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AN

INAUGURAL DISSERTATION

ON THE

PRINCIPLE OF ANIMATION,

READ AND DEFENDED AT A

PUBLIC EXAMINATION,

HELD BY THE MEDICAL PROFESSOR, BEFORE THE

HON. JOHN WHEELOCK, L. L. D. PRESIDENT,

AND THE

GOVERNORS OF *DARTMOUTH COLLEGE,*

FOR THE DEGREE OF BACHELOR IN MEDICINE,

JULY 18, 1799.

BY DANIEL ADAMS, A. B.

What can we reason but from what we know?——POPE.

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TO

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PROFESSOR OF MEDICINE AT *DARTMOUTH UNIVERSITY*,

AND

CORRESPONDING MEMBER

OF THE

LONDON MEDICAL SOCIETY,

THIS

DISSERTATION

IS

RESPECTFULLY INSCRIBED,

BY HIS

MUCH OBLIGED

AND

GRATEFUL PUPIL,

THE AUTHOR.

AN

INAUGURAL DISSERTATION.

THE healing art preſents an extenſive field for ſpeculation. No ſcience embraces a greater variety of principles, or affords more ſubjects of philoſophical diſquiſition. Its inquiries extend to all the operations of nature; its objects are ſcattered far as the ſolar light.

Notwithſtanding the painful reſearches and unwearied inveſtigations, which have been made to improve this branch of knowledge, ſo engaging in itſelf, and ſo important to the intereſts of ſociety, ſtill this art is yet incumbered with the ſwaddling clothes of infancy.

Syſtems of medicine have changed with times, and the phenomena of diſeaſes have been explained on principles of the reigning philoſophy; the buſineſs of one age has been to refute the reaſonings of a preceding, ſo that what began to be called a ſcience, in the days of Hypocrates, is yet eſtabliſhed on little better foundation than that of hypotheſis and conjecture.

The ſtudy of nature has been too much neglected, and thoſe intimations of her deſigns, which, in her operations, ſhe is continually ſuggeſting to every contemplative mind, have been too little regarded.—From this unpardonable neglect, much falſe theory has crept into medicine; reaſon and reflection have given way to fancy, while the pedantry of philoſophy, and an ambition to eſtabliſh a favourite ſyſtem has often triumphed over plain truths, obvious facts,

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and clear demonſtration. That has been done in the cloſet, which ſhould have been done in the open field, and phyſicians have ſought for that information on the theatre of the anatomiſt, which is only to be found on the theatre of nature.

Notwithſtanding many falſe theories have been offered to the public, which have ſerved in ſome degree to confound the inexperienced, and oftentimes to misguide the more underſtanding, yet one advantage has been realized; for by giving a new preſentation of facts, they have often ſuggeſted uſeful and important ideas in medicine. Every theory, moreover, however extravagant, ſerves this important purpoſe, that it excites inquiry; and the author, if he ſhall have conducted his reaſoning by experiments and obſervations, will have ſome claim to the candour of the world, although it ſhould afterwards appear, he had been too haſty in his concluſions.

In this field now open before us, the *principle of animation* becomes a ſubject of curioſity and uſeful inquiry. There is nothing in nature, which exhibits to our ſenſes ſuch a variety of ſtriking phenomena, as life. It has been the wonder of ages; philoſophers have contemplated it with admiration, and naturaliſts have acknowledged, that the utmoſt reſearches of human ſagacity were inadequate to an underſtanding of its myſtery.

That mankind can ever arrive to ſo much information, and ſuch an acquaintance with the operations of nature, as to be able to anſwer every inquiry on this important ſubject, is quite improbable; at preſent we are ſure the ſtock of human knowledge is too ſcanty for ſo much underſtanding. Still, however, we have grounds for ſuppoſing, that human genius is not bounded by thoſe narrow limits, which at preſent mark our knowledge on this ſubject; we have the

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means of knowing the inſtruments, by which nature does her work, although we may not be capable of underſtanding completely the particular mode of her operations ; and it is not unphiloſophical to ſuppoſe, that the principle of animation may be detected, although ſome things in the œconomy of life ſhould ſtill remain laſting expreſſions of the limited capacity of man.

Every one, in the exerciſe of his ſenſes, feels himſelf capable to diſtinguiſh living beings from thoſe poſſeſſing no life ; but to give an explicit definition of life has been attended with ſome difficulty, even with philoſophers. Dr. PLENK has defined life, *the property of acting from an intrinſic power*. This appears not ſufficiently definite, as it does not diſtinguiſh between *vitalaction*, and that *action*, which takes place by attraction and combination in various other bodies, deſtitute of life. Dr. BROWN has been leſs exceptionable ; but, in his definition, he does not tell us what are thoſe *phenomena* peculiar to the living ſtate, which characterize animate beings.

Obſervation teaches us, that all living exiſtences are organic ; that water, heat, air, and various other ſubſtances external to them, as well as thoſe contained within their own veſſels, do excite in them certain actions ; that by thoſe actions they have a power of receiving, by organs adapted for that purpoſe, portions of theſe ſtimulating ſubſtances, and thereby cauſing them to undergo ſuch changes, as ſhall aſſimulate them to their own nature and ſubſtance. We, then, come to this underſtanding of animate beings : they are organized bodies, excited to action by ſubſtances external, thereby aſſimulating to their own conſtitution and nature, things of different and oppoſite natures, in a way ſo as to continue their exiſtence, produce their growth, and perpetuate their ſpecies.

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This ability, which organized bodies have, of being excited to perform thoſe actions, which are characteriſtic of life, is called *irritability*. This is the ſame, whether we conſider the contraction of fibres irritated by mechanical impreſſions, or that action, by which fluids are taken up by the veſſels, the ſecretions performed, and excrementitious parts thrown off. It is this irritability, which characterizes life; exiſts where that exiſts; and, as ſoon as the former is deſtroyed, the latter becomes extinct.

But what that may be, which gives to organized bodies the capacity of being excited, or on what their life depends, has for a long time agitated the ſchools of medicine; philoſophers have kindly afforded their aid in this important inquiry, ſtill the ſubject is clouded with doubts, and perplexed with controverſy.—Both phyſicians and philoſophers have been pretty unanimouſly agreed, that a certain *ſomething* does conſtantly pervade the whole ſyſtem, and give life and activity to every fibre. The ancients early adopted this opinion. This ſubtle fluid they called the *Pabulum Vitæ*. The ſame is the *Anima Mundi* of Plato, the *Archeus* of Helmot, the *Vis Medicatrix* of Cullen, the *Excitability* of Brown, and the *Spirit of Animation* of Darwin. The ſtriking contraſt, exhibited in the different appearances of living and dead animals, naturally inculcates this idea. In both we find the ſame organization, the ſame ſolids, and the ſame fluids, with this ſurprizing difference, however, that in the former there is a conſtant ability to action, while the latter is utterly deprived of this power. This ability to action muſt depend on a cauſe, this cauſe muſt be ſomething, but what this may be, to the operation of which, are to be attributed ſo many phenomena in the œconomy of life, it is not at preſent agreed, and how it is introduced into the ſyſtem, and there operates to produce its effects, is a ſubject of ſtill greater controverſy. Some

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have ſuppoſed it to be a pure ætherial ſpirit, equally pervading all ſpace, and all bodies. Some have thought it might be fire, others that it might be electricity, while many have ſuppoſed it to be an extremely ſubtle fluid, ſecreted in the brain, and thence tranſmitted thro' the nerves to every part of the body.

Theſe theories, however ingenious they may be, do not explain to our ſatisfaction the phenomena of life; neither do they reconcile thoſe facts, which have been aſcertained by obſervation and experiment; and, conſequently, cannot be ſuppoſed to have ariſen from demonſtrated truths, and a careful attention to the circumſtances attending life.

Our obſervations, in reply to preſent exiſting theories, will be directed to ſhow, Firſt, the uncertainty, that the principle of animation is an ætherial ſpirit of ſuch extreme ſubtlety, as to pervade indifferently all bodies. Secondly, the improbability of its being a ſecretion of the brain.

This firſt hypotheſis, which attributes life to an ætherial ſpirit, pervading indifferently all ſubſtances, is liable to many objections. It does indeed ſeem quite ſuperfluous to attempt any refutation of a theory, ſo much the work of fancy, and wholly detached from experiment and obſervation. What appears to have led philoſophers to adopt ſuch an one, was the neceſſity of attributing the phenomena of life to ſomething. Still there was nothing in the ſyſtem of nature, with whoſe properties and qualities they were acquainted, to which, with fairneſs, they could attribute ſuch marvellous effects. The alternative, then, was to acknowledge their incapacity to underſtand ſo deep a myſtery, or elſe to attribute animation to the agency of ſomething yet unknown. They did the latter, and, conſequently, taught mankind to believe their powers of life and activity depended on *ſomething*, whoſe exiſtence they have neither proved, nor rendered probable to be

any where but in the imagination of its projectors.—Examine the writings on medicine, from the days of Hypocrates to the preſent time, not one fact is adduced to ſubſtantiate this hypotheſis, which may not be more rationally accounted for on other principles.—Nor indeed do they plead as an excuſe, for their opinion, that it is ſupported by obſervation, or experiment; in their ignorance, only, can we find an apology. So far from affording any light on the ſubject, this does but involve us in deeper obſcurity, and rivets on our minds the chains of perpetual ignorance, by aſſigning that to be the cauſe of animation, of which it is not poſſible we ſhould have any knowledge.

Diſguſted with a theory ſo unſatisfactory, others have aſſumed another hypotheſis, now become more general, although, perhaps, no leſs falſe, which is, that the principle of animation is a fluid ſecreted in the brain, and thence tranſmitted by the nerves to every part of the body. That this ſuppoſition is premature and erroneous, I think will be obvious to every one, who reflects with ſoberneſs, judges with candour, and reaſons with attention.

There are abundance of circumſtances to convince us, that the brain is an organ of vaſt importance in the animal œconomy. The diſorders produced in the ſyſtem, by affections of this part, are ſuch as might well be thought, would have led many to ſuppoſe this to be the ſeat of life. But ſuch is the reciprocal relation and dependence ſubſiſting between each organ of our bodies, that it is oftentimes extremely difficult, if not impoſſible, to diſtinguiſh the appropriate function of each, and to know its juſt agency in the ſyſtem.—The brain cannot perform its functions without the action of the heart, and the conſequent circulation of the blood; and without the myſterious influence of the former, the latter would ſoon ceaſe to move: Nor can either of theſe continue their operations without

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the act of reſpiration ; and were it not for the wonderful proceſs of digeſtion and aſſimilation, all other powers would be in vain to maintain life. It requires, therefore, a particular attention to the different parts, organization, faculties, and powers, of different animals, to learn the importance of each, and its juſt agency in the ſyſtem.

We have the fulleſt conviction, that the brain and its appendages, the nerves, are the ſeat of ſenſibility ; and that theſe are the medium of all our ſenſations and volitions. It exerciſes, therefore, one of the moſt conſpicuous functions in the animal œconomy ; confounding this with irritability, a thing before deſcribed, and very different, has led to many miſtakes in phyſiology.

Was it ſo that irritability depended on the ſame cauſe, as ſenſibility, we ſhould expect to find thoſe parts moſt irritable, to which were diſtributed the greateſt proportion of nerves. This, however, is not the caſe ; the heart is the moſt irritable part of the body, notwithſtanding its nerves are not numerous. It is always ſo in animals, that thoſe parts, or muſcles, deſigned for ſenſation, or voluntary motion, are moſt abundantly ſupplied with nerves ; while thoſe parts, which receive the greateſt number of blood veſſels, as the heart and inteſtines, poſſeſs the greateſt irritability.

Further to illuſtrate this idea, we know, that by paſſing a ligature round a nerve, or by dividing it with a knife, we deſtroy all ſenſation and voluntary motion in that part, which has its communication with the brain thus interrupted ; ſtill, however, it does not loſe its irritability. Indeed, ſo tenacious are parts of this power, and ſo independently of the brain do they exerciſe it, that this organ may be completely deſtroyed, and they ſtill continue to exhibit evident contractions. The heart and inteſtines, after being

being removed from the body, will have their motions excited by mechanical irritations.

There have been many inſtances of the nerves of one part having been deſtroyed, or their functions ſuſpended, while yet that part has been able to exerciſe thoſe functions, which were neceſſary to the continuance of life. This has often been the caſe in paralytic limbs. That the functions of the nerves are completely ſuſpended, we are certain; for the patient can exert no voluntary motion, nor is he ſenſible to any impreſſion of external bodies; and that the part is poſſeſſed of irritability and life, we are equally certain; becauſe there are often involuntary contractions of the fibres, the blood circulates, and abſorption and ſecretion regularly take place.

What makes this, if poſſible, more certain is, that no putrefaction occurs, which in all caſes commences ſo ſoon as the animal, or a part is dead.

Dr. MUNRO, that indefatigable anatomiſt, affords us a very concluſive argument, in his experiments on the nerves, one of which I beg leave to relate in his own words.

"In ſeveral frogs after cutting off the back part of the ſix undermoſt true vertebræ, I took out all that part of the ſpinal marrow with the cauda equina, which they cover. The lower extremities were rendered inſenſible to common injuries, and lay motionleſs, yet the frogs lived ſeveral months thereafter, and the wounded parts on their backs cicatrized, and the bones of their legs which I fractured united, the blood circulating freely in their veſſels."

In theſe animals the functions of life appear not to have been impaired, when all the nerves of the lower extremities were deſtroyed. Not only did the parts, deſtitute

deſtitute of nervous influence, retain their vital affinities, but exerciſed the moſt vigorous functions of life, that of uniting fractured bones and forming new graſulations.

But to underſtand a thing we muſt conſider it in all the circumſtances of its exiſtence; and to gain a knowledge of our ſubject, we muſt contemplate life, not only as pertaining to animals, but likewiſe to the whole vegetable creation, and obſerve what things conſtantly attend it, and are inſeperable from it, in all the modes of its exiſtence.

The life of vegetables is analogous to that of animals; they poſſeſs many functions in common; and certain circumſtances are indiſpenſible to its exiſtence, in both. Like animals they are excited to the proper diſcharge of their functions by ſtimulating ſubſtances; they elaborate and prepare their food in a way ſimilar to animals, and like them they perform a variety of ſecretions, produce their growth, and perpetuate their ſpecies. They have glands, they have veſſels, they have reſpiratory organs, and do exerciſe the functions of life, as perfectly as animals. Notwithſtanding this, they poſſeſs neither brain nor nerves, nor do they exhibit any marks of ſenſation. Neither the Senſitive Plant, ſo much celebrated by Naturaliſts, nor the Diconœa Muſcipula, or Venus' Fly Trap, the ſingularity of which is, that it claſps inſects in its leaves with ſuch power, as to deſtroy them, exhibit any other marks, than thoſe of irritability, common to muſcular fibres. Seeing, then, there are living exiſtences poſſeſſing no brain, and parts having their communication with the brain deſtroyed in beings poſſeſſing it, do ſtill retain their life, the unavoidable concluſion is, that life does not depend on the brain, but that the functions of this organ are entirely of a different nature.

But ſtill, to ſhow the abſurdity, as well as the utter impoſſibility

impoſſibility that the principle of animation ſhould be afforded by the brain, I would beg leave to ſuggeſt one conſideration further.

It is not ſufficient for our purpoſe to conſider how life is prolonged, but we muſt likewiſe inquire how the firſt vital motions are produced, and what are the circumſtances attending their production.

Animate beings are capable of producing their ſpecies. The different ways, in which they produce them, have laid the foundation for a diviſion of animals into *viviparous*, and *oviparous*. Vegetables produce their ſpecies by ſeeds, which are in ſome degree analogous to the eggs of animals. Notwithſtanding this variety of ways, the changes which take place, and the delineation of the embryo of each ſpecies are governed by much the ſame laws. What theſe may be, the egg affords us the beſt opportunity for inſpection.

After incubation, what firſt appears is the heart and umbilical blood-veſſels. In eggs, which I have examined, the heart was ſeen to beat diſtinctly two days before any traces of the brain could be diſcovered.—The ſame we learn, from good authorities, of viviparous animals. In all ſpecies of animals, the heart is the part firſt formed: it is here that vital action does firſt commence, and this is the organ which firſt exerciſes its function in the ſyſtem. By the action of the heart and its appendages, the arteries, the other parts become diſtended and evolved. Now the firſt pulſation of the heart is as much dependent on the principle of animation, as the ſame action is at a time when the animal has arrived to that ſtate, which is the ſtandard of its ſpecies; and by the ſame laws, the firſt particle that of matter becomes aſſimilated to this organ, it is, that the body receives its growth and nouriſhment. All this, however, as we have ſeen, takes place before there are any veſtiges of the brain, and ſome time before this

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organ can be ſuppoſed to exerciſe its functions. Here, then, is the fulleſt demonſtration, that the principle of animation is not afforded by the brain, as the functions of this organ are ſubſequent to the exiſtence of life.—As we have noticed this phenomenon in the egg, thoſe diſpoſed to quibble, cannot eſcape its conviction, by ſaying, that the embryo is dependent on its parent for its firſt vital actions, as the egg is detached from the animal, which bears it. It is indeed wonderful, that any men ſhould have ſuppoſed life to depend on a fluid ſecreted in the ſyſtem, when the very production of this fluid muſt of neceſſity require life and vital action, in the ſyſtem, in order to produce it. The ſuppoſition plainly carries this aſſertion, that a thing can at the ſame time act and not exiſt, than which there can be no greater abſurdity. This conſideration muſt be ſufficient to ſilence every murmur, and demonſtrate to the ſatisfaction of every one, that the principle of animation cannot be afforded by the brain.

Thus, I have conſidered thoſe theories, on which the phenomenon of life has been moſt uſually explained: I have, to my apprehenſion, found them inſufficient and unſatisfactory. Not becauſe they leave ſome points hard, and difficult to be explained, but becauſe they are contradicted by experiment, and do not correſpond with facts and obſervation.

It now remains to point out what this principle may be, and the ſource from whence it is derived.

In the firſt place, it may be uſeful to notice ſome conſiderations, which may ſerve to throw us into a proper channel of inveſtigation.

We have conſidered life, and pointed out its characteriſtics. From the obſervations then made, we are led to conſider thoſe products of animate beings, deſigned by nature for the propagation of their ſpecies,

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as void of life. This is evident, when we conſider that life conſiſts in certain actions before defined ;— that action implies change, and that ſeeds are kept for years without ſuffering any change, or alteration.— This obſervation applies to eggs, and is equally true, ſo far as it reſpects any vital change, in every ſpecies of animals.

Another conſideration, leading to the ſame concluſion, is, that all living beings have a power of reſiſting putrefaction. Thoſe affinities and combinations of matter, which take place in animate exiſtences, are diametrically oppoſite to thoſe, which take place in the ſame ſubſtances after death. The former may with propriety be called *vital*, and are thoſe, by which the principles of the body become combined, its ſize increaſed, and its waſtes repaired. The latter are called *chemical*, and are thoſe, by which theſe principles become diſunited, ſet at liberty, and the whole body diſorganized. Theſe different affinities, therefore, cannot ſubſiſt, and be going on in the ſame body, at the ſame time. Seeds of plants, and thoſe products of animate exiſtences, of which we are ſpeaking, and by which their ſpecies are propagated, as they are firſt afforded, have neither of theſe actions going on within themſelves. But there is a certain balance of affinities among their conſtituent principles, by which they continue the ſame without any change. As circumſtances may favour, however, one or the other of theſe kinds of action now deſcribed, is liable to commence in their ſubſtance ; either a vital action, by which is produced another of the ſpecies ſimular to that which afforded the ſeed or egg, or elſe a chemical one, called putrefaction, by which its principles are uncombined and ſet at liberty. When the ſeed or egg is not attended with thoſe circumſtances, favorable for its receiving vital action, it poſſeſſes no power of reſiſting putrefaction, any more than the ſtock of the plant, or carcaſe of the animal, which gave it exiſtence. We

We have now a view of what is to be underſtood by the *principle of animation*; it is *that*, which is the cauſe of the *firſt vital action* in thoſe different kinds of matter, by which the various ſpecies of animate beings are propagated; and, which, continuing to be ſupplied, does maintain and ſupport the flame of life, through all the varying ſtages of its exiſtence. We muſt, therefore, look for ſomething, which is as extenſive as life itſelf, and which is preſent, with living beings, and conſumed by them, not only when arrived to the ſtandard of their perfection, but likewiſe, which is afforded the embryo, and the germ in their moſt rude and imperfect ſtate, and, which being withdrawn, leaves all animated exiſtences to die!

Led by theſe different inquiries to the conſideration of life in the various circumſtances of its exiſtence, I am induced to believe, that *Oxygen* is the principle of animation, that it is received into the ſyſtem from the atmoſphere by the reſpiratory organs. So far as it can be proved by obſervation and experiment, that oxygen is received by every living exiſtence, that it is of indiſpenſible neceſſity, in order to the firſt excitement of vital action in the eggs of animals, and the ſeeds of plants, and on its being withheld, that life does immediately become extinct, ſo far, I conceive, this opinion will gain belief, and eſcape the cenſure of temerity, and the reproach of folly.

It is now generally known, that the atmoſphere is a heterogenius fluid conſiſting of two different kinds of gas; one maintaining combuſtion and animal life, exiſting in the proportion of about 27; the other contributing to neither, the proportion of which in the atmoſphere is eſtimated at 73. The former is called *oxygen, vital air, highly reſpirable air, dephlogiſticated*, or *empyreal air*; the latter has obtained the name of *nitrogene, ſepton, azote*, or *phlogiſticated air*. That oxygen is

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the principle of combuſtion, has been proved by the experiments of M. LAVOISIER, and others; the foundation of our belief for ſuppoſing it the ſame of animation, I proceed now to ſhow in the order before intimated.

Every one knows that reſpiring animals take air into their lungs, and that air, which, has once been breathed, is then unfit for reſpiration. But on what this phenomenon depended was not known till Dr. PRIESTLY diſcovered, that in the act of reſpiration, oxygen was abſorbed from the atmoſphere, through the thin membrane, which ſeparates between the bronchia and blood veſſels; and, that deprived of this, in ſome way or other, animals do immediately die.—It is further proved, likewiſe, that the blood having thus received the oxygen, acquires an additional degree of heat, and a florid colour. Theſe propoſitions having been already ſufficiently eſtabliſhed by various writers, I proceed to take notice that ſomething ſimilar to this takes place in all living exiſtences.

M. LAVOISIER has demonſtrated that oxygen is one of the conſtituent parts of water, and, likewiſe, that water contains air in its pores. Fiſhes, therefore, are not excluded from this vital fluid. Notwithſtanding the ſymptoms of uneaſineſs, diſtreſs, and even death, which happen to them, when removed into the atmoſphere, yet they can no more live without air, than thoſe animals, which inhabit the land. Fiſhes are provided with gills, which ſerve for them the place of lungs. Theſe are compoſed of a vaſt number of red *fibrillæ*, ſubject to perpetual motion from the water. Through theſe the blood circulates, coming from the heart; it is here again collected by ſmall veins, which uniting, form an *aorta*, by which the blood is carried to all parts of their bodies. That the blood is here oxyginated, as in the lungs of other animals, is very certain

certain from analogy. The blood, in both, undergoes the ſame changes; that in the gills of fiſhes appearing extremely florid, like that in the lungs of animals. In either caſe, that portion of the element reſpired has no longer the power of ſupporting life, conſequently, a renovation is continually required. Fiſhes exhibit the ſame ſymptoms, when deprived of oxygen, that other animals do—violent convulſions, and immediate death. In ſevere winters, when much of the communication of the air with water is intercepted, by means of ice, many of theſe animals die; by opening the ice, and admitting the air, they ruſh violently to the ſurface of the water, with ſuch eagerneſs for air, that they oftentimes ſuffer themſelves to be taken by the hands of the fiſhermen.

Inſects, likewiſe, are provided with organs for receiving air, called *trachea*; theſe being beſmeared with oil, they ſoon die.

Oxygen is not only neceſſary to the life of all animals, but, likewiſe, to that of all the vegetable creation. That the ſap of plants circulates through their leaves, has been aſcertained by experiment. On the upper ſurfaces of them, the ſap is expoſed to the action of the atmoſphere, beneath a thin pellicle. Here it undergoes a change, and is carried back by veſſels on the under ſide of the leaf. A ſtalk having been placed, ſeveral days, in a decoction of madder, on the upper ſurface were ſeen many red arteries going to the extremities of the leaves, which were not viſible on the under ſide. On cutting acroſs a leaf, by the help of a lens, the returning veſſels, on the under ſide, were ſeen to diſcharge a milky fluid, but none of the red fluid, contained in the veſſels, on the other ſide of the leaf. The upper ſurfaces of leaves, likewiſe, being covered with oil, they ſoon die. The leaves of plants, therefore, have an office ſimilar to the lungs in animals,

trachea

trachcæ in insects, and gills in fish. Excluded from the air, they decay and die, as has been proved by the experiments of SCHEELE, and others.

Thus it appears that all living existences do consume oxygen. This, however, is not only necessary to the continuance of vitality, but without it, neither the embryo of animals, nor the seeds of plants can be ushered into life. The first attention of nature, in the production of all the myriads of her existences, appears to be to make provision for a supply of this oxygen gas.—While as yet there are neither vessels, nor organs for receiving it, this vital principle is necessary to excite the first motions of life; at this early period therefore, there is a mechanism peculiarly fitted for that purpose.

This, in viviparous animals, is the placenta; its function is analogous to that of the lungs, after the foetus is delivered from its parent. It appears from the opinions and experiments of respectable writers, that there is no circulation of blood between the parent and the foetus; but that the blood of the foetus is carried to the placenta by an artery, and is there distributed to its extremities, and again brought back by veins. This appears, from this circumstance, that the placental vessels do not bleed when torn from the uterus, while those of the uterus discharge a large quantity of florid blood. This is accounted for by Mr. J. HUNTER. "That ingenious philosopher," says Dr. DARWIN, "has shown that there are numerous cavities, or lacunæ formed on that side of the placenta, which is in contact with the uterus; these cavities or cells are filled with blood from the maternal arteries, which open into them, which blood is again taken up by the maternal veins, and is thus perpetually changed; while the terminations of the placental arteries and veins are spread in fine reticulation on the sides of

these

theſe cells." From this relation it appears evident, that the placenta receives the blood for the purpoſe of oxygination; the ſame is further confirmed by the changes the blood there undergoes, which are the ſame as thoſe it ſuffers in the lungs of animals.

In oviperous animals producing their young from eggs detached from the parent, this proceſs of oxygenating the blood is not poſſible. Thinking, however, that oxygen muſt ſome way be communicated, I made the following experiments.

EXPERIMENT 1ſt.

In the large end of the egg it is well known there is included a ſmall bag of air. Having procured a number of eggs, I collected a quantity of this air in a glaſs tube, in contact with which I put a ſolution of ſulphure of potaſh, a property of which is to abſorb oxygen. Part of the air thus encloſed was ſoon abſorbed, after which there remained a portion of azote.

EXPERIMENT 2d.

Having aſcertained that eggs do contain oxygen within their ſhells, I wiſhed to know its importance in the incubated egg. For this purpoſe, I took a number of eggs, and having broken the ſhell into the air bag, I completely filled the cavity with a doſil of lint, ſopped in glue; over this I ſpread a varniſh, ſo as totally to exclude the air. Theſe eggs I put under a ſetting hen, together with other entire eggs. On the fourth day of incubation, I examined them; in thoſe which were put under entire, was diſtinctly ſeen the heart of the future chick beating, together with the umbilical blood-veſſels, beautifully ramified, and appearing exceedingly florid. At this time, in the place of the head, was ſeen a dark ſpeck, which did not appear two days before, notwithſtanding the heart and blood-veſſels were evident, as on this day. In thoſe eggs, whoſe

ſhells

ſhells had been broken, and the air, they contained, excluded, no vital action had been excited; on the contrary, putrefaction had evidently commenced.

EXPERIMENT 3d.

In another parcel of eggs, having opened into the cavity, or air bag, I introdoced ſulphure of potaſh, and ſealed it cloſe with varniſh, as in the other experiment. This abſorbed the oxygen, only, leaving the azote ſtill to occupy the cavity. Theſe eggs being ſubjected to incubation, the reſult was the ſame as in the preceding experiment; not one of them hatched.

From ſome diſappointments, and the inconveniency in my preſent ſituation, of making theſe experiments, I have not purſued this inquiry ſo far as I had intended; but that oxygen is contained within the ſhell of the egg, to be of uſe at the time of incubation, I think is evident from the experiments I have related. For without the preſence of this, the *cicatricula* of eggs is not animated, no part evolved, nor does it aſſume any action of life. At the time of making theſe experiments, a woman of more than common obſervation informed me, ſhe had a hen among her poultry, in whoſe eggs this portion of air was always wanting, and that not one of theſe eggs had ever hatched, although trial of them had been repeatedly made.

We are, therefore, led to this concluſion, that in conſequence of the heat, which the eggs acquire by incubation, the oxygen becomes active, and that in this way the firſt vital motions are produced; that it continues to oxyginate the blood till the time the chick is extricated from its ſhell. This will be evident to any one by inſpection, who will take the trouble to examine an egg, ſome days after incubation. Then may be ſeen an almoſt infinite number of blood veſſels ſpread on the membrane, which confines the air in one

end

end of the ſhell; theſe veſſels are collected, and form the umbilical artery, which leads to the heart. That the blood is carried here, for the purpoſe of oxygination, we have no cauſe to doubt; the appearance makes it almoſt certain. Theſe veſſels appear extremely florid, and of a bright red colour, whereas, the vein, which is ſpread on the albumen, appears of a dark modena.

We have next to examine, what part oxygen has in the germination of ſeeds. Seeds, when ſown, are in ſuch a ſituation that the air communicates with them freely. That proviſion, therefore, which is made to ſupply animals with oxygen, at an early period of their exiſtence, is not neceſſary for plants; ſtill, to determine what office oxygen might have in their vegetation, I made the following experiment.

I put into a glaſs globe a handful of beans, a little water, and ſtopped it cloſe, it being filled with atmoſpheric air. In this ſituation, it ſtood a week, in which time the ſeeds ſprouted, and grew half an inch. I then unſtopped the veſſel, having immerſed it in water.—On withdrawing the ſtopper, the water ruſhed in, and the air remaining was found to have loſt every particle of its oxygen. The ſeeds had begun to putrefy, which I ſuppoſe to be in conſequence of the oxygen having been conſumed, before the globe was unſtopped; the vital principle, then, not being afforded, the actions of life could no longer be continued—chemical affinities were therefore ſuffered immediately to take place.

Such are the facts we have been able to collect, to ſhow, that at the firſt dawning of life, vital action is excited and kept up by oxygen. We know it, becauſe eggs and ſeeds are not animated without it, becauſe nature has invariably made proviſion for its ſupply, and becauſe in all inſtances of life it is conſumed.

The

The neceſſity of reſpiration to animals, through the varying ſtages of their exiſtence, could not eſcape the attention of man. The obſervation has been made from time immemorial, but its uſe in the œconomy of life was not till lately known, nor even yet has its full importance been acknowledged. By this way oxygen is ſupplied to the ſyſtem, which in ſome way or other, as we have ſeen, is afforded to all living exiſtences.

Mr. CRUIKSHRANK, in his experiments on the reproduction of the nerves, relates one, from which, I think, he might have drawn more important inferences than he has. It ſhews in a ſtriking manner the importance of reſpiration, and how, independently of the brain, the functions of life are exerciſed.

Mr. CRUIKSHRANK took a dog, and by detaching the ſcapula from the ſpine, divided all the nerves of the *axillary plexus* on each ſide. He then divided the ſpinal marrow between the laſt vertebræ of the neck, and the firſt of the back, and likewiſe the parvagum and intercoſtal nerves. In this experiment, all communication of the heart, lungs, diaphram, and thorax with the brain, was cut off. The whole animal took the alarm; all the flexor muſcles ſeemed to contract, and inſtantly to relax again; all appearances of life were gone. He then opened the cheſt, and found the heart had ceaſed its motion. Then he introduced a large blow-pipe into the trachea, below the cricoid cartilage, and inflating the lungs, imitated reſpiration. The heart began to move again, and in about three minutes was beating 70 times in a minute. After ſome intermiſſion, this was again repeated, and continued for half an hour, the heart and arteries beating regularly all that time.

This experiment ſhews that reſpiration is the prime mover of the machine; and that the nervous influence, whatever

whatever it may be, ſerves merely as a ſtimulus to excite the action of the muſcles and diaphram, thereby to enlarge the thorax and favour the admiſſion of air into the lungs. Further, it explains, what at firſt thought, might ſeem difficult to be accounted for, that the chick, before the formation of the brain, will have its heart beating, whereas after its complete formation, and it has eſcaped from its confinement, the nervous influence is neceſſary in order to the continuence of this action. By this experiment, it appears, that nothing but a ſufficiency of oxygen is neceſſary to the action of the heart, and that the brain does contribute to this action by opening the way for this ſupply.

Animals ſubjected to inhale the ſame air, without renovation, ſoon die; that death in this caſe is in conſequence of a deficiency, or want of oxygen, and not from noxious vapour thrown off from the lungs, we know for this reaſon; that animals confined in any other gas, however pure, or in the exhauſted receiver; die with the ſame train of ſymptoms. When the uſual proportion of oxygen in the atmoſphere is diminiſhed, life languiſhes; but the moment this proportion is increaſed, the powers of life become invigorated, the functions are performed with alacrity, and the whole ſyſtem ſeems to have acquired a new degree of animation.

From a review of theſe obſervations, we may learn what advances have been made in favour of our ſubject.

Irritability we conſidered as the characteriſtic of life; and in thoſe actions, by which the functions of living beings are performed, does life conſiſt. Seeds of plants and thoſe products of animated exiſtences, by which their ſpecies are propagated, we conſidered as void of life, not poſſeſſing thoſe actions in which

life conſiſts. In theſe, likewiſe, we have proved by obſervation and experiment, that vital action does not take place without the preſence of oxygen, that the embryo of viviparous animals receives it from its parent; in oviparous animals it is afforded the young in the ſhell; that ſeeds in the time of germination do abſorb it from the atmoſphere. That a conſtant ſupply of this is neceſſary to every living being, for the ſupport of life, through the varying ſtages of its exiſtence——not an inſect moves, nor a plant ſhoots its branches, but by the inſtrumentality of this univerſal diffuſer of animation.

Theſe conſiderations are ſufficient to juſtify us, in our opinion, reſpecting its importance, in animation; and ſhould any doubts remain, perhaps further experiments and obſervations, may remove them, and finally enthrone ſcience in thoſe regions, which too long have been occupied by fancy and conjecture.

Let it not be thought an objection to this theory, that oxygen is ſomething, whoſe exiſtence is made certain, and many of whoſe properties have been aſcertained by experiment; and becauſe the chemiſt, in his laboratory, has not been able to excite life in thoſe ſubſtances, with which he has combined oxygen, that, therefore, nature is incapable of the operation.

It has been common, with philoſophers, in attempting to develope the myſteries of nature, when, from the concurrence of known cauſes, an effect has been produced out of the way of their common courſe of operation, in other circumſtances, to ſuppoſe that an unknown cauſe cooperated to produce this effect. But till the relation of things are all perfectly underſtood, and every combination of matter known, we may expect continually to be aſcertaining new properties, qualities, and effects, of thoſe things, which are the objects of our ſenſes.

In things, which men do not underſtand, they are always prone to run into great prolixity, and vain imagination. Nature is uniformly more ſimple, in her operations, than the bigotted opinion of man is wont to conceive. She proceeds to her object by direct ſteps, but man wanders a devious way, and thinks to purſue her, like the wily fox, through mazy windings and intricate paths.

When philoſophy ſhall have withdrawn the veil, from the eyes of mortals, and diſcloſed to human view, her operations, then will be ſeen the uniformity that ſo conſtantly marks her ſteps, and that ſimplicity, which pervades all her works.