A

CHEMICO-MEDICAL

ESSAY

TO EXPLAIN THE OPERATION

OF

OXIGENE,

OR THE BASE OF

VITAL AIR

ON THE

HUMAN BODY.

By BENJAMIN DE WITT, M. P. M. S.
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Whence in bright floods the VITAL AIR *expands,*
And with concentric spheres involves the lands;
Pervades the swarming seas, and heaving earths,
Where teeming nature broods her myriad births;
Fills the fine lungs of all that breathe or bud;
Warms the new heart, and dies the gushing blood;
With life's first spark inspires th' organic frame,
And, as it wastes, renews the subtle flame.

DARWIN.

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IMPRIMATUR,

J. WOODHOUSE.

INAUGURAL THESIS,

SUBMITTED TO THE

EXAMINATION

OF THE

REV. JOHN EWING, S. T. P. *Provoſt*,

THE

TRUSTEES

AND

MEDICAL PROFESSORS

OF THE

UNIVERSITY OF PENNSYLVANIA,

FOR THE

DEGREE

OF

DOCTOR OF MEDICINE.

ON THE THIRD DAY OF MAY, 1797.

NON FUMUM EX FULGORE, SED EX FUMO DARE LUCEM COGITAT.

HOR.

TO

DR. WILLIAM M'CLELLAND,

OF THE CITY OF

ALBANY,

THIS ESSAY IS INSCRIBED,

AS A PUBLIC TESTIMONY

OF RESPECT AND ESTEEM,

BY HIS

SINCERE FRIEND

AND FORMER PUPIL,

THE AUTHOR.

ESSAY, &c.

INTRODUCTION.

PERHAPS no branch of natural philoſophy has more engaged the attention of the learned, or been more ſucceſsfully cultivated, than the nature of the common air which ſurrounds us. Philoſophers formerly imagined it to be a pure, ſimple, elementary fluid; hence their attention was chiefly engaged in inveſtigating its mechanical properties. Modern diſcoveries, however, evince that it is by no means an elementary ſubſtance; but compoſed of different conſtituent parts, poſſeſſing chemical qualities, and having a very extenſive and wonderful agency, in a great variety of the operations, both of nature and of art.

THE knowledge of its being eſſential to the preſervation of animal life muſt have been coeval with mankind; it was from the beginning, as it is now "the breath of life:" But in what manner this was affected has long remained an impenetrable myſtery. It was left for modern chemiſts to ſolve this difficult problem. By decompounding the air which we breath, and by ſhewing the properties of its conſtituent parts they have enabled

us to view ſome of the moſt important functions of the animal ſyſtem, in a very different light from what our anceſtors were accuſtomed to do.

THE beautiful experiments of Lavoiſier prove that atmoſpheric air is compoſed principally of two elaſtic fluids. He procured them in a ſeparate ſtate,* and found that in the one, an animal died in a few ſeconds; in the other it became remarkably lively. A taper plunged into the one was immediately extinguiſhed; in the other it burnt with a dazzling ſplendor. In ſhort, the one incapable of ſupporting animal life and combuſtion; the other poſſeſſing that property in a high degree. The firſt was called Azotic (or more properly Nitrogene) gas; the other Oxigene gas, or vital air.

As a further proof of this important truth, if we recombine theſe two elaſtic fluids in certain proportions, we reproduce an air preciſely ſimilar to that of our atmoſphere, poſſeſſing the ſame powers of ſupporting combuſtion, reſpiration and calcination.†

BY other experiments it is found that atmoſpheric air contains alſo a ſmall portion of carbonic gas (fixed air), and moſt probably likewiſe ſome dydrogene gas (inflammable air); but neither of theſe appear to be eſſential to its conſtitution.

As that property of air which renders it capable of ſupporting life ſeems to reſide eſſentially in one of its conſtituent parts, it becomes an important and intereſting enquiry, which deſerves to be minutely inveſtigated, What is its nature, and what its effect upon the human body?

* Lavoiſier's Elem. Chemiſt. p. 82.
† See Lavoiſier, Briſſon, tom. ii. p. 35.

Of OXIGENE GAS, or VITAL AIR.

THIS ſpecies of air was firſt diſcovered by the celebrated Prieſtley, on the 1ſt. of Auguſt, 1774.* He called it dephlogiſticated or pure air. Scheele called it empyreal air, and Lavoiſier firſt named it highly reſpirable or vital air. The French chemiſts afterwards gave it the name of oxigene gas,† from its property of forming acids by combining with certain ſubſtances. This diſcovery has been emphatically ſtiled the "pride of modern philoſophy."

Oxigene gas exiſts in our atmoſphere in the proportion of twenty ſeven parts to the hundred, according to Lavoiſier.‡ It is compounded of a baſe or radicle, and caloric (fire, heat, igneous principle, &c.) which maintains it in a ſtate of elaſtic fluidity. Its radicle or oxigene has never been obtained in a ſeparate ſtate or ſolid form, on account of its great attraction for other bodies; it appears however to approach to this ſtate, as it exiſts in water in the proportion of 85 parts to the hundred. It poſſeſſes the excluſive property of ſupporting reſpiration and animal life: All the other ſpecies of air hitherto diſcovered appear to be inadequate, or perhaps injurious to that effect.

A large portion of the oxigene of our atmoſphere muſt be continually employed in the breath-

* Mr. Scheele, it is ſaid, made the diſcovery alſo nearly about the ſame time, though he did not know of Dr. Prieſtley's experiments. Lavoiſier ſays he alſo diſcovered it; but it is more probable, that he received the hint in a converſation with Prieſtley when in France.

† From the Greek words *(oxus)* "ſharp or acid," and *(geinomai)* "to beget or produce."

‡ Elem. Chemiſt. p. 86.

ing of animals, the burning of fuel, the putrefaction of ſubſtances, and numerous other operations carried on in the great elaboritory of nature. This conſumption is inceſſantly ſupplied by the action of the ſolar rays upon growing vegetables: hence an equilibrium is maintained, in the proportion of the conſtituent parts of the atmoſphere. Prieſtley, Ingenhouſz, and others, have ſufficiently proved that moſt plants, expoſed to the action of light, perſpire vital air, and abſorb the mephitic: Man, on the other hand, emits mephitic, and ſubſiſts upon vital air; hence the vegetable and animal kingdoms appear to labour for, and mutually to ſupply each others wants.

Of Oxigene as received into the System by the Lungs.

AIR taken into the lungs by reſpiration is diminiſhed in quantity, and parts with its vital property, which experiments ſhew to be abſorbed by the blood. Chaptal ſays, that the air in which five ſparrows had died yielded only $\frac{17}{100}$ of Oxigene. Count Morozzo placed ten ſparrows in ſucceſſion under a bell of glaſs filled with this gaſs, inverted over water. The firſt died in five hours and twenty three minutes, by which the air was greatly diminiſhed; the ſecond died in two hours and ten minutes, with a further diminution of the air, and the third in one hour and thirty minutes, without producing any viſible alteration. This diminution by the breathing of man is 360 cubic inches in an hour, according to the accurate experiments of M. de la Metherie.*

* The calculations of Hales in his Statics, and the experiments of Chaptal and Lavoiſier vary ſomewhat from this.

BLOOD we know has so strong an attraction for oxigene as to absorb it from the air after it is drawn out of the body ;* but as it does not come immediately in contact with the air in the lungs, it was difficult to conceive how they should unite ; and it was supposed that the intervening membranes would form a barrier to the reception of any part of the air into the system. This difficulty was entirely obviated by an experiment of Dr. Priestley : He enclosed a quantity of blood in a bladder, apparently more dense and impermeable to air than the vesicles of the lungs, and upon exposing it, the blood which it contained soon became as florid as if it had been in the open atmosphere. Dr. Goodwyn also found that even the coats of the vei in different parts of the body, were no obstruction to the process of floridification, which indicates the reception of oxigene ; the same effect is also produced though the blood being covered with a stratum of serum to the depth of two inches or more ;—oil, saliva or water however prevent its action.

THE experiments of Darwin† and Luzuriaga,‡ however, prove that air does not, and cannot consistently with animal life, exist in the blood in a gaseous or æriform state ; we must therefore necessarily conclude, that it takes on another form on entering the system : This no doubt is effected by its being decompounded, and parting with so much of its caloric as was necessary to maintain it in a state of elastic fluidity. In no other way can it be so satisfactorily explained.

* See Girtanner's experiments.
† Med. Com. vol. vi. p. 35.
‡ Inaug. Dissert. Edin.

THE air which is emitted from the lungs after having anſwered the purpoſes of reſpiration, is found not only to have loſt a portion of its oxigene, but at the ſame time acquired a new principle, to wit, carbonic or fixed air: This is proved by cauſing the expired air to paſs through lime water, which inſtantly becomes turbid; if received through tincture of turnſole, it reddens it, and if through a ſolution of cauſtic alkali, it renders it mild and effervescent.

THE nitrogene gas, which conſtitutes by far the largeſt portion of the atmoſphere, appears to undergo no perceptible change, either in quantity or quality, by being breathed.*

OF OXIGENE,

AS RECEIVED INTO THE SYSTEM, BY THE STOMACH AND INTESTINES.

THAT oxigene is taken into our bodies by the ſtomach as well as by the lungs, is not ſo evident from direct experiment. It can hardly be doubted, however, that it conſtitutes a large portion of the conſtituent parts of our daily aliment, particularly of acids and vegetables; and in that ſtate is moſt probably abſorbed into the blood, in ſome meaſure to anſwer the purpoſes of the animal economy. "No ſubſtances, (ſays Dr. Beddoes) are better calculated than acids, at leaſt, to impart oxigene to the ſyſtem; they contain it in abundance, and they eaſily part with it."† It does not appear

* See Prieſtley, Lavoiſier, Chaptal, Goodwin, &c.
† Letter to Dr. Darwin.

improbable to me that oxigene may be alſo imparted to the blood, circulating through the veſſels immediately on the ſurface of the inteſtines: When we conſider that the inteſtinal canal appears to be the only interior part of the body, except the lungs themſelves, to which atmoſpheric air has acceſs; and that this elaſtic fluid is ſwallowed in conſiderable quantities: When we conſider the aſtoniſhing congeries of ſmall blood veſſels ſpread upon its ſurface; and further, when we reflect with what eaſe oxigene is admitted through mucous membranes, and even through the coats of large veins when laid bare; and finally, when we conſider the change which the air undergoes in its paſſage through this canal, there can hardly remain a doubt that oxigene may in this manner be imparted to the blood in conſiderable quantity; more eſpecially as the area of the whole ſurface of the inteſtines is perhaps as large as that of the lungs.

Of OXIGENE as taken into the System by the Skin.

IT has been doubted whether oxigene could be taken into the ſyſtem by the ſurface of the body: If, however, water is abſorbed by the pores of the ſkin, it is evident that in this way oxigene is taken in, like that with the aliment by the inteſtines. Whether the water after entering the ſyſtem is decompounded, and its oxigene ſet at liberty, to anſwer other purpoſes of the animal economy, remains perhaps yet to be determined. Girtanner aſſerts, that from ſome of his experiments it is clear that water is decompoſed and recompoſed continually in organized bodies. But beſides, we

have ſome reaſon to conclude that oxigene is abſorbed from the air by the ſkin, in a ſimilar manner to that by the lungs. This is rendered probable from the ſtriking reſemblance between the matter of perſpiration, and the exhalation from the lungs. The experiments of the Count de Milley, and the obſervations of Foquet prove that the genuine matter of perſpiration is carbonic gas, the ſame with that exhaled from the lungs; like that it precipitates lime from its ſolution, and like that it is incapable of ſupporting flame and reſpiration. It appears further probable from thoſe caſes in which the lungs have been almoſt totally deſtroyed by diſeaſe;* and from which patients have ſurvived for years, almoſt wholly deprived of the advantage of reſpiration. In thoſe caſes the ſkin or the inteſtines muſt have in ſome meaſure ſupplied the office of the lungs in providing the ſyſtem with oxigene. What quantity the ſkin does abſorb is not yet (ſo far as I know) proved by actual experiments, though Dr. Beddoes aſſerts (upon what authority I know not) that "it is found "in equal times to take in three or four times as "much oxigene air as any other." Dr. Fothergill† alſo mentions that it has lately been diſcovered that vital air is abſorbed by the ſkin in conſiderable quantities.

* See Blumenbach.

† On the ſuſpenſion of Vital action, 1795.

Of the Effects of Oxigene on the Blood.

1. *On the craſſamentum or red globules.*

LOWER, in his treatiſe de corde, long ago obſerved, that the blood returned from the lungs by the pulmonary veins, was of a more florid colour than that in the arteries. The ſame was afterwards obſerved by Boerhaave, Haller, Hewſon, and others; and has ſince been noticed by almoſt every author who has written upon the ſubject. The cauſe of this difference in the colour of the venous and arterial blood has much engaged the attention of phyſiologiſts; but no ſatisfactory explanation could ever be given for it, until the immortal Prieſtley diſcovered that it is owing to what he calls dephlogiſticated or vital air.* He expoſed a quantity of venous blood to common air, and found that by agitation it immediately became of a more florid colour, and that this effect took place in a higher degree and in a ſhorter time when expoſed to oxigene gas. On the other hand, blood expoſed to any of the other airs, in a ſhort time loſt its bright red colour, and became black; but reſumed its floridity upon being brought in contact with vital air. Goodwin incloſed a quantity of

* John Mayow in the obſcurity of the laſt century (1668) was acquainted with many of the properties of oxigene air, though he did not procure it in a ſeparate ſtate. In his Tract de reſpiratione, he proved by experiment that the air is diminiſhed both in reſpiration and combuſtion; that the office of the lungs is to ſeparate from the air, and convey to the blood, one of its conſtituent parts, which he called nitro atmoſpherical, or fiery air particles: He ſuppoſed this coloured the blood, and was neceſſary to all muſcular motion, and eſpecially to the heart. His writings however ſeemed to be little taken notice of.

See Dr. Beddoes on Exp. of a Phil. in the laſt. cent.

oxigene gas in a glaſs receiver, inverted over mercury, and introduced into it 4 ozs. of blood, drawn from the jugular vein of a ſheep; it inſtantly became florid, and the mercury appeared to riſe in the receiver. Blood alſo becomes of a dark colour when expoſed in vacuo, according to the experiments of Beccaria, which have ſince been repeated by Dr. Prieſtley with the ſame reſult.

The blood returned from the extremities by the veins, being of a darker colour than that in the arteries, can only be explained by its having loſt a part of its oxigene in the courſe of the circulation; and not by its having acquired a larger portion of hydro-carbonic matter, as has been conjectured by ſome: for if oxigene gas be injected into a vein, the blood becomes as florid as that in the arteries,* without however having parted with its ſuppoſed ſuperabundance of carbone.

Several opinions have been offered as to the nature of that principle or property in the craſſamentum of the blood, by which it is peculiarly adapted to become floridified by an union with oxigene; but I confeſs they all appear to me to be unſatisfactory. The moſt probable opinion perhaps is, that it is owing to iron reduced to a ſtate of red oxid: but it is difficult to conceive how ſo ſmall a portion of iron as the blood contains, ſhould diffuſe that florid colour through ſo large a maſs of fluid; and it does not appear to have ſo ſtrong an attraction for oxigene at the ordinary temperature of the body, as to account for the inſtantaneous change which takes place in the blood circulating through the lungs. Other cauſes might perhaps be ſuggeſted with equal probability of

* See Hewſon, Girtanner and others.

truth.* It would afford an extenſive ſubject for much plauſible reaſoning to a ſpeculative theoriſt, but would lead too far into the field of conjecture. Upon this, as well as many other ſubjects connected with the animal economy, we muſt conſent to remain in doubt, until by future experiments and diſcoveries, we ſhall acquire a more extenſive knowledge of the ſublime operations of the chemiſtry of nature.

Of the Effects of Oxigene

2. *Upon the gluten, or coagulable lymph of the Blood.*

THAT oxigene acts upon the red globules of the blood, muſt now be evident to every one of the ſlighteſt obſervation, by the inſtantaneous change which it produces in its appearance, converting it from a dark red to a bright vermillion colour. But that it alſo produces eſſential effects upon the other component parts of the blood, is not ſo evident at firſt view: It is, nevertheleſs, highly probable to me, that its agency upon the coagulable lymph particularly, is no leſs conſiderable and important. This opinion is rendered probable when we conſider that in thoſe cold blooded animals, whoſe blood has no red globules, reſpiration is as eſſential to their exiſtence as any other. In a number of very accurate experiments made

* Dr. Darwin ſuppoſes it to be owing to phoſphorus, but I believe only upon conjectural grounds, as appears from the following lines:

"When air's pure eſſence joins the vital flood,
"And with phoſphoric acid dyes the blood,—"

Botanic Garden.

by Doctor Beddoes,* in order to ascertain the comparative effects of common and vital air upon animals; the blood appeared uniformly to coagulate much sooner and firmer, of those animals which had for some time breathed oxigene air, than of the others which lived upon common air, and were killed in the same instant. On the other hand, in most of those cases related by authors, in which we may conclude with tolerable certainty, that there was a deficiency of oxigene in the system; such as scurvy, for instance, and the cases given by Dr. Sandifort, of Leyden† and others; in which, from organic affection of the heart, but a minute portion of blood circulated through the lungs to the oxidated; so far as I can judge from their imperfect accounts of the state of the blood, it always appeared to have lost in some degree its property of coagulating. From these considerations I am inclined to believe, that the coagulable lymph of the blood owes its property as such in a great measure to this vital principle of the air; and that the influence of oxigene is perhaps essentially necessary to bestow upon it that condition, which renders it fit to become concreted into animal fibres, and to nourish the solid parts of our body.

Of the Influence of Oxigene in producing Animal Heat.

ANOTHER important effect accomplished by the agency of oxigene received into the body, is the production of animal heat. A very opposite

* On Factitious Airs, p. 16, and elsewhere.

† Observationes Anatomico-Patholog. Luqd. Batav. 1777, page 11.

circumſtance to the whimſical notion of thoſe, who imagined the lungs to perform the office of a bellows to cool the blood. Reſpiration, as we have already ſeen, is to be conſidered as an operation by which vital air continually paſſes from a gaſeous to a concrete form ; it muſt therefore at each inſtant abandon ſo much of its heat as was previouſly neceſſary to maintain it in a ſtate of elaſtic fluidity ; this heat being ſet at liberty, now manifeſts itſelf in a free and ſenſible form ; hence an abundant ſource of animal heat generated in the lungs.* Perſons who have reſpired vital air all agree in affirming, that they have perceived a gentle warmth vivifying the lungs, and extending to the more diſtant parts of the body. But the lungs are not the ſole focus or fire place where heat is produced ; for we have the ſtrongeſt reaſons to believe that it is alſo evolved in the courſe of the circulation, and particularly in the extremities of the arterial ſyſtem. If the lungs were the only ſource of animal heat, the parts of the body would become cold in proportion to their diſtance from this centre ; for we know that heat decreaſes as it recedes from the ſource whence it originated. If this were the caſe too, no part would be ſuſceptible of an increaſed heat, as is manifeſtly the caſe in topical inflammation ; nor no part except the lungs would reſiſt the topical application of cold.

Though oxigene in aſſuming the concrete form, by combining with bodies, looſes ſome portion of its caloric, that is, ſo much as was neceſſary to keep it in an æriform ſtate, it is nevertheleſs certain, that it carries a large quantity of latent heat along with it in aſſuming the ſolid form in

* See Crawford's experiments on Animal Heat.

various combinations;* if then this be the caſe, as it unites with the blood, it is eaſy to explain how it ſhould give out this heat, in the courſe of the circulation, by entering into new combinations.

THAT the evolution of heat is intimately connected with the action of the arteries, is a familiar fact; and it ſeems highly probable that their minute ramifications are of ſuch importance to the generation of heat, that as their action is weaker or ſtronger, a proportional diminution or increaſe takes place, in the heat of a part or the whole of the body. They appear to have the power of decompounding the blood, as in the various ſecretions, and of recompounding it again; and as the affinity for ſubſtances, is variouſly changed, when they undergo any chemical alterations, it is eaſy to conceive how blood when it undergoes theſe changes, ſhould throw out a large quantity of its latent heat.

"As the evolution of heat" (ſays Dr. Darwin) "attends almoſt all chemical combinations, it is probable that it alſo attends the ſecretions of the various ſubſtances from the blood, and that the conſtant combination or production of new fluids by means of the glands, conſtitutes the more general ſource of animal heat. This ſeems to be evinced by the univerſal evolution of the matter of heat, in the bluſh of ſhame or anger, in which at the ſame time an increaſed ſecretion of perſpirable matter occurs."

FROM theſe general and uniform ſources of animal heat in the body, we can eaſily explain, how all the parts of the body retain nearly the ſame

* See Lavoiſier's Elem. Chemiſt.

degree of temperature, and why it is ſo little varied, whether the ſubject be expoſed to the rigors of the coldeſt climate, or placed beneath the fervors of a tropical ſun.

Of OXIGENE as a Stimulus to the Heart and Arteries.

THE ſtimulating effects of Oxigene upon the heart and arterial ſyſtem is now eſtabliſhed by a multiplicity of experiments and obſervations. I ſhall mention only one. A young man having breathed pure undiluted Oxigene air for ſeveral minutes, his pulſe which before the experiment was 64, now roſe to 120 beats in a minute*. There is ſo intimate a connection between the quantity of air received by reſpiration, and the action of the heart and arteries, that by accelerating or retarding reſpiration by an effort of the will, any one may at pleaſure greatly increaſe or diminiſh the action of his pulſe, both as to frequency and force. The continuance of the action of the heart and arteries during life, ſeems to be very entirely owing to the inceſſant influence of this vital principle of the air;† for neither the ſtimulus of heat, nor the mechanical ſtimulus of the blood, appear to be at all adequate to this effect, as is abundantly manifeſted by the experiments of Goodwin‡ and others; and why does not the circulation go on, when the lungs are diſ-

* Minutes of the Society for Philoſophic Experiments, by Dr. Higgins, p. 146.

† Sir Iſaac Newton imagined that the atmoſpheric air might communicate an acid vapour to the blood of the lungs, which was neceſſary to keep up the action of the heart.—Optics, p. 351.

‡ Connection of life with reſpiration, &c.

tended with any other air which is inimical to life, only in ſo far as it withholds Oxigene from the blood?

OXIGENE differs from many other ſtimulants, perhaps, in this reſpect, that it does not appear to diminiſh, but rather to increaſe the irritability of the muſcular fibre*. It ſeems indeed to be ſo intimately connected with the irritability of the heart, and ſo eſſential to its ſupport, that in proportion to the increaſed or diminiſhed quantity of vital air received into the ſyſtem, there takes place a correſponding change in the irritability of that vital organ; and moreover, as irritability in a great meaſure accompanies and keeps pace with animal heat through life, it may be concluded with much plauſibility, that it depends upon the ſame principle; and hence, that Oxigene may be truly the ſource and proximate cauſe of the irritability of the heart and muſcular fibres, which enables them to perform the functions of vitality. This doctrine receives additional ſtability by being long ſince adopted†, and lately ſo well illuſtrated by the learned Dr. Fothergill in his ingenious prize diſſertation on the ſuſpenſion of vital action.

EFFECTS OF OXIGENE UPON THE NERVES, BRAIN, AND MIND.

THAT Oxigene acts powerfully upon the ſentient extremities of the nerves, may be inferred, from an experiment mentioned by Dr. Ingenhouſz, and ſince ſeveral times repeated by Dr. Beddoes,‡

* Girtanner's Experiments.
† Hints on Animation, 1783.
‡ On factitious Air, page 43.

that if the finger be blistered, so as to lay bare the naked and sensible skin, and exposed to common air, a smarting pain occurs; in Oxigene air it is more severe, but when exposed to azotic or carbonic gas, it entirely subsides, and returns immediately upon being withdrawn into atmospheric air.*

The ingenious Dr. Darwin, thinks that Oxigene taken into the system by respiration, "affords the material for the production of the sensorial power, which is supposed to be secreted by the brain, or medullary part of the nerves, and that the perpetual demand of this fluid, in respiration, is occasioned by the sensorial power which is supposed to be produced from it, being too subtile, to be long confined in any part of the system."—"The necessity of perpetual respiration shews" (continues he in another place,) "that the Oxigene of the atmosphere supplies the source of the spirit of animation, whence it is probable that Oxigene gas may increase the secretion of sensorial power, as indeed would appear from its exhilirating effect on most patients."† Be this as it may, numerous facts and experiments authorise us to say, that it uniformly produces vivacity, cheerfulness, gentleness, and serenity of mind, exhilirates and enlivens all the intellectual operations,‡ and produces alacrity and vigor in all corporeal exertions. It is very remarkable that Oxigene air, even when infused into the cellular substance of dogs, appeared in a short time to manifest stimulating effects: the animals became

* Dr. Thornton says he has seen a man whose finger was amputated, receive immediate relief from pain, by plunging his hand in fixed air.

† Zonomia, part 2. vol. 2. p. 377 & 399.

‡ "May not chemistry be able to exalt the powers of future poets and philosophers."

Beddoes.

exceedingly lively (maxima alacritas) by the experiments of Dr. Maxwell.*

Of the Effects of OXIGENE upon the Skin.

AMONG the numerous cauſes that have been called forth to explain the variation of colour in the human race, the agency of Oxigene has not been neglected; Dr. Beddoes was once nearly elated with the hope of having diſcovered the method of turning the Ethiopian white, by means of the Oxigenated muriatic acid air: The arm of a negro was introduced into a large jar full of this air, and the back of his fingers lay in ſome water impregnated with it at the bottom of the veſſel, they acquired an appearance as if white lead paint had been laid upon them, but it did not prove permanent; a lock of his hair was whitened by this acid. Similar experiments have been made by the profeſſor of chemiſtry in this univerſity, but without ſucceſs; it produced no change either on the ſkin or the hair. "Can the Leopard change his ſpots, or the Ethiopian his ſkin?"

Of the Effects of Oxigene upon the Bones.

BY chemical analyſis, the bones are found to be compoſed principally of Phoſphoric acid, and calcareous earth; now as we know that phoſphorus, as well as every other ſubſtance, is reduced to a ſtate

* Edin. 1787.

of acid only by uniting with oxigene, which ſeems to be the univerſal acidifying principle in nature; it is evident that its agency muſt be eſſential to the formation of bones. Phoſphorus by its ſtrong attraction for Oxigene, probably unites with it as ſoon as it is received into the ſyſtem, this again combining with the calcarious earth taken in with our aliment, will probably give the true theory of the formation of bones. This idea is farther confirmed, by a circumſtance occurring in certain caſes of diſeaſe in which the bones become ſoft and flexible; In many of theſe caſes the urine was found upon examination to contain a very large quantity of phoſphoric acid, and ſometimes a plentiful ſediment of earthy matter. May not the other ſolids of our bodies be formed by a chemical combination ſomewhat ſimilar to this?

Of OXIGENE as a Nutriment.

"SPIRITUS etiam alimentum eſt," are the words of ancient Hippocrates. From the large quantity of oxigene taken in, and from its entering ſo largely into the compoſition of our bodies;—it may, I think, with propriety be claſſed among the nutritious ſubſtances. It ſeems, indeed, when conſidered in this light, to be of much more immediate conſequence to the preſervation of life, than any of the other alimentary matters—"It is impoſſible to doubt (ſays Dr. Beddoes) that we are nouriſhed by the lungs as truly as by the ſtomach, and that what we take in at the former entrance, becomes like our food, a part of the ſubſtance of our ſolids, as well as our fluids."

Of the Effects of OXIGENE on the Fœtus in Utero.

WHEN we contemplate the young and tender fœtus, cloſely wrapped up in its mother's womb, and apparently cut off from all communication with the external air, we ſhould at firſt be apt to imagine, that it was entirely deprived of its genial influence; but this cannot be, for without it, all animated nature would become a lifeleſs maſs. It muſt therefore be through the medium of its parent, that it is continually ſupplied with this neceſſary fluid, and the placenta we know is the only communication that exiſts between them. It has generally been ſuppoſed that the blood of the mother was tranſmitted immediately to the fœtus through this medium, and that its ſole uſe was for the purpoſe of conveying nouriſhment; but I am rather diſpoſed to believe that no ſuch communication takes place. It is more probable that the maternal blood is only conveyed by arteries to the placenta, and immediately returned by veins, after it has imparted its ſuperabundant oxigene to the fœtal blood circulating through it, by an operation ſimilar to what takes place in the lungs of air-breathing animals, and the gills of fiſhes; in ſhort, that the placenta ſerves the office of a reſpiratory organ to the fœtus, while it remains in the womb.* Oxigene communicated in

* This doctrine I endeavoured to eſtabliſh and vindicate, in a memoir read before the Philadelphia medical ſociety on the 28th of December, 1796. To have entered into a detail of the arguments here, would have been foreign to the ſubject. It is an opinion that was held as early as the laſt century by John Mayow, Sir Edward Hulſe, and ſome others; but ſince it was controverted by the late Alexander Monro, it appears to have been the prevailing opinion, that the placenta was an organ of nutrition only, "owing perhaps (as an ingenious author obſerves)

this way from the blood of the parent, to that of the child, ſheds all that healthful influence upon it, which it continually does upon animals who live in the open air.

rather to the authority of ſo great a name than to the validity of the arguments adduced in its ſupport." That there is no direct communication between the maternal and fœtal blood, may be inferred,

1ſt. From the fact, that the veſſels of the uterus cannot be injected from the placenta.

2nd. From the fact, that if the child and placenta are both delivered ſuddenly, and the child, though alive, does not yet breath, the blood may be felt circulating with force through the funis, and when it is ſlighty preſſed, the arteries ſwell between the preſſure and the child, and the vein between it and the placenta, from the ſurface of which, however, no blood flows.

3d. From the fact, that while the placenta adheres firmly to the uterus, which remains ſtill diſtended by a child, if the funis be divided no more blood flows from it, than ſeemed to be contained by the placenta.

4th. From the umbilical vein carrying arterial blood. If that blood was derived immediately from the mother, it muſt have been changed from arterial to venous, as takes place in every other part of the body.

5th. From the probable utter impoſſibility of the embrio heart to propel forward the column of blood in the winding veſſels of the uterus, on its way to the mother's heart, &c. &c.

If, then, no direct communication exiſts between the blood of the mother and child, the placenta may be inferred to be a reſpiratory organ,

1ſt. From its ſtructure, as demonſtrated by Mr. John Hunter.

2nd. From the blood returning of a florid colour to the fœtus.

3d. From the fœtus immediately dying as ſoon as the placenta is ſeparated from the uterus.

4th. From its analogy with the mode of exiſtence of fiſhes in water, and the chick in ovo, &c.

Of the Morbid Effects of Oxigene.

OXIGENE, though it is the ſupport and ſtaff of life as it exiſts in its diluted ſtate in our atmoſphere; yet, when pure and unadulterated, it cannot be breathed without manifeſting a hurtful tendency; and by producing as it were an exceſs, finally extinguiſh life; like Milton's darkneſs, from an exceſs of light: "for as a candle burns out (ſays Dr. Prieſtley) much faſter in this than in common air, ſo we might, as may be ſaid, live out too faſt, and the animal powers be too ſoon exhauſted." Like ſenſual gratifications, in moderation it is the cordial, in exceſs the bane of life. Mr. Lavoiſier found that animals died when confined in oxigene air, long before it became unfit for reſpiration: On diſſection death ſeemed to have been occaſioned in every inſtance by an ardent fever and an inflammation; the fleſh was of a very red colour, the heart livid and turgid with blood, eſpecially the right auricle and ventricle, the lungs were very flaccid, but red, even externally; they were alſo turgid with blood.*

In alluſion to the above fact, concerning the morbid effects of oxigene upon animals, Dr. Beddoes aſks, "May not the ſlower and differently modified inflammation of the lungs in pthiſis, originate from a ſmaller exceſs of oxigene, thrown into the ſyſtem in a more gradual manner?" This the Doctor labours to eſtabliſh by much ingenious reaſoning, and many plauſible arguments. †

But whether there be really a ſuperabundance of oxigene in the ſyſtems of pthiſical patients or

* Mem. de la Societé Roy. de Med. T. and p. 575.
† See his Treatiſe on calculus, ſcurvy, pthiſis, &c.

not, it is eaſy to conceive that the ordinary proportion of oxigene in the air may exert morbid effects, and aggravate this, as well as many other inflammatory complaints, by acting as a powerful ſtimulus diſproportioned to the excitability of the ſyſtem: and hence, we need not wonder that in twenty caſes of this diſeaſe, in which oxigene air was inſpired, as deſcribed by Fourcroy, it uniformly aggravated the complaint. Upon theſe principles too we might hope for the beneficial effects of a lowered atmoſphere, in many diſeaſes of high excitement, which is indeed already manifeſted by the experience of Dr. Beddoes and others.

Since the active agency of oxigene upon the body has become known, phyſicians have not failed to call in its aſſiſtance to explain that ſtate of the atmoſphere which ſeems to diſpoſe to epidemic and malignant diſorders. Dr. Ruſh* aſcribes it to a ſuperabundance of oxigene, and Dr. Mitchell,† of New-York, to a certain combination of oxigene and azote, or nitrogene. But all our knowledge upon this ſubject appears to me to amount, as yet, to no more than plauſible conjecture. I do not know any facts or experiments which lead to a knowledge of that preciſe condition in which it conſiſts; and I might perhaps quite as well be contented to call it the "divine ſomething" of Hyppocrates, the "mineral vapour" of Sydenham, or the "marſh miaſma" of the preſent day, as to attempt to elucidate its nature by abſtract reaſoning from our preſent data. However, we may venture to conclude from what we already know of the properties of oxigene, that its morbid effects in undue quantity will be found to keep pace with

* Med. Enquiries and Obſervations, vol. iv. p. 75.
† On the gaſeous oxid of azote.

the extent of its ſalutary influence over the human frame. Under what circumſtances this may happen, or when it takes place, experiment is perhaps only adequate to determine.

One probable effect of oxigene, however, deſerves to be taken notice of; that is, the change which it would ſeem to produce in the matter of ulcerations, as of ſmall pox, cancer, abceſs, &c. Dr. Darwin* ſays, "the blood in ſmall pox will not inoculate that diſeaſe, if taken before the commencement of the ſecondary fever; becauſe the contagious matter is not yet formed; but after it has been oxigenated, through the cuticle in the puſtules, it becomes contagious.†" The matter of cancers does not ſeem to acquire a contagious quality until it is expoſed to the air; hence they are often ſucceſsfully extirpated in this ſtate; but after they become ulcerated, a hectic fever often occurs, and the neighbouring glands become ſwelled. The matter of common abſceſs too, appears to be mild and inactive, till it becomes changed by expoſure to air, when it acquires a ſtimulating and fever producing property. Are not theſe morbid effects of oxigene?—It is without doubt from this principle of the atmoſphere too, that we are to explain the deleterious effects of air, when accidentally admitted into any of the large cavities of the body; and it is eaſy to account for the inflammation which generally enſues, from the highly ſtimulating property of the oxigene which it contains. From theſe obvious effects which it ſeems uniformly to produce, it has been very ingeniouſly employed for the cure of hydrocele, by injecting it

* Zonomia, part 2, vol. i. p. 91.

† This is the reaſon, he ſays, why the fœtus in utero is ſometimes infected after the ſecondary fever, but never before it.

into the tunica vaginalis teſtis after evacuating the water, and with conſtant ſucceſs.

Of Oxigene as a Remedy in Certain Diseases.

OXIGENE, as being a powerful and durable ſtimulus which ſeems to exert its influence over the whole body, may be had recourſe to with perhaps ſingular advantages, in many of thoſe caſes in which this claſs of medicines has been recommended, as well as in thoſe in which there may be ſuppoſed to be a deficiency of that principle in the ſyſtem. When a ſuper-oxigenated air is inſpired for ſome time, it increaſes the ſtrength, and gives an alacrity for motion; produces gaiety and ſerenity of mind; mitigates pain, and diſpoſes to ſleep; increaſes the appetite for food, and ſtrengthens the powers of digeſtion; diffuſes a gentle warmth over the whole body, and imparts a degree of inſenſibilty to cold; gives life to the eye, and bloom to the countenance. I ſhall briefly enumerate ſome of the principal diſeaſes in which its efficacy ſeems already to be manifeſted.

Aſphixia.—Suſpended animation from ſubmerſion, ſtrangulation, and certain unreſpirable airs, being produced by the privation of oxigene, it muſt be evident that the only probable method of recovery is, to reſtore this to the blood by inflating the lungs. It is reaſonable to believe that a ſuper-oxigenated atmoſphere would be moſt effectual;* at any rate, the method of inflating by the

* The ſuperiority of vital air in reſtoring animation (ſays Dr. Fothergill) has been confirmed by many reſpectable writers both at home and abroad.

Suſpenſion of Vital Action, p. 113.

vitiated breath of another, as is too often done, appears to me very objectionable.

Scurvy.—It is probable that the efficacy of acids and vegetables in the cure of ſcurvy, is in ſome meaſure to be aſcribed to the oxigene which they impart to the ſyſtem. What effects breathing an oxigenated air would have, remains to be determined.

Typhus.—Dr. Thornton and Mr. Townſend have found it of remarkable efficacy in this diſeaſe. Dr. Wood from his own experience recommends nitre, and aſcribes its power to the oxigene which it imparts to the blood; "Nitre (ſays Dr. Beddoes) is doubtleſs decompounded in the primœ viœ, and capable of ſupplying much oxigene."

Aſthma.—"In true aſthmatic fits, its beneficial effects have already been many times experienced; no ſooner does it touch the lungs, than the livid colour of the countenance diſappears, the laborious reſpiration ceaſes, and the functions of all the thoratic organs, go on eaſily and pleaſantly again."*

Cancer.—Inhaling oxigene air ſeems to have been uſeful in, if not entirely removed this dreadful complaint.

Schrofula.—Schrofulous ulcers, tumors, and opthalimia's, have yielded to it, and been completely cured, as atteſted by Dr. Thornton and others. Is the remarkable efficacy of the juice of ſorrel in curing ſchrofulous ulcers, owing to the oxigene which it imparts to them? In every ulcer to which it is applied, there takes place a change from a dead pale to a ſcarlet colour.

* Beddoes.

Herpes.—A caſe of eruptions on the face, purple blotches on the body, hard ſcales on the arms, a dark coloured deep ulcer on the leg, and loſs of ſight, that had reſiſted every remedy for thirty years, was radically cured in a few weeks, by breathing oxigene air.

Hypochondriaſis.—Vital air might be ſuppoſed a priori, to be uſeful in this diſorder, it has accordingly been found ſo in a number of caſes.

Chloroſis.—Its undoubted efficacy in this affection is well atteſted by a number of phyſicians.

It has alſo been found of great benefit in a number of other diſeaſes; cured ſome, and relieved others; as dyſpepſia, melancholia, hyſteria, anaſarca, aſcites, palſy from lead, opium, &c. the advanced ſtage of conſumption, and diſeaſes of pregnancy. For a full account of caſes, I refer to Dr. Thomas Beddoes' conſiderations on the uſes of factitious air. From the formidable liſt of diſeaſes, many of them claſſed amongſt the incurables of our art, in which vital air has been found ſerviceable, it promiſes to become a moſt valuable acquiſition to the materia medica. "In deſperate caſes (ſays Chaptal) it is moſt certainly a precious remedy, which can ſpread flowers on the borders of the tomb, and prepare us in the gentleſt manner for the laſt dreadful effort of nature."

CONCLUSION.

THUS I have endeavoured in a compendious method to trace the influence of this active agent upon the human body. My object has been chiefly to develope the fundamental principles of its operation. In doing this I have avoided as much as poſſible, ſtraying into the flowery path of imagination, or launching into the open field of conjecture. I lament that I have not been able to throw more light upon this important ſubject by new experiments, but my time has been hitherto neceſſarily exhauſted, in a cloſe attention to the various other branches of the boundleſs ſcience of medicine.

IN taking a review of our ſubject, we are naturally led to trace the progreſs of the powers of the mind, in acquiring a knowledge of the laws and operations of nature; but a few years ago, philoſophers like the "children of the world*," amuſed themſelves with calculating the elaſticity, the denſity and preſſure of the air, without, perhaps, the moſt diſtant idea of its having thoſe more important chemical properties, which we now know it to poſſeſs. If our ſcience has already made ſuch rapid advances, as to analyze and divide aſunder, the inviſi-

* Lord Bacon.

ble atmoſphere which envelopes us; and to collect and adminiſter its different parts with the utmoſt facility, for the cure of diſeaſes.—If it can already command the powers of the air to its aſſiſtance, in mitigating the pangs of ſickneſs, and alleviating the diſtreſſes of ſuffering humanity, what may we not expect from time and perſevering induſtry? Go on, ye enlightened phyſicians and philoſophers, in your noble career! boldly preſs forward, into the rich and fruitful field for diſcovery and cultivation, which is opened to your view; led by the faithful hand of experiment, and illuminated by the torch of reaſon; draw aſide that veil of nature which hides from our eyes ſo many of her ſublime operations! and

——————— "Explore with eagle eye,
"Where wrap'd in night retiring cauſes lie;
"Trace their flight bands, their ſecret haunts betray,
"And give new wonders to the beam of day;
"Till, link by link, with ſtep aſpiring trod,
"You climb from nature to the throne of God."

BILLSBORROW.

And ye, Illuſtrious PROFESSORS OF THE UNIVERSITY OF PENNSYLVANIA, accept my warmeſt acknowledgments of gratitude, for thoſe valuable inſtructions which I have received from your lectures: and my ſincereſt wiſhes for your individual happineſs. Long, very long may ye continue with united ſplendor, like the bright orb of day, to diffuſe the ſalubrious rays of medical ſcience, in every direction, to the moſt diſtant parts of our weſtern world; to cheriſh and nurture thoſe tender plants of ſcience, which are juſt putting forth their bloſſoms!

"*Vive, Valeque.*"