

174 the external Air will enter where there is one
of less density. This is understood by you all.
Take a Bladder whose cavity communicates wth
the Atmosphere; you may make air enter by
pulling asunder its two sides; or if you can place
the Body in the receiver of an Air Pump. Or if
you suppose it placed in ~~an~~ ^a series of Bellows
so as that Air can only enter in by an orifice
in any of these ways it can be understood how air
enters in by certain cavities; such is the situa-
tion of the Lungs, in a cavity which does not
admit air but by the Glottis. Their cavity in
its natural state keeps the Lungs greatly con-
tracted; within the size that their dilatable
membrane readily admits of. The Lungs are
I say, enclosed in the Thorax, are bounded at
their inferior part by the Diaphragm. The
relaxed state of the Diaphragm is such as from
its attachments to the Sterna, mediastinum
&c, it is convex towards the Thorax & concave
towards the Abdomen; and by the movable Ribs
the Capacity of the Thorax is most diminished.

The Thorax being in this contracted state is capa-
ble of considerable enlargement; first by the contrac-
tion of the Diaphragm, which brings it to form

a Plain more nearly circularly, moving its ¹⁷⁵
middle part from above, downwards, and thereby
increasing its dimensions. This enlargement al-
one answers most of the ordinary purposes of
Aspiration. But the abdominal viscera must
be removed which is Difficulted by pregnancy,
Dropicæ, and by the vapine posture; therefore
Nature has provided for the lateral Dilatation
of the Thorax, which is done by the motion of the
Lungs and the flexibility of the Cartilages. If
the middle part of the Ribs is drawn upwards
every two opposite parts will be set at a greater
distance, and the transverse section enlarged; &
the elevation of the ribs will not only bend
but perhaps push forward, the sternum, & the
Capacity of the Thorax below the sternum &
and Vertebra will be increased. The Ribs are
moved upwards by the intercostal muscles in
ordinary respiration; in extraordinary, are as-
sisted by many others that lie between the sca-
pula & Vertebra, or between the former and
bones of the Head. The only question arises, with
regard to the intercostales interni. The intercos-
tal muscles are divided into two layers; it has

176 been doubted whether they could concur in one and the same operation; they have been thought to act alternately; Haller will shew how much they have been controverted. He concludes that the internal as well as the external, pull the Ribs upwards. The external are so situated that their fibres in passing from a ~~upper~~ rib to a lower, are inserted in the upper, nearer, in the lower, farther from the center of motion. They are fuller towards the Vertebra. The contrary happens in the external layers, they are full towards the sternum, and wanting toward the Vertebra. And this shews what are the effects of their action; Haller does not mention this in the prime denia, but it is fully displayed in the larger work. If the Thorax is empty there will be a vacuum around the lungs or air will be dense, and the internal surface kept pressed with air, or if they are filled with elastic air it will dilate the lungs, but become more rare, It has a connection with the external.

This may be variously modified as there is no air in the new born infant, or as it is dilated, it does not signify whether there

is air between the Pleura and Thorax or not, 177 for air must enter just in proportion to the enlargement of the Capacity. We have then accounted for inspiration. Next the air soon after is again expelled; without touching at the cause why, I speak of the means whereby this happens; these are various; first, the elasticity of the cellular membranes themselves. The contractility of these with the surrounding membrane will always bring the lungs to their contracted state, and they have a share in expelling the air, but this is assisted by the muscular power of the Bronchia, viz. that portion which is muscular. As distension is the most common stimulus in irritable fibres, this will occasion their contraction and the expulsion of Air. But if the Thorax was to continue in its dilated state, these last powers would have to oppose the whole pressure of the external atmosphere.

Lect. XXXIII. Dec. 26th

I mentioned the effects of the contraction of the diaphragm, the elevation of the Ribs, and the action of the muscles subservient to respiration. But this might be merely in consequence of the elasticity of the lungs, the surrounding mem-

118 frame and muscular fibre). Yet not only these powers, but contraction must also take place which is the restoring the Thorax to its contracted state.

The Elasticity of the ligaments and the weight of the Ribs will bring the Lungs into their former situation. The Ribs are actually pulled down by the additional muscles. These powers restore the contracted situation in as far as it depends upon pulling down the Ribs: But the contraction of the Diaphragm has the chief effect; it must, be relaxed and pulled upwards by the elasticity of this part; but the abdominal muscles, all of them ^{press} upon the viscera and push the Diaphragm. These are the powers by which the Thorax is reduced to its contracted state. —

In ordinary cases the sterno-costal tend. to pull down the Ribs, and in extraordinary the sacro-lumbal &c.

Why are the motions of the Lungs alternate? But we must first consider the effects of these alternate motions upon the basis of the Blood. —

The Arteries and Veins of the Lungs are subdivided, or nearly, into the same degree of minuteness as elsewhere, at least into capillary arteries; and as the subdivision happens in a shorter space, there must be much more frequent ramification and change of Direction. Now their Vessels

are every where dispersed among the cellular substance of the Lungs; and unless the Vessels of the Lungs are perfectly rigid, they will not suffer their diminution of cellular substance without being

But may not the change of the state of the Blood be affected by a peculiar circumstance. Winslow and Helvetius say they are formed into Rugae and can reduce themselves into a less capacity; but I have not found it so by observation or reading other Authors. The bronchia from mixture of cartilage and membrane, are stretched out in length by the air, and contracted again after its expulsion. It would seem to me that there are circumstances in the Blood Vessels corresponding to those of the Bronchia. Upon this occasion Physiologists enter into this, and also think that the contraction of the Lungs, may have an effect in compressing the Blood Vessels. I see no reason for such an opinion, when we consider how easily the contractibility of the Lungs is overcome, and occasion a considerable distension. At the end of inspiration the course of the Blood must be considerably interrupted. I need not mention, that at the end of expiration and Inspiration all the symptoms appear of the Blood being interrupted, the emptying of the right ventricle of the Heart depending in the Cava, and particularly the Vessels of the face. This is done both by expiration and inspiration. In the

180 last some have supposed that a full inspiration might increase the flexure of the vessels, but this is not confirmed by observation. Therefore when the Thorax &c. yield no farther the Blood may be compressed in the Lungs. Haller has raised Difficulties, which it will be worth your while to attend to in P. CCLXVII. and the following. But here Haller is wrong; first in supposing the change of the air to unfitness, for respiration, consists in a diminution of its elasticity; and if confounding the cause of the interruption of the Bloods motion in so full an inspiration, with the cause of death whenever the air is contained for any length of time in the Lungs. By a construction of the statics the interruption of the course of the Blood is to be accounted for. The motion of the Blood in the Lungs is interrupted, by their strong distension, flexure, and compression of their small vessels. The Bloods motion is most free at an intermediate state, but which rather approaches to a full inspiration. The expiration is never full, a considerable force keeps the Lungs in a loose and extended state, and inspiration is always shorter than expiration. This we shall apply in explaining morbid Phenomena hereafter. But as to the motion of the Blood it appears, that if a great quantity is to be transmit-

ted, it requires a more frequent respiration. And 181 a frequent alternate respiration will necessarily expedite the motion of the Blood. And thus a quicker return of Blood to the right ventricle will make a more frequent respiration, and vice versa. But to understand the cause of alternate motion we must consider the effects of air taken into the Lungs. —

1st The atmosphere is cooler than the human body, when taken into the Lungs it must suffer a change of temperature; but it is of more consequence that air being frequently employed in respiration comes to be considerably changed; in what manner the Physiologists have long doubted. Perhaps it loses some of its Elasticity, But air of various Degrees of Elasticity is pretty well accommodated to the Business of respiration. Accordingly men breathe easy upon the tops of high mountains, where the Mercury has stood at 60. Dr. Hales has given an experiment leading to explain this. He took a quantity of Air sufficient to serve the Lungs for two minutes, and by applying it to a mixture of fast Alkali, he made it to last ten minutes. From this experiment Haller concludes, that Alkali has a remarkable power, of absorbing a moisture from the air. But tho' it does

182 This it is dry Alkali not dissolved which has
employed; and as it was an alkali not supple-
ment (which absorbs mephitic air) it renders
this explicable. Now such a mephitic air does
arise from the lungs of living animals. —
the purest air that you will take in and throw
out again if you apply it to a solution of calca-
reous earth it precipitates it; and it renders a
caustic Alkali mild. This air is a sudden poison;
so animals placed in the way of exercising liquor,
or fermentations, from which a great quantity
of it is always escaping, are immediately killed.

— Sect. XXXIII. Dec. 24th. —

A question has been started, whether this me-
phitic air is to be considered as totally distinct
from common air or a species of it. We shall
consider it as a species since it is steady in
its appearance. So you may take Limestone
and take a way its air, then, upon restoring it
you will find it exactly the same. Mephitic
air may be present in Bodies in considerable
quantity. From whatever source it is drawn
it kills living Animals. It is equally poisonous
to the animals that do not breathe at all as to the
breathing animals. A frog will die as soon as a
Bird in an Air replete with mephitic air. Next
observe that it is rendered innocent merely by being

mixed with common air, and in that case it loses
loses all its distinguishing qualities. A mephi-
tic air seemingly generated in animal Bodies
is absorbed by the the common air in inspi-
ration and thrown out in expiration. It
may be applied to supply the place of fresh air
for it has the same effect. If fresh air is constan-
ly renewed it will render the mephitic air inno-
cent. But if the whole air about an animal
be taken in and thrown out in a certain time
so as to be more and more impregnated, it
will kill from double poison and interruption of
Respiration. It appears that atmospheric air
unites with it and forms a neutral in a certain
quantity. It is observed of most poisonous sub-
stances that a certain degree of diffusion renders
them innocent. The effects of common air in
rendering the mephitic innocent has been
supposed to be owing to diffusion. An air
enclosed with an animal

. But air dissolves va-
rious bodies and unites with them, and so
it is with mephitic air. The whole doctrine
of the effects of air upon animal Bodies, will
enter into our Oitology. I must not touch
the effects of air arising from inflammation.
Here is some thing analogous to breathing, that

184 burning Bodies are constantly resolved into
Vapours, which extinguishes all Inflammation.
Mephitic air, extinguished fire, and the vapours
of burning Bodies is equally a poison to
Animals. I own, that the air of burning Bo-
dies will reduce a Caustic Sphale, is a Doubt
Mephitic air is more purely present in the
case of burning Bodies; in the case of infla-
mation more blended with a volatile acid.
By what means the motions of Respi-
ration are necessarily alternate.

Here there have been various Hypotheses
which you will find in Haller, but nothing satis-
factory; and the motion may be more simply
explained—

First as to the necessity of expiration following
inspiration. A by the power of the will the
the power that lifts the ribs upwards, the elas-
ticity of the ligaments and cartilages compress
the lungs. If we can find that Dis-
tension is a stimulus to all muscular ca-
vities, And the contraction of the Diaphragm
pushing downwards becomes a stimu-
lus. Next follows inspiration; with regard to
the renewing of it, we are to notice without
having recourse to the power of the will, we
shall find that most of the alternate motions
of the System proceed from instinctive Uncon-

scious. The motion of the Blood, and hence the
evacuation of the right Nostrile is interrup-
ted, there is a reorganization of the Venous Blood
all of which give uneasiness.

Miscellaneous Particulars of these
I shall give one. I observed that respiration
depended upon an equilibrium,
as in most cases of the condition of Animal life
the external air is cooler than the bodies of
men, and therefore taken into the most inter-
nal parts of the Body, and it must be heated
beyond what it was, and thus increased in elas-
ticity. Take a Bladder, and tie it up with a very
small portion of air and expose it to the heat of
the fire and you will soon find it extended and
able to overcome the pressure of the whole ex-
ternal atmosphere. This happens every time
that fresh air is taken into the Lungs. Some
have thought that necessarily a portion of air
was if its exit by the Glottis be any how pre-
vented the Lungs must be distended to a ve-
ry great degree. But it explains some of the
most difficult Phenomena of Hales, Hous-
ton &c. as that of the air issuing out of the Lungs
and giving room for the fresh air to rush in
but it is supposed to be. But an aperture

186 made in the Thorax does not immediately interrupt respiration. Now it goes farther, for when not only this, but when the sternum was entirely taken off and both Cavities of the Thorax laid open, the Animal continued to breathe. Hence some thought that animals had a power of breathing. But that is explained by the difference of temperature between the external and internal air. When the Thorax was entirely laid open and the animal continued to breathe a large quantity of fresh air was taken in and thrown out merely by the alternate contraction and opening of the Glottis. A short time elapsed and the Glottis was contracted again &c. but they were constantly smaller and smaller till after a few respirations, they entirely ceased. In the case of one Cavity being opened, it had its contractions and dilations tho' not synchronous with the other, which was owing to the air being pushed in and stimulating respiration; A great many considerations are touched as the use of respiration to the Economy, but these belong to the Chemical part of our course, where we will consider it under the Head of sanguification, ^{the considerations} of coughing, laughing

It will be rather more properly considered 187
under the Pathology —
Lect. XXXV. January 6th
The Action of Muscles depends upon a Power conveyed to them thro' the Nerves. The motion of the L^{is} Nervus depends upon the Soul. We can observe, all the modifications of thinking depend ultimately upon the impressions of external Bodies on nervous parts. Hence the consideration of this subject must be of the greatest importance in the animal Economy. This which I have made my second part should have been sooner introduced but it is embarrassed with some difficulties and obscurity, and therefore for this year not brought in till now. We now enter upon it following D^r Haller. It is about 100 years ago only, since the subject was touched, and by D^r Willis who's theory was trifling. But the whole Physiologists were engaged soon after in another system which took off their attention. However from this Baglivi not long after aimed at a system in this way. From him and the fanatical ^{of France}, something is to be learned. Hoffman made a complete system of it. Stahl and his followers necessarily took it in their. Haller on the occasion he has given for inquired into sensibility and Irritability, has contributed

188 his share, and Gaubius has introduced it as a principal part of his Pathology. In the curious posthumous piece of Boerhaave, *De Nervis* we have many usefull things upon it. No body has touched the subject more fully than my worthy predecessor Dr. White. Dr. Robert Hux in the 4th Section of his Lectures on Light, has given a Theory of the operations of the Nerves; Dr. H. has attempted the same thing

He in this Analysis of the soul has given usefull observations. All these have touched the subject superficially, and given no tolerably complete enumeration of particulars. I shall give you quite a new plan. Whether you take the human system to be a purely material system, or partly material partly immaterial you will find it to be a *Machine*. *sic generis*, and must be studied in it self. Nevertheless whatever peculiarities may be in it, it may be put at length upon the same footing with every other object of the human understanding. General facts or laws as we call them may at length be obtained. But it will be difficult to do that from the diversity of *Phaenomena*. Seldom do the same external agents produce the same effects; because the subject operated upon, is liable to the greatest diversity. Not only, one man differs from another, but the

same man is hardly two hours or two minutes ¹⁸⁹ the same with regard to himself, as also happens in the moral World. But the diversity occurs chiefly in what we call the mental operations and our subject taken in its full extent necessarily therefore takes in the History of the human mind; on this I shall give a good number of reflexions. No body can judge of parts till he has heard the whole, you are therefore to suspend your criticisms till then; in the meantime while nobody has been able to avoid entering into the history of the human mind, Boerhaave has said all problems, with regard to the physician are solved, when our enquiries are pushed up to the human mind. But if our soul ever acts separately, in that case, I own its causes are out of sight. But tho' the soul should be allowed to be a separate and distinct substance, yet it is by its mutual connection with the Body influenced by it and again influences it. It is of no consequence to attempt the *modus operandi* of this mutual action. ~~as we must do~~ But admitting, as we must do, their mutual operation, we must on many occasions enquire how the soul acts upon the Body. Boerhaave here could not observe his own rule. I say all this to show that metaphysics are unavoidable to us. It is well understood

30 by every man of science, that metaphysics are necessary in every part of it, and particularly in this part of ours. I formerly mentioned many grounds of Doubt on this part of our course arising from its particular Nature. But the absolute necessity of metaphysics will perhaps render it always Difficult. Most of men either have not the necessary leisure to enter into it, or can not enter into it for want of shades and genius. Now I may frequently appear to you superfluous, and somewhat obscure and difficult, but this may be owing to your not perceiving the application, and to your want of in the exercise, or even to your Dulness. —

PLAN

There is here no room for mathematics upon which we can sufficiently build the rest of our system. It must be got by the method of induction, which requires the enumeration of facts and Phaenomena; But I must attempt a choice of order, and so far as I do that, I am attempting more general facts, or leading towards them. My general plan then is the enumerating facts and Phaenomena so as to render them most usefull. With regard to what are the proper limits of our ^{subject}. The common origin of the Nerves, medulla cerebri and cerebelli, medulla oblongata and

spinalis, and the productions of them which are very minutely dispersed thro' every part of the Body. In the extremities they are connected with the organs of sense and motion. The first are of variety and much greater than has been supposed commonly. How the organs of motion are diversified is more uncertain, but we may take them in one general view. It is in these organs of sense and motion that our subject is limited. It is merely the sentient extremity of the Nerve only that belongs to the consideration of the nervous system. And all the apparatus for receiving and communicating sensation to it do not properly belong to that system. Again in the Muscles their contraction in its causes, modes, and effects, do belong to the nervous system. But the effects of that contraction in moving the Body do not belong to the subject, and may, as we have already done in the last part be considered Separately. In like manner on the other hand in the chemical system the fluids are often moved by Muscular contraction; but that may be considered as the Action of certain mixts upon one another, totally distinct from the nervous system. Now having thus fixed the limits of this part, within these we seek for the proper argument of the Phaenomena mentioned. It will be best to consider them as causes and effects and in the order that they lead to. Other Bodies in nature are in constant

192 motion, and, touch, move, and impell, other Bodies.

We can perceive that their motions are chiefly confined to organs of sense. We shall find that the sentient extremities of the Nerves thus moved by other Bodies, propagate a motion to their other extremities, or sensorium commune, and this impressed motion, is very generally and very universally attended with thought. And according to the nature of the external Body moving and to the organ moved, various modifications of thought arise.

There is a certain series of modifications of thought which constantly produce the action of Muscles and here we have motion communicated to the sentient extremity, as a cause of muscular contraction its effect. We can perceive this, our order will divide itself commodiously into three distinct parts Viz:

Impression, Perception & Contraction

which is our plan. The action of external Bodies on animal Bodies is what I call impression. Whenever the impression ceases these modifications of thought take place, which is perception. Under this I consider every thing that consists in modification of thought which produces action of Muscles, and this muscular action is the contraction I speak of.

Lect. XXXVI. Jan. 4th

193

It may be a question whether Perception always intervenes between impression & contraction, as Dr. White imagined, or as others, that impression, without the intermeditation of perception produces contraction. It is certainly more rare that the intermeditation of perception does not take place; In many instances all that we can say of impression is taken from perception; and the contraction is the effect of the other two yet the mind perceives these contractions, and accordingly they may be considered in their turn as impressions, and the matter to go on in a circle. But we must keep them as distinct as possible in order to talk of them with the greater clearness. To return I have taken the hint from Dr. Gaubius in the Division of mine but have made some difference in his terms. What I have called impression, he has called irritation. But it surely is not evident that every impression proves a cause of contraction; and so far as impressions affect the motions of Animal Bodies they are not all irritants, but many of them are sedative; that is to say tend to allay the motions of the Body. Two remarks are to be made on stimulus and irritation. Here is a proposition of Dr. White, "a stimulus"