

XIII. *Observations on Respiration, and the Use of the Blood.*

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R. Jan. 25,  
1776. **T**HERE is, perhaps, no subject in physiology, and very few in philosophy in general, that has engaged more attention than that of the use of *respiration*. It is evident, that without breathing most animals would presently die; and it is also well known, that the same air will not long answer the purpose: for if it has been frequently respired, the breathing of it is as fatal as the total deprivation of air. But by what property it is, that air contributes to the support of animal life; and why air that has been much breathed will no more answer the purpose, seems not to have been discovered by any of the many philosophers and physicians who have professedly written upon the subject; and it might have continued to elude all *direct investigation*, when it discovered itself, without any trouble or thought, in the course of my researches into the properties of different kinds of air, which had at first quite another object.

In these experiments it clearly appeared, that respiration is a *phlogistic process*, affecting air in the very same manner

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as every other phlogistic process (*viz.* putrefaction, the effervescence of iron-filings and brimstone, or the calcination of metals, &c.) affects it; diminishing the quantity of it in a certain proportion, lessening its specific gravity, and rendering it unfit for respiration or inflammation, but leaving it in a state capable of being restored to a tolerable degree of purity by agitation in water, &c. Having discovered this, I concluded, as may be seen Phil. Trans. vol. LXII. p. 187. and *Observations upon Air*, vol. I. p. 78. 277. that the use of the lungs is to carry off a putrid *effluviu*m, or to discharge that phlogiston, which had been taken into the system with the aliment, and was become, as it were, *effete*; the air that is respired serving as a *menstruum* for that purpose.

What I then concluded to be the use of *respiration* in general, I have now, I think, proved to be effected by means of the *blood*, in consequence of its coming so nearly into contact with the air in the lungs; the blood appearing to be a fluid wonderfully formed to imbibe, and part with, that principle which the chemists call phlogiston, and changing its colour in consequence of being charged with it, or being freed from it; and affecting air in the very same manner, both out of the body and in the lungs; and even notwithstanding the interposition of various substances, which prevent its coming into immediate contact with the air.

As it may not be unpleasing or unuseful, I shall, before I relate my own experiments, briefly recite the principal of the opinions which have been held con-

cerning the use of respiration, from HALLER's excellent *System of Physiology*, and some others of the most eminent writers upon that subject.

HIPPOCRATES reckoned air among the *aliments* of the body. But it was more generally the opinion of the ancients, that, there being a kind of *vital fire* kept up in the heart, the heat of the blood was tempered in the lungs. GALEN also supposed, that there was something equivalent to a fire constantly kept up in the heart; and that the chief use of the lungs was to carry off such vapours as were equivalent to smoke thrown off from that fire. HALLER, vol. III. p. 354. CARTESIUS maintained the same vital fire in the heart, supposing that air was necessary for cooling and condensing the blood. *Ibid.* p. 343.

Of the more modern physiologists, some have thought that the air itself is taken into the lungs; others, that it is only something extracted from the air, as the more subtle parts of that fluid, an ether, or aerial nitre; while others suppose it to be the air itself, but dissolved in water, and therefore in an unelastic state, *ibid.* p. 321.

Most of those who think that air is taken into the blood suppose it to be taken in by the lungs, *ibid.* p. 330. Some suppose, that the effect of the admission of this air into the blood is a fermentation, p. 332. Others suppose, that it acts by its spring, preventing the too close contact of the globules, and thereby preserving its fluidity, intestine motion, and heat, *ibid.* BERTIER supposed, that the circulation of the blood was, in a great measure, owing to the admission of air into it. VAN HELMONT ascribed the volatility of the fixed elements

ments in the food to this air, p. 336.; and STEVENSON thought, that the air which had circulated in the blood, and which had heated the blood too much, was exhaled by the lungs, p. 355.

Others say, that the air itself is not admitted into the blood, but only some active, spirituous, and ethereal particles; that this vital spirit passes from the lungs to the heart and arteries, and at length becomes the animal spirits, which are by this means generated from the air, p. 333. Others, who do not admit that the animal spirits are derived from the air, still say that some other *vital principle* comes from thence. This vital principle MALPIGHIOUS supposes to be a saline vapour; LISTER, a hot, inflammable, sulphureous spirit; VIEUSSENIUS, a volatile acid salt, which keeps up the fermentation of the blood; and BRYAN ROBINSON, the aerial acid, which preserves the blood from putrefaction; preserves also its density, and strengthens the animal fibres. For this reason he supposes it is that we feel ourselves refreshed in cold air, as it abounds with a more plentiful acid quality, p. 334. They who suppose that nitre is taken from the air into the blood, ascribe to that principle its fermentation, its heat, and its density, p. 334.

It is a received opinion, that one use of the lungs is to attenuate the blood, p. 359; and MALPIGHIOUS adds, that by this means, the different particles of the blood become thoroughly mixed together; while others think that the blood is condensed in the lungs; and others, that the globules, and all the finer humours, receive their configuration there, *ibid.* Some, without considering the  
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air as of any other use than to put the lungs in motion, think, that heat is produced in the lungs by the attrition of the blood in passing through them. *Misc. Taurin.* vol. V. p. 36. The red colour of the blood has been thought by some to be caused by this attrition in the lungs; but LOWER refuted this notion, chiefly by observing, that the attrition of the blood is greater in the muscles, from which, however, it always returns black, *Ibid.* vol. I. p. 74.

Dr. WHYTT thought there was something of a vital and stimulating nature derived from the air into the blood, by means of which it made the heart to contract, HALLER, vol. III. p. 336.

BOERHAAVE says, that air not changed is deadly; not on account of heat, rarefaction, or density, but for some other occult cause. *Misc. Taurin.* vol. V. p. 30.

Dr. HALES, who has thrown much more light upon the doctrine of air than all his predecessors, was equally ignorant of the use of it in respiration; and at different times seems to have adopted different opinions concerning it.

In his *Statical Essays*, vol. II. p. 321. he supposes, that air is rendered alkaline by breathing, and corrected, in some measure, by the fumes of vinegar.

In agreement, as he observes, with BOERHAAVE, he says, p. 100. that the blood acquires its warmth chiefly in the lungs, where it moves with much greater rapidity than in any other capillary vessels of the body, vol. II. p. 87; but that one use of the air is to cool the blood, p. 94; and he makes an estimate of the degree of this refrigeration. The red colour of the globules of blood, he says, p. 88, intimates

intimates their abounding with sulphur, which makes them more fusceptible and retentive of heat than those bodies which have less of it.

He also supposes, p. 102, that another great use of the lungs is to attenuate and separate the globules of blood; and that the floridness of the arterial blood above the venal may, in a good measure, be owing to the strong agitation, friction, and comminution, which it undergoes in passing through them. In like manner, in an experiment which he made for the purpose, blood much agitated in a close glass vessel was observed to be very florid, not only on its surface, but through its whole substance, as arterial blood is, vol. II. p. 102. I would observe, however, that in this experiment, the blood must have acquired its florid colour from the air with which it was agitated.

He adds, that it is probable, that the blood may, in the lungs, receive some other important influence from the air, which is in such great quantities inspired into them. In other places, however, he explodes the doctrine of a *vivifying spirit* in the air. It has long, he says, been the subject of inquiry to many, to find of what use it is in respiration; which, though it may in some respects be known, yet it must be confessed, that we are still much in the dark about it, vol. II. p. 102.

Suffocation, he says, vol. II. p. 271. consists chiefly in the falling flat of the lungs, occasioned by the grossness of the particles of a thick noxious air, they being, in that floating state, most easily attracted by each other, as we find that sulphur, and the elastic repelling particles of air are;

and consequently unelastic, sulphureous, saline, and other floating particles, will most easily coalesce, whereby they are rendered too gross to enter the minute vesicles, which are also much contracted, as well by the loss of the elasticity of the confined air, as by the contraction occasioned by the stimulating acid sulphureous vapours. And hence it is not improbable, that one great design of nature in the structure of this important and wonderful *viscus*, was to frame the vesicles so very minute, thereby effectually to hinder the ingress of gross, feculent particles, which might be injurious to the animal economy.

Lastly, he concludes, that the effect of respiration is to abate, and in part destroy, the elasticity of the air; and as this was effected by sulphureous vapours, and he could breathe for a longer time air that had passed through cloaths dipped in a solution of salt of tartar, he concluded, that the air had been mended by the tartar having strongly imbibed the sulphureous, acid, and watery vapours, vol. I. p. 267.

HALLER, after reciting the opinions of all that had gone before him, supposes, with Dr. HALES, that, in consequence of the air losing its spring in the lungs, they cannot be kept dilated; and therefore, they must collapse, and the circulation of the blood be impeded, vol. III. p. 258. When he states his opinion concerning the use of the lungs more fully, he says, that the true use of them is partly inhaling, and partly exhaling, p. 351. That the lungs inhale both water and air; but that in the lungs the air loses its elastic property, so as to be easily soluble in water or vapour, p. 352.: and he thinks it probable,

probable, that this air serves as a cement to bind the earthy parts together. He also makes no doubt, but that various other matters, miscible with water, are inhaled by the lungs; and he even thinks it not improbable, that the air may carry some electric virtue along with it. The principal exhalation of the lungs, he thinks, to be water, abounding with oily, volatile, and saline principles; and these oily and fetid vapours, he thinks, to be the *fuligines* of GALEN and other ancients, p. 354.

Mr. CIGNA of Turin, has given much attention to this curious subject, as appears by two Memoirs of his; one in the first volume of the *Miscellanea Taurinensia*, in which he very well accounts for the florid red colour of the blood; and the other, which is a much more elaborate Memoir, intitled, *De Respiratione*, in the fifth volume of the same work, just published, or about to be published, the copy of the article having been sent to me by the author.

He takes it for granted, that air which has once been breathed is unfit for farther respiration, on no other account than its being loaded with *noxious vapours*, which discover themselves by a fetid smell. *Misc. Taurin.* vol. V. p. 30. And he takes it for granted, that the elasticity of air is diminished by respiration, though he does not consider that diminution of elasticity as the cause of its noxious quality. He therefore concludes, that air which has been breathed, suffocates by means of the irritation which it occasions to the lungs, by which the bronchia, and the lungs themselves, are contracted, so as to resist the entrance of the air; and therefore, that respired air is



noxious on the same account as mephitic vapours, or those of burning brimstone, p. 31; that, in frequently breathing the same air, it becomes so loaded with these vapours, as to excite a convulsion in the lungs, and thereby render them unfit for transmitting the blood, p. 42.

This philosopher supposes that air enters the pores of the blood, retaining its elastic power, p. 50. and that it continues at rest there, because its endeavour to escape is counteracted by the equal pressure of the ambient medium, p. 52. This air, he supposes to be introduced into the blood by the chyle, and never by the way of the lungs, except when, by some means or other, the equilibrium between the air in the blood and the external air is lost, p. 57. If the external air be rarer than the internal, the air in the blood, expanding itself, will inflate the animal, and have the same effect as air introduced into the veins.

What we are chiefly indebted to M. CIGNA for, is his decisive experiments with respect to the florid colour of the blood, which he clearly proves to be caused by the contact of air; though he afterwards seems willing to desert that hypothesis. It was often imagined, that the reason why the lower part of a quantity of blood was black, while the surface was red, was, that the black particles, being heavier than the rest, subsided to the bottom; but this opinion our author clearly refutes. He found, that when he put a little oil upon a quantity of blood, it remained black throughout; but that when he took away the red part, and exposed to the air the lower  
*laminae,*

*laminae*, which were black, they also became successively red, till the whole mass acquired that colour, *Misc. Taurin.* vol. I. p. 73. Also, at the request of M. CIGNA, Father BECCARIA tried what would be the effect of exposing blood in *vacuo*; and he found, that in those circumstances, it always continued black; but that, by exposing it again to the air, it became red, p. 68.

M. CIGNA concludes his first dissertation with observing, that it is not easy to say how it comes to pass, that the lower part of a mass of blood becomes black, whether by the air which it had imbibed escaping from it, or by its depositing something saline, necessary to contribute to its redness, or by the pressure of the atmosphere; but he inclines to think, that air mixed with blood, and interposed between the globules, preserves its redness: but that by concreting it is expelled from it, or becomes so fixed as to be incapable of making it red. This opinion, he thinks, is rendered in some measure probable, by the increased density of concremented blood, and by the emission of air from other fluids in a concrement state, p. 74.

Notwithstanding what he had advanced in his first Memoir, yet in the second, which was written several years after it, he doubts whether the change of colour in the blood takes place in the lungs; but if it does, he inclines to ascribe this effect to the *evaporation* from the blood in the lungs: and though he always found, that the colour of the blood was changed by the contact of air, yet when he considered that evaporation must, as he thought, necessarily attend the contact of air, he imagined, that this

effect might equally be attributed to this circumstance. But he acknowledges, that this hypothesis ought not to be received till it be confirmed by experiments, *Misc. Taurin.* vol. V. p. 61.

Upon the whole, he concludes, that the principal use of air to the *blood*, is to preserve the equilibrium with the external air, and to prevent the vessels from being rendered unfit to transmit the blood, on account of the external pressure; whereas, by means of the air they contain, the fluids move in their proper vessels as freely as in *vacuo*, and the membranes and viscera also easily slide over each other, p. 63. And with respect to the use of the *lungs*, since he imagined that air is not introduced into the blood by means of them, he thinks, that because such lungs as those of man are given to the warmer animals only, the chief use of respiration is exhalation, and consequently the cooling of the blood, p. 65.

The last writer whom I shall quote upon this subject, is the late ingenious Mr. HEWSON; who says, in his *Experimental Inquiry into the Properties of Blood*, p. 9. "As the colour of the blood is changed by air out of the body, it is presumed, that the air in the lungs is the immediate cause of the same change in the body." That this change is really produced in the lungs, he is persuaded, he says, from experiments, in which he distinctly saw the blood of a more florid red in the left auricle of the heart than it was in the right; but how this effect is produced, he says, is not yet determined.

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Since some of the neutral salts, and particularly nitre, has a similar effect on the colour of the blood; some, says he, attribute this difference to the nitre absorbed from the air, while in the lungs. But this, he adds, is a mere hypothesis, for air contains no nitre, and most of the neutral salts produce the same effect in some degree.

Since, however, a solution of nitre does produce this effect upon blood, instantly making the very blackest of it of a beautiful florid red, though this effect is not peculiar to nitre (for a solution of common salt does nearly the same thing) I own I am inclined to ascribe this effect to the air; especially since I have proved, as I apprehend, that atmospherical air consists of earth and spirit of nitre. Possibly, therefore, the air we breathe may be so far decomposed, as to communicate something of nitre to the blood, in its passage through the lungs.

After this review of the observations and opinions of others on this important question in physiology, I shall proceed to recite my own. It may appear something extraordinary, that among such a variety of opinions concerning the use of respiration, the right one should never have been so much as conjectured, though unsupported by the proper proof. But indeed, this animal function, and the phlogistic processes in chemistry, especially that of the calcination of metals, which is, perhaps, the most simple of them, are to appearance very different things; and therefore, it is the less to be wondered, that no person should

should have imagined, they would produce the same effect on the air in which they were performed.

That respiration, however, is, in reality, a true phlogistic process, cannot, I think, admit of a doubt, after its being found, that the air which has served for this purpose is left in precisely the same state as that which has been exposed to any other phlogistic process. And since all the blood in the body passes through the lungs, and, according to Mr. HEWSON's observations and others, the remarkable change between the colour of the venal and arterial blood takes place there, it can hardly be doubted, that it is by means of the *blood* that the air becomes phlogisticated in passing through the lungs; and therefore, that one great use of the blood must be to discharge the phlogiston with which the animal system abounds, imbibing it in the course of its circulation, and imparting it to the air, with which it is nearly brought into contact, in the lungs; the air thus acting as the great menstruum for this purpose.

Though I had no doubt concerning this conclusion from my former experiments, I thought so great a problem deserved as much illustration as could be given to it; and therefore I was willing to try, whether the blood was of such a nature, as to retain any of this power of affecting air when congealed, and out of the body, that it has when it is fluid, and in the body; and the experiments have fully answered my expectations.

Having taken the blood of a sheep, and let it stand till it was coagulated, and the serum was separated from it (after which the surface, being exposed to the common

air, is well known to assume a florid red colour, while the inside is of a much darker red, bordering upon black) I introduced pieces of the crassamentum, contained in nets of open gauze, or of wire, sometimes through water, and sometimes through quicksilver, into different kinds of air, and always found that the blackest parts assumed a florid red colour in common air, and more especially in dephlogisticated air, which is purer and more fit for respiration than common air (and accordingly the blood always acquired a more florid colour, and the change was produced in less time in this than in common air) whereas the brightest red blood became presently black in any kind of air that was unfit for respiration, as in fixed air, inflammable air, nitrous air, or phlogisticated air; and after becoming black in the last of these kinds of air, it regained its red colour upon being again exposed to common air, or dephlogisticated air; the same pieces becoming alternately black and red, by being transferred from phlogisticated to dephlogisticated air; and *vice versa*.

In these experiments the blood must have parted with its phlogiston to the common air, or dephlogisticated air, and have imbibed it, and have become saturated with it, when exposed to phlogisticated, nitrous, inflammable, or fixed air. The only difficulty is with respect to the fixed air; for all the other kinds certainly contain phlogiston. But, as I have observed in the account of my experiments on vitriolic acid air, phlogiston seems to be necessary to the constitution of every kind of air; and besides, the blackness of the blood may arise from other causes than

than its acquiring phlogiston. GABER, for instance, observes, that blood becomes black when it begins to putrify, as it does also whenever it is dried and hardened near the fire. Father BECCARIA also found, as I have observed, that red blood *continued* (and he could hardly fail to observe also, that it *became*) black in *vacuo*, where it could not have imbibed phlogiston. This I found to be the case when the blood was covered two inches and a half with serum; but it regained its florid colour when it was exposed to the open air.

In general, however, it cannot be expected, that when blood has become black without having received phlogiston *ab extra*, it will recover its florid colour by being exposed to the air. For the delicacy of its texture, and consequently its capacity of being easily affected by phlogiston, may be essentially altered by internal causes of blackness. This is even the case when blood has become black by being exposed to nitrous and inflammable air, though this change is probably effected by its imbibing phlogiston.

I exposed pieces of the same mass of red blood to these two kinds of air, and also to fixed air at the same time. They all became black; but that which was in the inflammable air was the least so, and none of them recovered their florid colour in the open air. But at another time, a piece of crassamentum, which had become black in fixed air, did, in some measure, and very slowly, recover its florid colour in dephlogisticated air. Perhaps the pieces that had lost their colour in the nitrous and inflam-

inflammable air might have recovered it by means of this more powerful menstruum.

Since, however, blood, after becoming black in phlogisticated air, is always capable of resuming its red colour on being again exposed to pure air, it may be concluded, that the preceding blackness, discharged in the pure air, and producing the constant effect of phlogiston, in depraving the air, was owing to the phlogiston it had imbibed in the former situation, and which it parted with in the latter. And this is remarkably the case when blood is transferred from phlogisticated into dephlogisticated air. Even the circumstance of the *deeper colour* is sufficient to give a chemist a suspicion that it contains more phlogiston than blood of a lighter colour.

When I had found how readily pieces of blood changed their colour, according to the quality of the air to which they were exposed, I proceeded to examine the state of that air, in order to observe what change had taken place in it; and as dephlogisticated air admits of a more sensible change of quality than common air, I gave it the preference in this experiment; putting a piece of crassamentum, about the bigness of a walnut, into the quantity of about five ounce measures of this air.

This process I continued for the space of twenty-four hours, changing the blood about ten or twelve times; after which I found the air so far depraved, that whereas, at the beginning of the experiment, one measure of it and two of nitrous air occupied the space of no more than half a measure, the same mixtures afterwards occupied



the space of a measure and a half. Now since air is universally depraved by phlogiston, and in this sense, I believe, by nothing else, it is evident, that this black blood must have communicated phlogiston to the air; and consequently its change of colour from black to a florid red must have been occasioned by the separation of phlogiston from it.

The next day, when, of course, the blood was nearer to a state of putrefaction, in which every kind of substance, without exception, will injure respirable air, I put a quantity of red blood, tinged in a few places with black, which I could not easily separate from it, to about the same quantity of the same dephlogisticated air, and suffered it to stand, without changing, for the same space of time; when it was so little injured, that the measures abovementioned occupied the space of only two-thirds of a measure.

That blood has a power of taking phlogiston from air, as well as imparting phlogiston to air, I satisfied myself by exposing blood of a very beautiful florid colour to nitrous air, inflammable air, and phlogisticated air. The two first mentioned kinds of air were considerably diminished by the process, which was continued two days, during which time the blood had been changed five or six times.

The nitrous air, by this means, lost a great proportion of its power of diminishing, that is, phlogisticating, common air. For now two measures of common air and one of this occupied the space of  $2\frac{1}{4}$ , instead of  $1\frac{3}{4}$  measures. The inflammable air, though still inflammable,

was rendered in some degree wholesome by the process; being, after this, considerably diminished by nitrous air, which is a state to which it is brought by agitation in water, and which, continued longer, deprives it of its inflammability likewise. It cannot be doubted, therefore, but that, in both these cases, the red blood, by becoming black, received phlogiston from these two kinds of air.

With respect to the phlogificated air, I only observed that, after a few hours exposure to the red blood, it was sensibly, but not much, diminished by nitrous air, which otherwise it would not have been in the least degree. This blood, however, was of the lightest colour; that is, according to my hypothesis, the most free from phlogiston, of any that I have ever seen; and I have tried the same thing, without success, with blood of a less florid colour, though as florid as the common air could make it. But it should be considered, that the proper function of the blood is not to receive phlogiston from *air*, not meeting with any phlogificated air in the course of its circulation, but to communicate phlogiston to air; and therefore, there is by no means the same reason to expect, that air will be mended by red blood, as that it will be injured by black blood.

It may be objected to this hypothesis, concerning the use of the blood, that it never comes into actual contact with the air in the lungs, but is separated from it, though as Dr. HALES states it, at the distance of no more than a thousandth part of an inch. The red globules also swim

in a large quantity of serum, which is a fluid of a quite different nature.

In order to ascertain the effect of these circumstances, I took a large quantity of black blood, and put it into a bladder moistened with a little serum, and tying it very close, hung it in a free exposure to the air, though in a quiescent state; and the next day I found, upon examination, that all the lower surface of the blood, which had been separated from the common air by the intervention of the bladder (which is an animal membrane, similar to that which constitutes the vesicles of the lungs, and is at least as thick) and likewise a little serum, had acquired a coating of a florid red colour, and as thick, I believe, as it would have acquired, if it had been immediately exposed to the open air; so that this membrane had been no impediment to the action of the air upon the blood. In this case it is evident to observe, that the change of colour could not be owing to *evaporation*, as Mr. CIGNA conjectures. This experiment I repeated, without previously moistening the bladder, and with the very same result.

I observed also, that when I cut out a piece of the crassamentum, and left the remainder in the vessel with the *serum*, not only that part of the surface which was exposed to the air, but that which was surrounded with *serum*, and even covered with it to the depth of several inches, acquired the florid colour; so that this deep covering of serum, which must have effectually prevented all evaporation, was no more an impediment to the mutual action of the blood and the air, than the bladder had been.

been. The serum of the blood, therefore, appears to be as wonderfully adapted to answer its purpose, of a vehicle for the red globules, as the red globules themselves: for the slightest covering of water, or *saliva*, effectually prevents the blood from acquiring its florid colour; and Mr. CIGNA found that this was the case when it was covered with oil.

That it is really the air, acting through the serum, and not the serum itself, that gives the florid colour to the blood, is clearly ascertained by the following experiment. I took two equal portions of black blood, and put them into equal cups, containing equal quantities of serum, which covered them to the depth of half an inch. One of these cups standing in the open air, and the other being placed under an exhausted receiver, the former presently acquired a florid colour, while the other continued twelve hours as black as at first. Being taken out of the receiver, it stood all night in the open air without becoming red, and continued black ever after, even when the serum was poured off.

I also more completely satisfied myself of the influence of the air upon the blood, through a body of serum, by the reverse of this experiment. For I found that red blood became black through the depth of two inches of serum, when the vessel containing it was exposed to phlogisticated air; so that the red globules of the blood both receive, and part with phlogiston by means of the air, notwithstanding the interposition of a large body of the fluid in which they naturally float.

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Except serum, *milk* is the only animal fluid that I have tried, through which the air can act upon blood: for black blood became red when it was plunged in milk, in the same manner as if it had been covered with serum. In urine, indeed, black blood becomes instantly red; but this is not owing to the action of the air, through the urine, but to the saline nature of that fluid.

In some cases, care must be taken to distinguish the floridness with which some detached parts of a quantity of blood are tinged, from that which penetrates the solid parts of it. In *saliva*, and in water impregnated with alkaline salt, fixed or volatile, and also in spirit of wine, the extreme angles and edges of pieces of crassamentum and small detached parts, floating in those liquors, will appear of a very florid red, while the compact mass of blood continues dark. The florid colour of the prominent and detached parts, in these cases, seems to be the mere effect of the minute division of the parts of the crassamentum in the fluid in which those parts float; when at the same time it has no such effect on those parts which remain compact, nor has the air the least power of acting on the blood through the liquor.

I had imagined, that since black blood contains more phlogiston than red blood, that difference would have appeared in the *air* produced from them, either by being simply dissolved in spirit of nitre, or when dried and made into a paste with that acid. But the difference was too small to be sensible to this kind of test. For this purpose, however, I had some blood drawn from the vein  
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of a sheep, and also took some that came first after killing it, as the butchers usually do, by dividing the *carotid* artery; but though I dissolved the black part of the former, and the red part of the latter, in equal quantities of the same spirit of nitre, I found no sensible difference in the air that they yielded. The air that I got from them when dried, and made into a paste with spirit of nitre, was likewise equally indistinguishable. The quantity of air from this process was very great, and was produced irregularly, as I have observed it to have been when produced by a solution in spirit of nitre without drying. *Observations on Air*, vol. II. p. 155. Half of this produce was fixed air, and the rest phlogisticated, except that a candle burned in it with a lambent blue flame. It is evident, however, from this experiment, that even the most florid blood contains a considerable quantity of phlogiston; for, otherwise, this air would have been dephlogisticated.

I would conclude this paper with observing, that I have found a very great difference in the constitution of blood with respect to its property of being affected by the influence of the air; some becoming very soon of a light florid colour, and the *stratum* of this colour soon growing very thick; whereas, in other cases, the colour of the blood, in the most favourable circumstances, has continued much darker, and the lighter colour has never penetrated very far.

As the principal use of the blood seems to be its power of receiving and discharging phlogiston, and the degree in

in which it possesses this power is easily ascertained by the eye, it might not, perhaps, be unworthy of being particularly attended to by physicians. To estimate the goodness of blood, according to this criterion, nothing is requisite but to observe the lightness of the colour, and the depth of the light-coloured *stratum*, after it has been exposed to the air for a given time. In cases in which the blood is unusually black, and but little affected by common air, it should seem, that breathing a purer air might be prescribed with advantage.

In general, the blood that I have been able to procure in the city has not been so good as that which I have got in the country; owing, perhaps, to the cattle having been much driven, and heated before they were killed.