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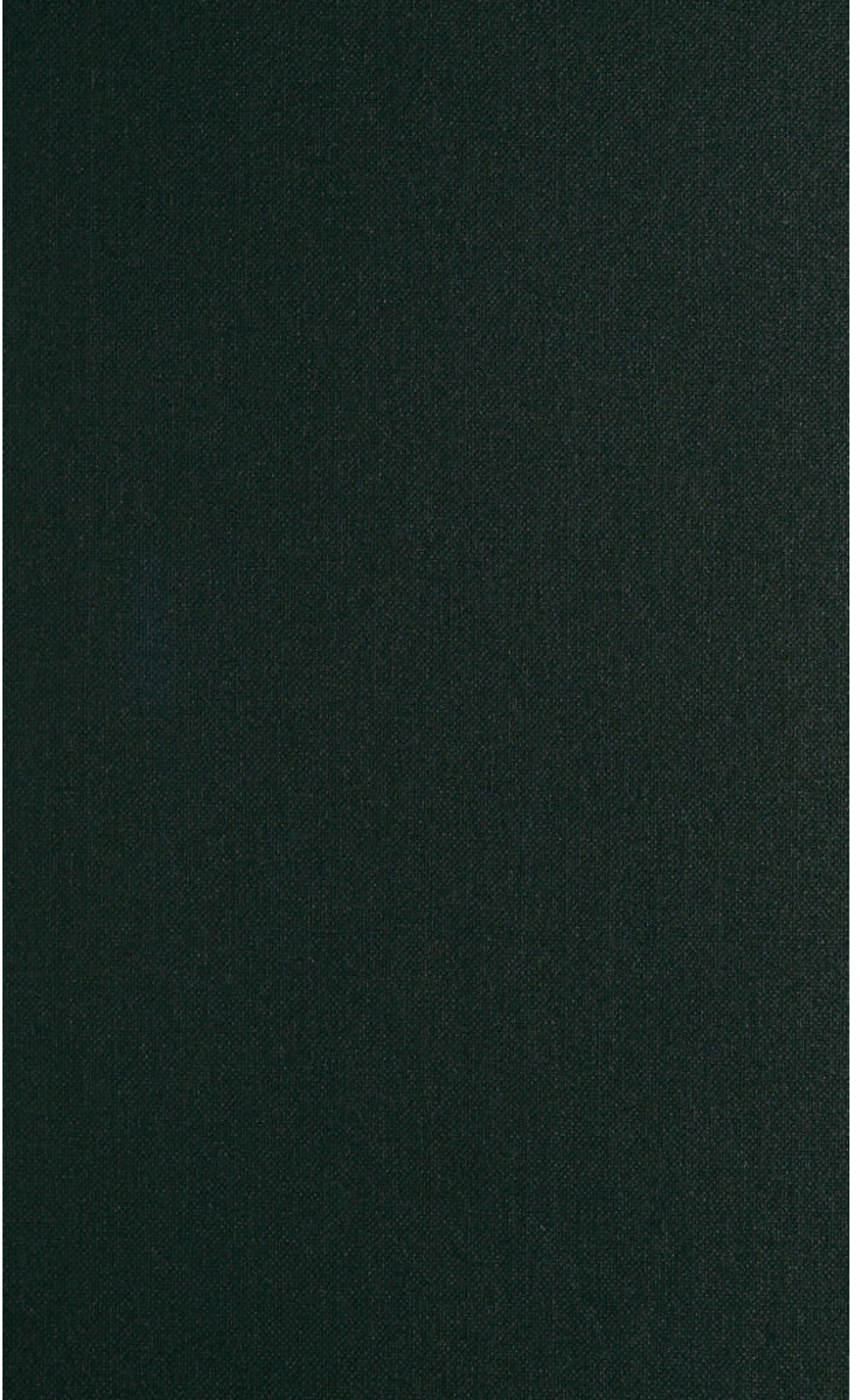
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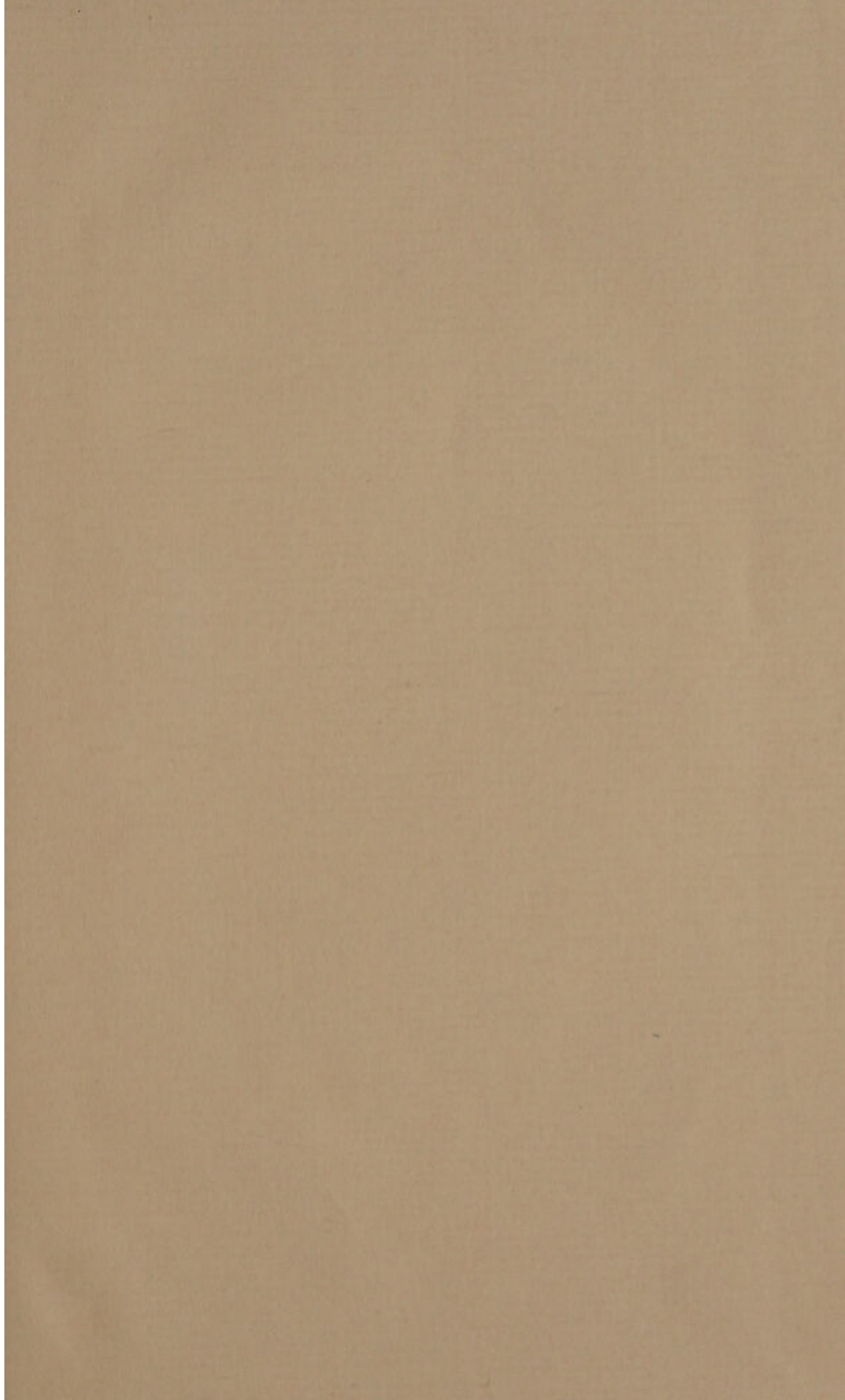














AN
INAUGURAL DISSERTATION
ON THE
PRODUCTION OF ANIMAL HEAT:

READ AND DEFENDED AT A
PUBLIC EXAMINATION,
HELD BY THE MEDICAL PROFESSORS, BEFORE THE
REV. JOSEPH WILLARD, S.T.D. L.L.D. PRESIDENT,
AND THE
GOVERNORS OF HARVARD COLLEGE,
FOR THE DEGREE OF BACHELOR IN MEDICINE,

JULY 10, 1797.

BY LYMAN SPALDING.

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1898

ALBANY

1898

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1898

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TO
NATHAN SMITH, M. B.
THIS
DISSERTATION
IS
RESPECTFULLY INSCRIBED,
BY HIS
GRATEFUL PUPIL,
THE AUTHOR.



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A N

INAUGURAL DISSERTATION.

THE heat of the human body, in health, is generally about ninety six degrees of Farenheit's thermometer. Yet so admirably is the economy of man adapted to the variations of heat, as not to be materially affected by it, excepting in its extremes.

MAN can dwell in all climates, free of danger, from the intense cold of Siberia and Spitbergen, where mercury congeals spontaneously in the thermometer, to the perpendicular rays of Amazonia. Nay more, Doctor Fordyce has by experiment proved, that man can exist in a room, walled with bricks and gradually heated to the degree of boiling water, *i. e.* two hundred and twelve degrees;

degrees ; and all these variations of place and temperature ; a difference of three hundred and thirty two degrees, or more, without destroying life, producing disease, or altering the temperature of the common mass of fluids, but a few degrees, from the standard ninety six.

It is surprising wherein consists the cause of this equilibrium of animal heat, whether the subject be exposed to the freezing blasts of the pole or scorching beams of the equinoctial sun.

ANIMALS therefore have a power of generating heat, when placed under the poles ; and a still more surprising power of resisting the introduction of heat or generating cold, when in a heated room.

IN the first instance the fluids are guarded from congelation, and in the second prevented from passing into elastic gases ; both of which principles are wanting in the vegetable kingdom.

WHAT

WHAT havoc heat and frost make in the husbandman's plantations! where a few hours midday sun or midnight frost, lays waste many months of labour; mars the beauty of the fields, and disappoints the expecting husbandman.

OF all the phenomena of the animal economy, none is more striking, none more worthy the attention of philosophers, than those, which accompany the function of respiration. Little as we are acquainted with the object of this singular operation, we are satisfied that it is essential to life, and that it cannot be suspended for any length of time, without exposing the animal to immediate death or imminent danger. It is universally known that air is the agent or rather the subject of respiration. But at the same time there are some kinds of air, which will not support life, in the higher order of animals.

THERE have been almost as many theories, as writers, on animal heat. It is perhaps needless

less and unseasonable for me to enter into an investigation of them. Some have supposed it to be generated by the tendency of the fluids and solids to putrefaction; others attributed it to the attrition of the blood in circulation.

WE will observe the different processes, by which heat is known to be generated. These may be confined to two; which are, first, Combination and Decomposition; second, Friction.

WE will take a cursory view of these, and see which best agrees with the phenomena of animal heat.

FIRST, of

COMBINATION AND DECOMPOSITION.

THE theory of combustion is now explained on the absorption of the vital principle from the air; and setting at liberty the azotic and carbonic principles, which arise in smoke.

THAT

THAT the air is decomposed and robbed of some of its constituent parts, which it possessed previous to its exposure to the burning body, and is combined with some other matter, which did not before appear in it, is evident from comparing atmospheric air, previous to combustion, with the same afterwards ; the *former*, of its common purity, M. d' Lavoisier found, by experiments, to consist of ,27 of oxygen, ,73 of azote, and ,01 of carbonic acid ;* the *latter* consists of little or no oxygen at all, a small share of azote, but perhaps one half is carbonic acid.

THE union of concentrated acids with water, quick lime, pure alkalis, or metals, is productive of a strong heat ; but the combination of the nitric acid with certain oily substances is so powerful this way as to cause inflammation.

B

LET

* These names were first introduced by the French, in their new Nomenclature, instead of the old terms, vital, impure, and fixed air.

LET us compare these phenomena with those of animal heat, and notice the agreement between them. It will be first asked *where are*, and *of what* consist, the combination and decomposition? Will it be thought sufficient if I say, in the lungs, during respiration, a part of the air is combined with the blood, and *that* in its turn sends off carbone* with the air expired.

THIS process appears similar to combustion, the smoke of which is exactly similar to our breath expired; the presence of oxygen is necessary to the support of the one as well as the other, during both of which the caloric† of the oxygen is separated from the air; their residues are totally unfit to support respiration or combustion, until they are again oxygenated. This, not being thoroughly understood, has been treated as *hypothetical*.‡

THEREFORE

* This is the coaly principle, the base of carbonic acid.

† Matter of heat.

‡ Cullen's Physiology.

THEREFORE, having found it impossible to account for it on these principles, resort was had to

F R I C T I O N,

WHICH we find was the favourite theory of most of the ancients, as it has been that of the moderns. This theory was powerfully supported by the celebrated Cullen, who saith that the cause of animal heat is "the motion of the blood."

SINCE FRICTION has been generally attributed as the *generating cause* of animal heat, we need not be surprised at the many hypotheses advanced respecting the manner *in which*, and the parts *on which*, it operated to produce it.

I AM disposed to favour and support a theory, which attributes the production of animal heat to the combination and decomposition of air and blood, in their passage through the lungs, during the act of respiration; by which
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the caloric in the air is disengaged from its constituents, and appears combined with the blood ; which may be deduced from this : the expired air having lost its caloric, which it possessed before inspiration ; and the blood having acquired an additional quantity of it, to what it had previous to its entering the lungs.

IN support of this, I shall first notice some general facts respecting the air's containing caloric. Then, that this caloric is disengaged from the air in its passage through the lungs. Thirdly, that a decomposition of the blood takes place at the same time. Fourthly, that there is a combination of some substance with the air expired. And, lastly, that a certain matter is combined with the arterial blood in the lungs.

THOSE truly ingenious philosophers, Doctors Black and Crawford, have proved, by a number of nice experiments, (which it would be difficult to give a just idea of without engravings) that the caloric is contained in the oxygen ;

oxygen; and that *expired* air contains only one third part of the heat, which was contained in it previous to inspiration; it follows that the former must necessarily have given off its excess of absolute heat in the lungs.

THE comparative heat of florid arterial blood is, to that of venous, as eleven and an half to ten; the heat of that blood, which is returned from the lungs, is greater than it was previous to its entering them, from which it must have received its supply.

WE may conclude from hence, that, in the lungs, during the process of respiration, a quantity of absolute heat is separated from the air, and combined with the blood.

DR. CRAWFORD has inferred, from experiments, that, in the conversion of arterial blood into venous in the capillaries, the heat is disengaged from the arterial blood, and combines with the surrounding substances. So that venous blood must have, by far, less specific heat, than what appeared just before in the arterial; and, if
that,

that, on its arrival in the lungs, should be converted into arterial blood, without receiving any supply of absolute heat from the air, its sensible heat would be so diminished, as to fall from ninety six degrees, to below the freezing point.

IN a warm medium, the same animal decomposes less air, in a given time, than in a cold one, also less heat is disengaged, the difference of colour in the arterial and venous blood is less ; and these in proportion to the temperature of the circumambient air. A cubic inch of air, of the temperature of two hundred and twelve degrees, contains, by far, less oxygen, than when of a temperature one hundred and twenty degrees below 0 ; and in the decomposition of equal quantities of air, of so different temperatures, an amazing excess of heat will be in favour of the cold air. Hence inflammatory diseases are most prevalent in the cold seasons ; it is this, which, in animals, wards off the destructive effects of cold in the polar regions.

ON

ON the other hand, the quantity of caloric being very trifling, that is disengaged from the warm air, instead of increasing the heat of the arterial blood, it does not equal the cold produced by the conversion of venous into arterial blood; and, instead of increasing the heat, it generates cold. On this, and evaporation, it is that man is capable of enduring an atmosphere heated two hundred and twelve degrees, without suspending the functions of life.

THE air is decomposed in its passage through the lungs, and the caloric disengaged from it.

ATMOSPHERIC air, or that which we respire, is a heterogeneous fluid, composed of oxygen, azote, and carbonic acid. The former maintains life by respiration, and fire by combustion; both the latter are totally unfit for either of those purposes.

OXYGEN is also a compound, consisting of a principle of solidity and caloric, fire, or the matter of heat. Caloric is most abundant in oxygen; other airs, such as air expired, smoke,
&c.

&c. contain but little if any at all; in any air that is nearly proportional to ~~this~~ ^{its} power of supporting life.

AN animal, placed in a vessel containing air, as soon as it is nearly all changed by respiration, sickens, is convulsed, and dies, if not removed. This happens instantaneously in carbonic acid, almost as soon in azote, later in atmospheric air, and latest in oxygen, which supports life about four times as long as atmospheric air, and is perhaps the much celebrated PABULUM VITÆ of the antients.

IN the third place, we have to show that there is a decomposition of the blood, in the lungs, during respiration.

THE venous blood, when brought to the lungs, is of a dark modena red, which is produced by the presence of a large quantity of hydrogen or azote, and absence of oxygen. To prove this the following experiments were instituted, two ligatures were made on the jugular vein of a living cat, one half of the blood contained

contained between the ligatures was drawn off, the vein filled with hydrogene ; an hour after the blood, being drawn from the vein, was fluid, but had acquired a colour almost as dark as ink. At, and for, the same time, an equal quantity of blood was intercepted between two ligatures, on the crural vein of the same animal. This blood, being drawn from the vein, was found in some measure coagulated, but miscible with water ; communicating, by far, less colour to it than the former. Hence it may be inferred ; that, when hydrogene or azote are in contact with the blood, they increase its colour and diminish its tendency to coagulation.

WE will shortly state how hydrogene and azote may be introduced into the circulating mass.

BLOOD attracts hydrogene and azote, which are separated from animal substances, by heat and a tendency to putrefaction.

THE colour of the arterial blood is a light scarlet ; it undergoes the same change in completing

pleting a circulation, as by exposure to hydrogen or azote. Therefore, we may conclude, that it is united with these, in some part of its routine, and perhaps in the capillaries, where they are separated by heat and the putrefactive process. These, united with the blood, account for the dark grumous colour of it in the vena portarum, where it has absorbed an unusual quantity from the semiputrescent contents of the alimentary canal. The air, contained in the large intestines, is mostly hydrogen.

THE greater the heat of the animal, and tendency to putrefaction, the more *impure air* will be disengaged, and the venous blood darkened proportionally.

WE have now to consider the combination of some substances with the air expired, which did not appear in it, when inspired; these are fixed air and carbone.

AN expiration consists of fixed air, hydrogen, ~~azote, and carbone.~~

THE

THE presence of fixed air is proved by its precipitating lime water, when agitated with it.

THE quantity of carbonic acid is greatly increased by respiration (where the oxygen combining with the carbone, in the proportion of seventy two to twenty eight, forms pure carbonic acid) instead of being one part in an hundred, as in atmospheric air, makes, perhaps, one tenth of the whole expiration.

FOURCROY observes, that carbonic acid is produced by respiration, combustion of coals, and is exhaled from plants in the shade; is instantaneously fatal to animals, and extinguishes flaming tapers.

AZOTE arises mostly from putrefying animal matters; is very noxious to animals and flames.

THE presence of these two gases is the cause of the great fatality observable in tight bed chambers, where a pan of coals has been added to ward off the cold, during a winter's night; in prison and cartel ships, hospitals, jails,

jails, &c. where numbers are crowded together, without proper ventilation.

THIS is evident, from the symptoms of those, who languish, being the same as are observable, when introduced into carbonic acid, or azote, as mentioned above, they first appear stupified, soon agitated ; respiration becomes laborious and hurried ; from this, the symptoms of distress fast increase, till subultus tendinum and convulsions close the scene with death.

THE same cause we give for the production of endemic diseases in compact towns, during the hot seasons of the year, when the putrefactive process seizes all inanimate animal substances and many vegetables, disengaging therefrom the noxious azote, which remains stagnant for want of a current of air to disperse it.

L A S T L Y,

WE have to speak of caloric, which is combined with the arterial blood in the lungs.

THIS

THIS is separated from the air in respiration, and changes the colour of the *venous*, to a light scarlet, and greatly increases the absolute heat of the *arterial* blood.

To prove this, the experiment above related may be introduced, with this difference; introduce oxygen into the vein in lieu of hydrogen. The blood when drawn will be of a most beautiful scarlet. Also, expose a glass of venous blood to the action of oxygen, the same effect will be produced; or sprinkle it with a neutral salt, as muriate of soda, nitrate of potash, &c. which, on decomposition, are known to send forth a large portion of oxygen, and we shall see the surface changing rapidly to a light scarlet.

WHEN two or more bodies are united by the attraction of composition or glandular attraction, their temperature suffers a change. The oxygen is combined with the blood in the lungs by this attraction of composition, and there eliminates a part of its heat; but when it arrives at the capillaries, which are actually glands,

glands, a new attraction of composition, with a glandular attraction, eliminate the remainder, which was the greatest part of the caloric.

THE heat of the arterial blood is, to the venous, as eleven and an half to ten ; this is sufficiently established by direct experiments.

FROM the preceding observations, may be drawn the following inferences : animal heat, and heat sent forth by combustion, depend on the same cause. Animals, who respire little or no air, are always cold ; such are fishes, toads, lizards, insects, serpents, &c. whose arterial blood is destitute of that florid redness.

R E S P I R A T I O N,

THEREFORE, appears to be but combustion in a less degree, in which atmospheric air is decomposed in its passage through the lungs, is robbed of its vital principle, caloric of the oxygen, which is combined with the blood, and with it diffused through every and the minutest part of the system, spreading its genial warmth

warmth and animating every fibre ; till, in the capillary vessels, it is exchanged for hydrogen and azote, where the blood parts with its scarlet hue for a dark modena red ; furcharged with these new properties, it returns to the lungs, where they are disposed of and a new routine commences.

IN this manner then, is animal heat generated ; and all parts of the body receive constant supplies from this great fountain of heat, the lungs.*

MAN does not receive his natural warmth from the temperature of the surrounding atmosphere.

* The author, since reading his Dissertation, has found some observations in Dr. Darwin's Zoonomia, which correspond so nearly with his own opinion and observations, that he was almost persuaded to introduce them to elucidate this work ; but to abridge is a *delicate task*. However, he hopes those, who are not fully persuaded of the truth of this theory, will consult that justly celebrated work ; particularly Section XXIII. 4. Section XXXVIII. and Class II. 1. 1. 2.

mosphere. Why should we expect his body to be of the temperature of Spitbergen or Amazonia, as he may chance to inhabit one or the other place? We find the principles of animal heat innate with him, and never diminishing nor increasing beyond bounds; although the surrounding atmosphere should vary three hundred and thirty two degrees, or more. Such is the wonderful economy of nature.

It may be asked, if combustion and respiration be similar processes, why does not light and flame appear from the one as well as the other? The answer is plain, the process of RESPIRATION is like combustion, but accomplished in a *much more gradual manner*; the rapidity of the former ill suits the slow progress of the latter. However, the phenomena of the two bear the same affinity to each other, as the phenomena of the *sudden and general*, the *moderate and partial* combination of nitric acid with oil. The former bursts into flame, shewing light, heat and all the phenomena of combustion; but the latter is more moderate, like respiration,

respiration, not being accompanied with any signs of light or flame, but all the other phenomena of the former, as heat, &c. Nevertheless the two processes are identically the same, only differing in degree.

PERHAPS these observations have been couched in too chemical terms, to be strictly adapted to the animal economy, which is not to be compared to a chemist's laboratory ; but the process is so similar to a chemical DOUBLE ELECTIVE ATTRACTION, that, without this order, the definition could not have been perfect.

THE foetus, egg, and seed, receive their vivifying heat from the parent animal or earth ; but as soon as the animal is ushered into perfect existence, we find it capable of generating this principle, independent of its parent, but the vegetable, ever so perfectly formed, is dependent on its parent earth for existence.

HERACLITUS maintained that FIRE was the vivifying principle of all bodies, both animal and vegetable. The ingenious Dr. Brown has added that their existence, growth and maturation depend on something, which acts from without, and this a "stimulus."

LIVING animals and vegetables have, besides the common properties of matter, a peculiar something, which distinguishes them from dead ones ; in these we see all the solids and fluids too : what then is lacking ? A gentle oscillation, or motion of the fluids, a circumgiration of the liquors, which is produced and continued through life by a certain something, absorbed from the air.

OUR ingenious professor, in a "Discourse on the Principles of Vitality," observes, "it is a portion of that subtle electric fluid, which fills the immense space of the whole universe, pervades all bodies, and actuates every particle of matter. By it the phenomena of magnetism, fire, and light are produced ; and on it
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the various and astonishing phenomena of
VEGETATION and ANIMATION depend."

THE arterial blood, having received the caloric, from the lungs, is directly distributed to every part of the body, and in every part is changed into venous blood, in the operation of which, it disengages the matter of heat, and absorbs a proportional quantity of hydrogen and azote, which are plentifully supplied from fermenting and putrefying matters; the greater the quantity of hydrogen and azote, yielded in any one place, the greater will be the quantity of heat exchanged for it in that place: instance fermentation in the stomach, called heart burn, what an increase of *heat* in that region.

ALSO,

PUTRID FEVERS,

IN which, to the accelerated velocity of the blood add, that the solids and fluids are tending to putrefaction; hence an unusual quantity of hydrogen and azote will be yielded, and

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an unusual quantity of heat will be exchanged for them at the conversion of arterial into venous blood. To these causes it is probably owing that the heat of the human body is greatest in these fevers.

LOCAL inflammation is accompanied with redness, tumour, and unusual heat, with increased circulation, and at length with a stagnation of serous fluid, which is effused into the adjoining cellular substance, the putrefactive process, commencing, the heat in the part is then greatest.

IN the state of health, the motion of the blood through the different parts of the system, and the hydrogen and azote with which the blood is supplied in these parts, is adjusted so exactly to each other that the exchange is equal through every part of the system.

BUT if by any excess the balance be destroyed, as by increased circulation, or by a tendency to putrefaction, it is evident that a greater quantity of heat will be extricated in
that

that part, in a given time; this heat will stimulate the vessels into more frequent and forcible contractions, by which the velocity of the blood, and consequent extrication of heat will be still farther increased. On this principle we may probably account for the partial heats, which are produced by topical inflammations, and those, which arise in hectic and nervous complaints. So the fire increases in that place where the air is gently agitated by the bellows.

DR. CRAWFORD observes that the doctrine which results from his experiments on animal heat, will probably lead to an explanation of the uses of the spleen and lymphatic glands.

MAY not the spleen, says he, be intended partly to apply a proper degree of heat to the left side of the stomach, and partly to supply the liver with azotic blood? As a quantity of fire is extricated, during the conversion of arterial into venous blood, in the capillaries, if blood, which is changed in the spleen, had passed to the liver, as arterial blood, and had been changed

changed into venous in that organ, it seems evident there would have been a redundancy of heat in the right hypochondriac region, and a deficiency of it in the left.



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