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LIV. On respiration

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faction than if I had taken out a patent and made a fortune by it. With regard to any reward for my experiments and trouble I am not sanguine: if it be said of me that I have been useful to my country, and have not lived in vain, I shall be satisfied.

As the idea of flax being furnished by broom is new, I have sent specimens of the flax to the Royal Society, to the Board of Agriculture, to the Society of Arts, to the British Museum, &c.; and I have sent you the inclosed specimens, that you may inform the public in what manner the poor, in counties where broom is plentiful, if they want employment, may find one, easy and by no means unprofitable.

I am, &c.

JAMES HALL.

P.S. The fibres of all kinds of mallows I find are uncommonly beautiful; particularly the *malva sylvestris*. They are finer and prettier than camel's hair, which they somewhat resemble; and there is no difficulty in procuring them.

LIV. *On Respiration.* By WILLIAM ALLEN, Esq., F.R.S. and WILLIAM HASLEDINE PEPPYS, Esq., F.R.S.*

ONE of the most prominent features in our last communication was the evolution of a considerable quantity of azote, when oxygen gas nearly pure was respired; and although a considerable part of this azote must undoubtedly be attributed to the residual gas in the lungs, after the most forcible attempt at expiration, yet the fact seemed to demand still further investigation, it appearing of consequence to ascertain whether the increase of azote was uniform throughout the latter stages of the experiment, or *solely* confined to the earlier periods.

By adverting to our former paper, it will be found, that in an experiment where more than 3000 cubic inches of oxygen passed through the lungs in seven minutes and a quarter, 62 cubic inches of azote were found in the first 250 cubic inches expired, though the gas originally contained but 2.5 per cent., or only 6 cubic inches in this quantity; in the two next portions expired, consisting of 562 cubic inches, we found 56 cubic inches of azote, though this quantity of gas, before it was respired, contained only 14; these, first portions, were given off in about

* From Philosophical Transactions, Part II., for 1809.

two minutes, and contained nearly 100 cubic inches of azote more than could be accounted for in the oxygen employed; hence it is plain, that a large proportion of the increase is evolved in the first periods of the process.

Our attention was particularly directed to this point in the following experiment. The oxygen, procured as usual from hyperoxygenized muriate of potash, was found to contain four per cent. of azote; the experiment was conducted in the same manner as the preceding ones, except that the tubes of the gasometers were filled with oxygen, and the gas was not merely passed *once* through the lungs, but breathed backwards and forwards in order to prolong the duration of the experiment, which began and ended with a forcible expiration. Portions of the respired gas were preserved for examination from each of the gasometers, in the following order:

No.	No.
1. 244	7. 254
2. 294	8. 288
3. 282	9. 252
4. 266	10. 168
5. 230	—
6. 266	2544
	—

The portion of oxygen remaining in the water gasometer of the original quantity, not employed in the experiment, was found upon trial to contain four per cent. of azote, as before.

Summary of the Experiment.

Bar.	Therm.	Cub. Inches of Oxygen inspired.	Cub. Inches of Gas ex- pired.	Defi- ciency.	Time.
29.9	51	2668	2544	124	13 minutes:

here the deficiency was greater than we had ever remarked before; but on passing an equal quantity of common air from the water gasometer, and registering it in the mercurial ones, we were satisfied that the apparatus was quite perfect. It is, however, to be considered, that the respiration in this case was not natural, and that some small degree of force was required when the inspirations and expirations were made in the mercurial gasometers, which renders this experiment rather different from those which had preceded it; and it appears to us probable, that a portion of air was forced into the extremities of the bronchia, which could not be suddenly expelled by the strongest attempts at expiration. Hence also, perhaps, the constant though smaller deficiency, even when the air was only once passed

passed through the lungs; but when the process is continued for a much longer time, it is probable that the vessels recover their tone, and are able to expel nearly the whole of the volume admitted.

The air expired in the present instance being examined in the manner described in our last paper, we found that 100 parts from each of the gasometers contained the following proportions:

No. 1.	10	carbonic acid
	21	azote
	69	oxygen
	<hr/> 100 <hr/>	
No. 2.	10	carbonic acid
	11	azote
	79	oxygen
	<hr/> 100 <hr/>	
No. 3.	10	carbonic acid
	8.5	azote
	81.5	oxygen
	<hr/> 100 <hr/>	
No. 4.	10	carbonic acid
	7.75	azote
	82.25	oxygen
	<hr/> 100 <hr/>	
No. 5.	10	carbonic acid
	7	azote
	83	oxygen
	<hr/> 100 <hr/>	
No. 6 to 10 mixed	10.5	carbonic acid
	5.5	azote
	84	oxygen
	<hr/> 100 <hr/>	

We shall first calculate the total quantity of azote existing in the gas before the experiment, and afterwards estimate what

what was produced in the different periods during the first half of the experiment.

Calculation for Azote.

2668 cubic inches of oxygen were employed containing four per cent. azote : then

$$100 : 4 :: 2668 : 106.72$$

the total quantity of azote in the gas consumed, was 106.72 cubic inches.

Azote found after the Experiments.

	Cubic Inches.			Azote found.
No. 1.	244	100 : 21	::	244 : 51.24
2.	294	100 : 11	::	294 : 32.34
3.	282	100 : 8.5	::	282 : 23.97
4.	266	100 : 7.75	::	266 : 20.61
5.	230	100 : 7	::	230 : 16.10
6 to 10.	1228	100 : 5.5	::	1228 : 67.54
Total				211.80 cubic inches.

The whole azote, found after the experiment, was - - - 211.80 cubic inches.
 Azote detected by the same tests before the experiment only - 106.72

Increase of azote 105.08

Now, as the whole time was thirteen minutes, if we divide this by the number of gasometers filled, it will give us one minute eighteen seconds for each, and the following will be the periods in which the azote was evolved.

	Time.	Azote found.	Azote in the Oxygen.	Increase.
No. 1.	1.18	51.24 less	9.76 equal to	41.48
2.	1.18	32.34 -	11.76 =	20.58
3.	1.18	23.97 -	11.28 =	12.69
4.	1.18	20.61 -	10.64 =	9.97
5.	1.18	16.10 -	9.20 =	6.90
6 to 10.	6.30	67.54 -	49.12 =	18.42
13 min.		211.80	101.76 *	110.04

Here the increase of azote appears rather greater, viz. 110

* The apparent deficiency here 4.96 arises from this circumstance, that the *separate* portions of oxygen not having been ascertained, this calculation has been made with the corresponding but smaller portions of expired gas.

cubic

cubic inches, but the calculation in this case is made upon the gas *expired*; and, from the above statement, we may see that the evolution of azote goes on diminishing; we have sometimes even found, that towards the close of an experiment it has been almost reduced to nothing. The question now is, whether this increase of azote can be owing to the residual gas contained in the lungs at the beginning of the experiment, or whether a portion of oxygen is not actually exchanged for azote, when pure oxygen gas is respired.

Here it may be useful to compare the azote found in our former experiments on oxygen, with the present.

No.	Bar.	Therm.	Oxygen			Time.	Quantity respired in a minute.	Azote evolved.	Inferred Capacity of Lungs
			Gas inspired.	Gas expired.	Deficiency.				
1.		53	3260	3193	67	9'20"	348	110	141
2.	30.3	70	3420	3362	58	7.25	461	177	225
3.	30.15	70	3190	3060	70	8.45	357	187	236
4.	29.9	51	2668	2544	124	13.	205	105	133

The greatest increase of azote was in the 2d and 3d experiments, when the thermometer was at 70°, which might materially influence the results: in the other cases, it was not higher than 53.

From the experiments of Goodwin, we might be inclined to admit the capacity of the lungs, inferred from the 1st and 4th experiments, as very possible; but it seems difficult to conceive that it can amount to 236 or 225 cubic inches; and yet this must be the case, unless a portion of azote is given off from the blood, or there is some process in nature by which it is capable of being produced from oxygen.

Having, by the kindness of our friend Henry Cline, jun., been furnished with the lungs of a stout man, about five feet ten inches high, taken from the body not long after death, and in a sound state, we proceeded to ascertain the quantity of air contained in this organ after the most complete expiration, as in death.

Henry Cline had judiciously taken the precaution to divide the trachea just below the cricoid cartilage, before he opened the thorax; he then inserted a tube with a brass stop-cock, which he tied firmly to the trachea, and attached an empty bladder to the other end. The cock was then turned, so as to communicate with the bladder, and on opening the thorax $31\frac{1}{2}$ cubic inches of air were expelled into it. The weight of the lungs was four pounds one ounce. A very large glass jar being placed in a shallow tin vessel,

vessel, was filled to the brim with water, the lungs were then completely immersed, and the water which flowed over, and was the measure of their volume, weighed six pounds two ounces: we next cut a portion of the lungs into small pieces, under a large inverted glass of water, and attempted to squeeze the air from the cells; but although several cubic inches were thus procured, we were soon convinced that it was utterly impossible to arrive at our object by these means, as no force that we could use seemed capable of expelling the air from the cellular membrane, into which it escaped from the vesicles. We therefore took portions of the lungs, which weighed 2774 grains; the mass being put into a piece of new hair cloth, was subjected to the action of a powerful screw press, and the fluid was received in a vessel; after twice undergoing this operation, the mass weighed only 660 grains. Its specific gravity was very nearly that of water, viz: $\cdot 930$ water being $1\cdot000$; the fluid procured by the press was of the specific gravity of $1\cdot019$; this would make the specific gravity of the lungs $\cdot 997$, water being $1\cdot000$: hence it appears, that the substance of the lungs, and the contents of the blood-vessels together, are so near the specific gravity of water, that they may be fairly considered as the same.

Then, as the mass of the lungs was equal to 4 pounds of water, though 6·2 pounds of water were displaced by them, and as a pound of water occupies the space of 28·875 cubic inches, we have the following calculation:

lbs.	oz.	
6	2	water displaced by the lungs
4	1	weight of the lungs

2 1, or 59·554 cubic inches of air in the lungs, to which must be added 31·580 the volume of the air forced into the bladder on opening the thorax.

91·134

and this gives us 91·134 cubic inches, as the air contained in the lungs of this person after death; and when we reflect that the air must have been under compression, when the lungs were immersed in water, some force being required to keep them down, and also that not less than 7 or 8 cubic inches must be contained in fauces, &c., we cannot estimate the whole at less than 100 cubic inches.

It is further to be noted, that these 100 cubic inches would occupy much more space in the temperature of the human body, than in the mean temperature in which the examination was made; and this difference would be nearly

8 cubic

8 cubic inches; the air left in the lungs, after complete expiration, would therefore be 108 cubic inches; but the mean of our experiments would make it 183.

Experiment 1.	141
2.	225
3.	236
4.	133
	<hr/>
4)	735
	<hr/>
	183
	<hr/>

We are then almost compelled to allow that when pure oxygen is respired, a portion of azote is given off from the blood.

We now resolved to perform a series of experiments upon some animal which lived wholly upon vegetable food, and made choice of the Guinea pig as one of the most manageable.

The apparatus consisted of our two large mercurial gasometers, which were made to communicate with a strong trough E, in the middle of which a small mahogany table D was made fast by a screw, for the purpose of supporting the animal under the bell-glass A; two holes were made through the table for the insertion of tubes to supply and take off the air, each of them communicated with one of the mercurial gasometers; the tube B delivered gas towards the upper part of the glass A, in order to bring the supply of fresh air near the head of the animal: the opening of the tube C was placed within half an inch of the table to convey off the respired air; the gasometer connected with this tube was made to communicate with a mercurial bath G, in which portions of the respired air were preserved for examination. Quicksilver being poured into the trough E, so as to rise to a level with the top of the mahogany stand, we placed a Guinea pig upon it, with the bell-glass over him, and as its edges were immersed in quicksilver, the animal was completely confined in atmospheric air: we found that his body occupied the space of 39 cubic inches, which deducted from the cubic contents of the glass A, left 55 cubic inches for the air confined with the pig, to which must be added 5 more for that contained in the tube C.

First Experiment with Atmospheric Air.

The pig was placed upon the stand, and the apparatus arranged as represented in the plate: 250 cubic inches of
 Vol. 34. No. 139. Nov. 1809. Bb atmospheric

atmospheric air were admitted into the mercurial gasometer communicating with B: the gasometer communicating with C was quite empty, the apparatus being tried was found perfectly air tight, and the whole quantity of air 310 cubic inches.

The cocks H and I being opened, gentle pressure was made upon the glass of gasometer B, so as to cause the air to pass through A, which consequently drove an equal portion through the tube C into the empty gasometer; a quarter of an hour was employed in passing the gas, which measured exactly 250 cubic inches in C, so that there was no alteration of volume; the cocks H and I were now closed, and the respired air being examined by the usual methods, 100 parts were found to contain

5 carbonic acid
16 oxygen
79 azote
<hr/>
100
<hr/>

As the air after the experiment had experienced no alteration of volume, and as it contained the same proportion of azote as atmospheric air, this substance had remained unaltered. But 15.50 cubic inches of oxygen had been converted into carbonic acid gas.

$$100 : 5 :: 310 : 15.50.$$

Summary of the Experiment.

Bar.	Therm.	Atmos. air inspired.	Gas after experiment.	Cub. inches of carb. acid.	Cub. in. of carb. acid per minute.	Time.
30°	43°	310	310	15.5	.62	25 min.

Experiment II. Atmospheric Air.

The experiment was repeated in exactly the same manner; the animal, except from confinement, appeared much at his ease all the time. The air after the experiment contained in 100 parts

5.5 carbonic acid
15.5 oxygen
79 azote
<hr/>
100
<hr/>

Here the proportions of azote were undisturbed, and 17.05 cubic inches of carbonic acid procured.

$$100 : 5.5 :: 310 : 17.05.$$

Summary

Summary of the Experiment.

Bar.	Therm.	Atmos. air inspired.	Air after Experiment.	Carb. acid found.	Carb. acid per minute.	Time.
29.66	38°	310	310	17.05	.68	25 min.

Experiment III. Atmospheric Air.

The apparatus being arranged as before, we kept the pig in the glass A for one hour, and during that time passed 1000 cubic inches of atmospheric air through it, which measured 1001 : portions of the respired gas had been preserved in the mercurial bath, and the usual trials made upon the mixture, which was found to contain 5 parts of carbonic acid in every 100, or 53 cubic inches in the whole quantity ; the azote was unaltered ; 100 : 5 :: 1060 : 53.

Summary of the Experiment.

Barom.	Therm.	Atmos. air before expt.	Air after expt.	Increase.	Carb. acid found.	Carb. acid per min.	Time.
29.8	56°	1060.	1061	1	53	88	1 hr.

[To be continued.]

LV. Description of certain Inventions for the Improvement of Naval Architecture, for increasing the Comforts of Mariners, and for facilitating Naval Enterprises. By Messrs. R. TREVITHICK and R. DICKINSON.

THE inventions alluded to in the above title form the matter of a patent granted to Messrs. Trevithick and Dickinson. They are at the same time so novel, ingenious, and useful, that we are persuaded we shall confer a favour on many of our readers by giving some of the particulars detailed by the patentees in a prospectus which they have circulated among their friends.

I. A wrought-iron moveable Caisson with a Rudder, for Docking a Ship, while riding at her Moorings, in any Depth of Water, leaving her Keel dry in a few Hours, without removing her Stores or Masts.

“ This floating dock is made of wrought-iron, half an inch thick, 220 feet long, 54 feet wide, and 30 feet deep, and will weigh about 400 tons, with a flanch six feet wide on the top, for the workmen to stand upon, and also to strengthen the caisson.

“ The weight of this caisson, when immersed in water, is nearly 350 tons ; but, for reasons mentioned below, it

B b 2

is