marks the degree of compression to which it is subjected, will either become so feeble, as to be readily controled by the same means which were ineffectual, while the quantity of blood, and, of course, compression on it were greater, or it will cease spontaneously; as it does, on the other hand, in consequence of a suspension of arterial action from fainting, during which the blood obviously remains uncompressed.*

* Hewson, in the course of his experiments, ascertained, that in bleeding an Animal to death, the first cup of blood which is drawn, is later in coagulating than the second; the second than the third, and so on, unless convulsions supervene; when, the blood will be later in coagulating than that which was drawn previous to this occurrence: and if fainting should take place (the effects of which are, a suspension of arterial action and a declension of animal heat) the blood will coagulate as it flows. Now, in cases of hemorrhage, the equilibrium between arterial action and the resistance to it, necessary to constitute compression on the blood, fails as the blood flows; and as the blood flows, the tendency to coagulation, which marks the loss of caloric suffered by the blood (since it cannot possibly coagulate or become solid, until it has parted with its caloric of fluidity) increases in a ratio nearly uniform, and uninfluenced by the accelerated pulse accompanying it, unless such an inordinate action in the arteries, proceeding from convulsion, take place, as can leave little doubt that the compression on the blood has experienced a temporary increase; during which, the disposition of the blood to coagulate is lessened, in consequence of a momentary rise in its temperature.

Now, as the quantity of caloric, generated in the frame, depends on the degree of compression the blood has undergone in the arteries, blood drawn, when inflammatory fever is present, must contain more free caloric than that which is taken from a person in health. Consequently, as it contains more caloric it will be longer in parting with it or becoming solid. Which perfectly accounts for the slow coagulation of inflammatory blood, and at the same time explains the

In cases of this nature, the pulse and temperature of the body are not the least remarkable phenomena which present; for we find, that, as hemorrhage proceeds to excess, the pulse becomes more rapid; while, contrary to the general rule, the bodily temperature uniformly declines as the quantity of blood, and, by consequence, the degree of compression it undergoes, is diminished.*

To place this in a more familiar point of view, we shall suppose a case of synochâ or pure inflammatory fever; in which the pulse amounts to perhaps 120 strokes in the minute, and the temperature of the body is so high as to preclude sleep or rest. When we examine the pulse, we find, in addition to our observation as to the number of pulsations, that it is full, hard and unyielding to pressure—This being ascertained—we immediately determine on removing a quantity of blood, by which, provided the quantity removed be sufficient to render the pulse softer and more yielding to pressure, we know, from experience in similar cases, that a reduction of nervous excitement, vascular action and bodily temperature will be directly effected.† If on the contrary, the quantity

reason why, in local inflammations, blood drawn from the system will not, in general, exhibit the characteristic coagulation of inflammatory blood; since the blood, so drawn, may not have been subjected to any increased compression.

* Much has been said concerning the vitality of the blood; nay its sentient powers have been spoken of, but, I believe, it will be all found to resolve itself into this. Blood rendered florid, by the compressing power of the arteries or by the acquisition of caloric from exposure to oxygen, possesses a vitalizing or stimulating property, which it loses in proportion as it parts with its free caloric, and assumes the venous character.

† Whenever we find an intense degree of heat occupying the surface of the body in all its parts, and that we have clearly ascertained that it has not arisen from the recent application of some stimulus, such as ardent spirits, fermented liquors, small doses of opium, &c. &c. &c. nor, from much bodily covering or a medium of too high a

be not sufficient to reduce the pulse in fulness and hardness, neither arterial action, bodily temperature or nervous excitement will be perceptibly diminished. But should the quantity of blood removed, bear a considerable proportion to the entire mass in the circulation, the pulse will no longer exhibit those characters of distension and resistance: the fever will either be removed, or its type, of necessity, altered; and synochâ, that is genuine inflammatory fever, cannot possibly be re-excited by any means whatever;* because, the degree of resistance, which the blood must be capable of giving to arterial action for the purpose of being compressed, cannot now be afforded, by reason of its deficiency in quantity.†

temperature (all of which have the effect of exciting the nervous system or remote cause of Animal Heat) in such a case, no matter what the state of the pulse may seem to be, or whether we apply to it for information or not, we may set it down as a general rule, that the lancet may be employed not only with safety but advantage; because we know that such a degree of heat, as we have just described, could not be generated unless the action of the heart and arteries was increased, and unless there existed in the vessels a quantity of blood, sufficient to afford a full and effectual resistance to the compressing power of the arteries.

* In fever, no very high degree of temperature ever attends the soft pulse, nor would any judicious practitioner think of rendering it softer by bleeding. Well aware of the precarious and protracted state of debility that succeeds extensive losses of blood, he declines removing more from the system than may be directly indicated by the peculiar symptoms of the case, or the fulness, hardness and celerity of the pulse.

† In cold climates, the absence of perspiration increases the quantity of blood in the circulation, and consequently renders the degree of its compression greater; which is obviously necessary in order that an excess of caloric might be generated to meet the loss sustained in the rapid abstraction of it by the surrounding medium—In warm climates, on the contrary, the quantity of blood is constantly diminished by perspiration, in order to obviate the pernicious consequences, which would arise from a high degree of compression on the blood in a medium where the temperature is too high to permit an excess of caloric to pass off. In such situations the external heat alone would quickly terminate life, were it not for the cooling effects resulting from evaporation thus produced.

After an immoderate bleeding of this description, should fever still continue in consequence of the presence of other stimuli, it will be of a low nervous species, characterized by a yielding, and indistinct pulse, surpassing, perhaps by countless strokes, the pulse of inflammatory fever, and yet attended with a temperature of body, not only inferior to that of inflammatory fever, but considerably under the temperature which accompanies the slow and placid vascular action of health, exerted on a sufficient quantity of blood to resist it steadily and effectively.*

In the venous parts of the circulation, the absence of those circumstances, whose joint presence we have shewn to be essential to the compression of arterial blood, at once declares their inability to compress the blood, and consequently the impossibility of their contributing, in any measure, to the maintenance of Animal Heat. In the arterial part of the circulation, the degree of resistance, (supposing the average quantity of blood present) which the blood gives to vascular action, depends on the impetus with which it is urged from the trunks towards the branches. But in the veins, the blood flows from the branches into the trunks, from which, it is obvious, let the rapidity of its motion be what it may, that it cannot meet with any resistance, except what may arise from extraneous or casual circumstances, and consequently, if the veins were even possessed of a pulsating or contractile power, like the arteries, the blood circulating through them would nevertheless escape compression.

* In hemorrhagic cases, or cases of vascular exhaustion, unattended by any organic disease, the transfusion of blood, performed so as to prevent the access of air during the operation, seems to offer fair and rational grounds to rest our hopes of success on. The exhausted vessels, being replenished with blood, the necessary resistance would be again opposed to arterial action; compression of the blood would be again effected, and, of course, the natural temperature of the body restored.

In order to satisfy ourselves as to this, we have but to recollect the necessity for creating an artificial resistance (by bandage) to the return of the blood, when we wish to make it project from a vein, in the operation of phlebotomy. When we may also satisfy ourselves, that the force, with which the blood is projected, depends on the same causes, artificially exerted, by which it is, naturally, projected from a punctured artery, by observing the increased projection, which is produced, when we force the blood with our hand along the vein towards the orifice; and the diminished projection which takes place, when we cease to force the blood towards the resisting power or bandage—and finally, the complete cessation of the blood's projection, when the artificial resistance is removed and the blood suffered to resume its wonted course.

On the same principles of vascular construction it is, that the uncompressed state of blood, in those animals whose circulations are venous, and whose temperature of body, in consequence of it, is so much inferior to that of animals possessing a general arterial circulation, is to be explained. Some circumstances however are to be met with in these circulations, which, although incapable of producing effects different from those which attend the venous part of hot blooded circulations, yet being deviations, such as, in some respects, create a resemblance between them and the arterial circulation, we think it but right, that we should notice them, in order to remove every doubt which might remain on the mind, with respect to a matter of so much moment towards the establishment of this theory.

In the circulation of a cold blooded fish,* which is

* The Whale is an instance of a warm blooded fish, its circulation resembles that of man.

one of the best examples we could adduce of a red, yet cold blooded circulation, we find that the blood proceeds from a single heart to the branchæ or gills, through the pulmonary artery (the only artery to be found in that circulation) at the extremities of which, it is received by corresponding veins, which enlarge as they proceed to form a trunk to supply the body—Here the circulation strictly resembles the venous part of warm circulations, and, consequently, the blood does not suffer compression. But as this vein or aorta, as it is termed, advances towards the opposite extremity, it becomes aborescent, like the arterial circulation. This, however, is but one, out of the three circumstances which we have shewn to be necessary to the compression of the blood; of the other two, that is the vis a tergo and arterial contraction, the one exists, in a very inferior degree, the other not at all.

Having now demonstrated how absolutely the quantity of heat generated in the frame depends on the immediate operation of the proximate cause, the principal difficulty may be considered as overcome: for in order to establish the dependance of Animal Heat and, consequently, Inflammation on the remote cause, through the agency of the proximate, nothing more is requisite than to show, that when the nerves cease to exert their influence over any member or part of the body, the vessels of that part, of necessity, become so inert, that a suspension of Animal Heat will there take place, as certainly as we have found it to do in those cases, where their action had been rendered ineffective by other means too direct to allow their immediate agency to be called in question.*

* Mr. Abernathy in his detail of the progressive symptoms of concussion, which he divides into three stages, says, "as long as the stupor remains (that is as long as the remote cause continues inert)

Thus, for instance, when a limb becomes paralytic, or is rendered so, by the application of a ligature to its principal nerve, or nerves; or their usual influence is arrested by the pressure of a luxated bone, violence from without, or any other cause whatever, the energy of arterial action subsides, in the general abolition of muscular power which marks this disease, and with it, the natural warmth of the part disappears, never to return, unless the vigour of the circulation be restored, in consequence of a recovery of the nervous sensibility, on the influence of which, the action of the arteries, in common with that of every other part of the frame, is directly dependant.*

the inflammation of the brain seems to be moderate, but as the former abates the latter seldom fails to increase." On this principle only, can we account for the beneficial effects resulting from the removal of all nervous stimuli, in cases where a high degree of inflammation is present—In Ophthalmia, the absence of light is essentially necessary to the abatement of inflammation. In inflammation of the brain, the absence of light, noise, etc. are not less necessary to assist our other means of relief: nor are we unacquainted with the advantage derived, in most diseases, from inspiring hopes of a speedy recovery, and preventing any depressing passion from taking possession of the mind or imagination, which we are aware, from experience, may even generate diseases of the most distressing and intractable nature.

* In paralysi, sensus plerumque superest, aliquando deletur. sæpe obtunditur. Raro quod tamen pessimum est, motus, sensus, pulsus, calor artuum, qui solvuntur, simul pereunt; scilicet ipsæ arteræ paralyticæ fiunt. Gregory's Conspectus Medicinæ Theoreticæ, p. 121.

This description, which must be allowed to be a fair and correct representation of the usual effects of paralysis, if considered with a reference to the proximate and remote causes of Animal Heat, adopted in this theory, so pointedly applies to the causes of the failure of Animal Heat in Mr. Brodie's experiments, already spoken of, as, in our conception, to remove entirely that difficulty with respect to them. The animals on which he performed artificial respiration were pithed (that is, the spinal marrow was divided in the neck) and the head removed. Now although, after such a death, the irritability of the heart will remain for some time, from its possessing that property in a greater and more permanent degree than any other part of the body, and consequently, the circulation may, through its means, be carried on for a certain time, it is evident that the arteries, like every other part of the body, losing their irritability sooner than

It is not necessary, we presume, to occupy further time or space in demonstrating the dependance of the proximate on the remote cause. The connexion between them, like those dormant sympathies, that are known to exist between different portions of the animal frame, and yet, are scarcely felt until nervous sensibility becomes augmented by disease, is exhibited by the effects of paralysis, in colours so strong, and characters so legible, as to preclude the possibility of its being overlooked or disavowed.

Thus far then, with respect to the general circulation, this theory appears to develop itself uninterupted by the ocurrence of any fact or argument capable of lessening its real claims to our assent.* We saw, on the general principle, that compression of the blood

the heart, the energy of their action, depending on that property, must fail sooner (which in fact we find to have been the case in these experiments; for Mr. Brodie states, that at the end of an hour the pulse was imperceptible, although the heart continued to act; which, again, we know to be the case with dying persons, in whom the pulse and heat first fail at the extremities and last of all at the heart) therefore, as the disengagement of Animal Heat depends on a vigorous arterial action, it must, in such experiments, soon fail to be disengaged; because the circulation of the blood, maintained by artificial respiration, is in a short time, dependant on the heart alone, since the arteries soon become passive after the destruction of the nerves, on which their action immediately depends.

Such a circulation therefore, must evidently be not only incapable of maintaining Animal Heat, but will have the direct effect, should the lungs be more fully inflated than they are in ordinary respiration, of hastening its departure from the body, by exposing each portion of the blood successively to the cooling effects of atmospheric air.

* Although we freely admit our inability to remove or lighten, except by conjecture, some of those difficulties which obscure the first or general source of Animal temperature; such an admission is not to be considered as an admission of the imperfection of this theory on that account. Those difficulties refer strictly to the doctrine of respiration, and therefore cannot possibly extend to or be confounded with the causes of Animal Heat and Inflammation: which are (as already shewn) perfectly distinct from the function of respiration, and totally unaided by it, except in a subsidiary capacity, that is, as a means of revesting the globules of the blood with a quantity of caloric equal to that expended in each circuit which they make through the body.

would be a cause adequate to the extrication of heat from it—We saw it demontrated, on irrisistable grounds, that compression of the blood takes place in a powerful degree, during the healthy vascular action, and that when that action becomes morbidly increased, the degree of compression affecting the blood is such as to give rise to that elevation of bodily temperature, characteristecally designated by the term inflammation. While, on the other hand, we found that when the compression sustained by the blood was diminished, in consequence of an abatement of arterial action, a corresponding fall of temperature was the result; and finally, when natural construction, that is, a venous circulation, excluded the operation of that principle, or that it was rendered ineffective, in consequence of a deficiency of the blood itself, or a suspension of nervous influence, Animal Heat was no longer generated or maintained—But, when we come to consider the circulation of the lungs, where we find an artery, unaffected by mechanical interposition, or any disease of the proximate or remote cause, uniformly circulating and containing dark blood, we pause at once on the appearance of a phenomenon which seems, at the first blush, subversive of that part of our doctrine which teaches, that the florid colour is a necessary and direct result of arterial action. But if we take a more deliberate view of this part of the circulation, bearing in mind its connexion with the general venous system, as well as the precise object of its functions (according to which the powers of the circulation are ever adapted and proportioned) resting our inferences, at the same time, on that most satisfactory species of evidence, in matters of this nature, the anatomical structure of the parts themselves, we shall soon be convinced, that that which appeared, at the first glance, to carry with it a direct contradiction, is, in reality, a corroboration

of our explanation of the causes on which the florid colour of arterial blood depends, as well as a medium through which we shall be enabled to detect and remove similar difficulties, arising from the occasional appearance of an arterial circulation in the inferior classes of animals, the colour and temperature of whose blood, scarcely permits them to be distinguished from the strictly cold blooded animal, whose general circulation is venous.

The blood in its transit through the lungs, having acquired the glowing brightness imparted by caloric, is immediately subjected to the powerful action of the left ventricle, by which it is impelled through the general arterial system, where a similar action is maintained. But having passed the capillaries, and entered the veins, where compression ceases to affect the blood, and, consequently, the tendency of caloric to become latent, in the globules, ceases to be resisted, it shortly begins to lose its florid colour, and assume a deepened hue indicative of a diminished temperature. In this state of inferiority to arterial blood, with respect to colour and temperature, it again arrives at the heart. But here we will find, on comparing the structure of the right ventricle and its appended vessels, to which the blood is now delivered, with that of the left ventricle and its vessels, as great an inferiority in point of muscular strength, as venous blood bears to the general arterial blood, in colour and temperature.

To accomplish this part of the circulation, no greater powers were requisite to the ventricle and its vessels, than would be sufficient to impel the blood through the pulmonary capillaries—Such powers they possess—Greater would only have augmented the chances of inflammation and hemorrhage from slight causes, and therefore have been wisely withheld.

Now as the compression of the blood must be, in all cases, cæteris paribus, proportioned to the powers of the vessels acting on it; the compression, affecting the blood contained in the right ventricle and its vessels, cannot be equal to that which affects the blood while circulating in the more powerful vessels belonging to the general circulation; nor can it be of that vigorous and energetic description that would be requisite to re-produce the florid colour, by forcing out caloric which had become latent in the globules of the blood,* in consequence of its uncompressed state, during its passage through the general venous circulation; it therefore, still bears the characteristic appearance of uncompressed or venous blood.

Since then, amidst the vessels composing the vigorous circulation of Man, we discover some that are naturally incompetent to exert any effective compression on the blood, while any and all of them are liable, from a failure of nervous sensibility, such as constitutes paralysis, to be so far divested of the power of compressing the blood, as to be incapable of supporting the natural heat of the body: and since, in the advanced stages of existence, when every vestige of physical power, by which the former animal could be recognized, glides away in quick succession, the action of the vessels becomes so feeble and tardy, that the temperature of body, keeping pace with it, is almost levelled and assimilated with that of the cold

* If the globules of the blood did not contain a considerable share of latent caloric, they could not continue giving it out so long, and in such quantities as we find disengaged by the action of the vessels in phlegmonous inflammation, where the blood, remaining unchanged, ceases to visit the lungs, and consequently, ceases to receive those regular supplies of caloric, which it did previous to its incarceration in the local vessels.

blooded animal;* it is easy to conceive, that cold blooded animals may be found, furnished with a circulation, apparently arterial, but, in reality, no more capable of effecting that degree of compression on the blood which is requisite for the evolution of Animal Heat, than the inert system of vessels, belonging to the strictly cold blooded circulation.

It follows therefore, that the circumstance of a low temperature of body, in conjunction with an arterial circulation, conveying dark or even florid blood,† would not, of itself, be sufficient to constitute a solid or real objection to this theory. To establish such, (that is with respect to the leading principles, on which it is founded, for it were vain to expect, that a new and uncanvassed doctrine, like the present, would be found perfect or free from objection, in all its minor bearings) it would be necessary to exhibit a cold blooded animal, possessing an arterial system, replete with red blood circulating in a direction from the trunks towards the branches, and, of course, not only similar in structure, but, necessarily, endowed also,

* Under such a reverse of the animal economy, pathological experience tells us, that general inflammation or pure inflammatory fever is not to be found: and where local inflammation makes its appearance, its dark colour, low temperature and inconsiderable tumefaction, at once betray the nature of the vascular action with which it is connected.

† Animal Heat depends, not on the presence of a quantity of caloric, merely sufficient to maintain the florid colour of the blood, but, on an excess of caloric, generated by the vigorous action of the vessels composing the general arterial system, over and above the quantity which would be sufficient to support the florid colour, as testified by the fact, that arterial blood retains its florid colour, notwithstanding the vast expenditure and loss of caloric, which it is constantly undergoing in the diffusion of a quantity so great as is requisite to support the high temperature of Animal Heat throughout the frame, and as confirmed by the experiments of Mr. Brodie, (already quoted) in which the blood contained in the femoral artery was seen to be florid, although the vascular action was, at the same time insufficient to preserve the natural temperature of the animal.

with powers of action equal to those vested in the arteries belonging to the general circulation in warm blooded animals.

Such instances however, are not to be found on record—Nor is it possible that such a temperature and vascular system could coexist or be associated in one and the same individual; since, as the phenomena of both morbid and natural animal heat clearly evince, the quantity of heat generated in the frame is as unerring and conclusive a test of arterial strength or debility (assuming the requisite structure; course and and quantity of blood to be present) as even the projection of blood itself, which, as a criterion, cannot possibly lead to a false or deceptive estimate.

FINIS.