

An inquiry how far the vital and animal actions of the more perfect animals can be accounted for independent of the brain : in five essays being the substance of the Chandos lectures for the year 1739, and some subsequent years / By Thomas Simson.

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A N
I N Q U I R Y
HOW FAR THE
VITAL and ANIMAL ACTIONS
Of the MORE PERFECT ANIMALS
Can be ACCOUNTED for
Independent of the BRAIN.

In FIVE ESSAYS.

Being the Substance of the *Chandos* Lectures for
the Year 1739, and some subsequent Years.

By THOMAS SIMSON, M. D.
CHANDOS Professor of Medicine and Anatomy in
the University of *St. Andrew's*, and Honorary Member
of the College of Physicians at *Edinburgh*.

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In the following SHEETS,

Page 34. line 19. for nobiliorem read mobiliorem.

99. l. 24. *f. was r. as.*

109. l. 14. *f. quæ r. quo.*

120. l. 12. *f. mimosa r. nimosa.*

134. l. 7. *f. breasts r. breast.*

144. l. 9. *f. breathed out r. breathed with.*

218. l. 12. *f. more ordinary r. ordinary.*

223. l. ult. *f. Ariæo r. Arcæo, Angenio, Augenio.*

260. l. 5. *f. roughly vitiated r. thoroughly vitiated.*

In the following sheets

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T O

ROBERT SIMSON, M. D. Professor of
Mathematicks in the University of
Glasgow.

DEAR BROTHER,

I Here present you with five Essays on the vi-
tal and animal actions of the more perfect
animals ; for though, of late, we seem to have
made a considerable progress in the theory of me-
dicine, yet the causes assigned for these princi-
pal parts of the animal oeconomy, are not at all
depended on.

The schools had indeed adopted certain ma-
xims, which would have persuaded us that they
had come to rest satisfied in their accounts of
them ; but some of the wiser part of the pro-
fession still shew a distrust in these accounts ; and
daily suggest some new considerations to make them
perfect : And as I reckoned nothing of greater
importance to medicine than a just theory, so I
could find nothing whereby I could better an-
swer the worthy design of the Founder of the

Chandos lectures here, than to do something to establish these principal parts of it upon a sure foundation. And indeed, if I mistake it not, the foundations of theory and practice in our art are to be laid after the same manner, both of them by an exact observation of the occurrences in the body, and of what contributes to produce them. The theory consists chiefly in observing such as take place in health, and the irregular causes which disturb them; the mere practice, in considering the irregular courses, and what management contributes most to restore them to the more perfect state, without regard to the causes. And who can imagine, that if we are not able to trace the more constant and regular courses, that we should be able to trace the irregular and less frequent? A very little thought must satisfy us, that the person who is not fit for the one, can never be fit for the other; and therefore genuine theory can never be cried down by any but the advocates for ignorance. I acknowledge we have had many bad theories which have done great mischief, but not more than we have had bad accounts both of diseases and medicines by professed empiricks. And against this we have no better antidote than a just theory:

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the more the springs of actions are traced in the body, and the more distinctly we view how every part is employed, we must be the more pointed and distinct in our observations of their disorders. But nothing is to be depended on which we have not seen in one shape or another; our guesses are never to be admitted as part of our observations; though often we are obliged to do the best we can this way, in dangerous cases, where we cannot get the evidence we wish for; and to evite it as much as possible, we repeat our observations. The great work is to bring to view, in the best light, what we would see, and then to transcribe it with accuracy; which requires no small attention and art, no less than what we find in the ingenious face-painter, who, before he begins to draw, is well skilled in perspective, in the doctrine of light and shade; and then, after he has drawn the outlines of his work, fills up every particular part with what corresponds in the archetype, according as his art directs: If he ventures to put any thing in of his own, he spoils the whole piece, and lies, while he publishes it as a transcript from nature. Here is required the piercing judicious eye to take a right view; an

eye trained up to direct the hand in transcribing; to give every part its due place, magnitude and shade, so as to make it appear uniform and just to the spectator.

If Physicians had entertained a just sense of this, their works would not have swelled to such an enormous bulk; and the few they published, like Raphael's paintings, would have always gained the applause of succeeding ages: whereas the small attention they have given, in examining and representing facts, has multiplied our theoretical and practical pieces greatly, without increasing our knowledge of what passes in the body: And thus it is that most of our medical writings are better fitted by way of ornament to our closets, than for the advantage of study; for amongst them the judicious inquirer tires himself greatly, and meets with little, quod tollere vellet, that is of value.

The primitive Historians would naturally fall a describing things as they found them; the meeting with something curious being the first motive that we can imagine should have enticed people of genius and fancy to describe: And thus
the

the first Poets and Physicians are reckoned to abound more with natural descriptions than the later, who seem to have taken the humour more to amuse and surprise, than to instruct their readers. It must indeed be owned, that in antient authors we sometimes find a mixture of romance joined with their better descriptions; and, if we were to admit all the pieces under Hippocrates's name to be really his, we could hardly defend our great Founder from having used too much liberty in his accounts of things: But as we find many things, amongst his works, done after the best taste, we would be very unjust to him to put to his account what is otherwise; especially after the evidence we have how unjust posterity had been to him, in crouding in their naughty pieces with his elaborate works, without any distinction of names. We have no less than five spurious pieces amongst seven, upon epidemics; and the two acknowledged to be his, have cases added to them, most of them quite foreign to the constitution described; which shews the bad taste of those who had the collecting of his works: Nevertheless we have undoubted examples of the genius of that great man, both in investigating and describing what belonged

belonged to our art : how exact is he, in the two books of epidemics which we allow to be his, in describing the diseases and their various courses, according to the seasons that accompanied them ? which Sydenham has imitated to so much purpose, making this reflexion upon the method, that when it is followed out thoroughly, the observer has very little trouble in inventing remedies, which is reckoned the most difficult part of our work ; for the history itself, if complete, gives the best indications of cure. And the whole remedies Hippocrates used, appear to have been suggested by such indications. But in chronical cases, where the humours were less concerned, and the changes did not shew themselves so much, nor did proceed with such constant and equal steps, he was obliged to regard Anatomy more, to satisfy himself about the parts affected ; their position, connexion, uses, and every other circumstance, as far as his industry and penetration could discover ; and from this he was directed in his management and indications of cure. So far is it from being true, that this great pattern, in cultivating medicine, slighted the theoretical part of it. And indeed I look upon his example in this to be of
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So much importance to form the taste, that I cannot give a better introduction to my Essays, than by giving some instances of the simplicity of his theory, and how it was wrought into his more practical pieces.

And this I reckon must be agreeable to you, dear Brother, by whose repeated advice and arguments I first engaged in the study of Hippocrates with any warmth; I hope thereby to give you a proof, that I have had some sense of the spirit of the author: And, if I have imitated his example in the caution and simplicity with which I have managed the argument in the following Essays, I shall not doubt of their being acceptable to such of our profession as are at pains to inform their judgment before they pass sentence. Nothing gives me more pleasure, than the obvious and simple account which Hippocrates gives of the periodical evacuation which the sex have so certainly upon their approach to their compleat stature. In a few words he tells us, in his book de genitura, that the uterus, by which this discharge is made, is impervious in the younger; but, increasing with the other parts of the body,
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it comes at length to have its vessels so much increased in bulk, as to transmit blood to its cavity. What more evident cause could be assigned for a phænomenon happening, so invariably, with the growth of the body, so necessary for the reception of a child? For I cannot shew any regard to that hypothesis, That, upon completing the growth, there commences a redundancy of the blood, according to Sanctorius, of a pound or two; which no other statical examiner could ever confirm; and which is contradicted by every fact. Nothing is necessary for the phænomenon, and all the symptoms accompanying it, but a patent way; and the more patent it is, the discharge is greater, and with less disturbance: And thus, in the introduction to his first book on the diseases of the sex, he acquaints us, that these who have born children, by which the uterus is greatly stretched, have the evacuation with less disturbance. And in the 15th section, there he tells, that the blood evacuated in that case, in a person in health, is as pure as that shed in sacrificing; so that it comes unchanged from the mass. These are simple and plain accounts, and quite agreeable to the phænomena. And as by this
account

account he appears to have been sensible, that the vessels of the uterus opened into its cavity; so nothing could be more natural for him than to entertain the notion, that it was into these very passages the placenta was ingraft; especially if ever he had had the opportunity to see the pregnant uterus laid open, as I had lately in a woman, who died suddenly in the seventh month of her pregnancy; where, in separating the placenta, I drew out its processes, to the length at least of half an inch, in great numbers, rising all over the placenta, some of them as thick as a goose quill; nay, over the whole chorion, fibrous threads, as small as hairs, arose and penetrated into the uterine pores; but in pulling out these of the placenta, they immediately shrunk in, and appeared on it something like the granulated surface of the mulberry fruit. How much would such a view have confirmed his notion? But suppose he never saw it in the human uterus, yet what is seen in cows, which could not well escape one of his diligence, must have made this supposition probable to him; and consequently, that any thing which rendered this ingraftment less firm, would contribute much to produce an abortion. And when he

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found

found that such as were subject to the fluor albus, were most subject to abortion: What could he infer from this, but that this very flux of humours prevents the firmer ingraftment? as he declares in aph. 45. lib. v. and that bleeding would put the woman in hazard of abortion, as he declares aph. 31. since its native effect is to make parts subside when more than ordinary tumid, as is the uterus when pregnant; though 'tis probable the too frequent bad consequences of it, when tried upon the weak, had brought him to be so positive in ranking it among his maxims. From the same view of things he had certainly tried fumigation, so well fitted to open the pores in obstructions; whose success he declares aph. 28. And an attention to the correspondence between the breasts and uterus, had made him conclude, that the placenta had yielded when the breasts suddenly subsided, as we find he did, aph. 37. and, in consequence of this observation, ordered cupping to the breasts, to divert the uterine hæmorrhagy, aph. 50. though bleeding would not in the weak, who are most subject to these hæmorrhagies: Nothing causing a more sudden relaxation of the vessels than bleeding, as is observed
by

by Duretus, in his glossary upon Hollerius de morbis internis, where he treats of this subject; Soleo sæpe dicere et crebris usurpare sermonibus (*says this great Student of Hippocrates*) quod dum menstrua quiescunt, si vena secetur cientur; atque ideo vereor de sanguinis detractiōe in gravidis mulieribus, non quod fœtus suo fraudentur genio, sed quia sanguis fertur ad uterum, unde citatis mensibus contingit abortus. *How different are these ways of judging in Hippocrates and Duretus, from that of our modern Plethorists, who having persuaded themselves, that neither exercise, abstinence, or evacuations can prevent the plethora, make the supposition, that every woman keeping regular must be always plethoric; and that in pregnancy there can be no better remedy than bleeding. And thus, in some countries, the Ladies of distinction are regularly bled, to prevent abortion; tanta prejudicata opinio potuit, ut etiam sine ratione valeret autoritas!*

I am far from imagining, that when one pregnant takes a disease which requires bleeding, that it is to be neglected: nor can any person imagine, that either Hippocrates or Duretus

could be such ill judges as to neglect it in these cases : But to make people use it with a due caution, it was just in the founders of our art to shew the native tendency of such an operation.

The whole I have cited from Hippocrates are plain and simple observations, agreeable to what is passing in the body, and to the mechanism of the parts, as we see them formed and connected, and in fact employed : And a small pains and attention to that great man's writings, would furnish us with more examples of this kind, than we are at first view aware of. We find, by his experiments, in his book de corde, that he laid himself out greatly in the anatomical way, to know the course of things ; and through his whole works we meet with instances of it, especially in the aphorisms, which to me seems the best digested of all his works, and wrote in imitation of the data of the ancient Geometers : They appear plainly to be a collection of the essential steps necessary to lead and guide us in the solution of problems relating to the diagnostics, prognostics, and indications of cure of most diseases. They are ingeniously

niously adapted to the Physician's use, to make him know the import of every thing passing with his patient, and to reduce into order what is irregular: How far what I have cited from them confirms this, I leave every one to judge; to me they give the greatest evidence, that Hippocrates's attention to the circumstances of particular bowels, assisted him more in forming his practice, than what a more extensive knowledge in Anatomy has done the moderns, who seem to deal too much in general observations. The mass of blood, the circulation, and some few of the fluids seem to me to have ingrossed their attention. The circulation certainly has great effects, as have the spirits or nervous juice, and many other of the humours; but these must be all ascertained after the Hippocratic method, if we would reap advantage from them. Our assertions concerning them must be made plain and obvious, agreeable to what every one may discover who examines into the phænomena and structure of the parts concerned with them, and must lead us directly to comprehend the irregularities attending their actions.

This

This has been my study in the following Essays, in explaining the animal and vital actions. The most obvious phænomena attending them have been altogether neglected in the common explications of them; and others advanced greatly out of the reach of our senses, and whose force is not at all explicable; nor is it easy to find how they should be serviceable in the practice of Medicine.

Nothing is more obvious than the changes I assert in the muscles when acting; nothing more intelligible, nothing more consistent with the powers of elastic bodies: This is not only evident in the more simple cases, where the muscles are employed, but in respiration and the circulation; in which actions, though all allow that the muscles have a great share, yet none of their accounts help us to understand the cause of their constant and involuntary acting in them. To explain this, we find nothing further to be considered, than what we said in general on the muscles, except the vessels through which the circulation is carried on, and the action of the perspiration in the breast; which is not an invention of mine, but has been more or less asserted

serted ever since the force of the air has been regarded; but never so well illustrated, till of late the Reverend Dr. Hales made a calculation of it, as shewing itself in his experiments. And many of the changes these actions undergo in irregular cases, offer themselves to confirm our doctrine, and seem to bring us to a juster view of some very considerable diseases, and to provide materials for augmenting our aphoristical maxims. But I shall not further insist upon my own opinion on a subject which I put into your hands to judge of, who will be sure to form your opinion as the evidence and weight of argument shall direct you: therefore I leave it to you to determine how far I have followed Hippocrates's example; how far I have been attentive to the most material phænomena, and viewed their dependencies. If I have in any degree attained to this, my thanks are due to you who first laid the plan, for pursuing my studies, before me, and recommended Hippocrates so warmly for an example, as one well skilled in all the literature of the antient Greeks, and animated with their scientifick spirit: permit me therefore to inscribe to you the following Essays, as a small testimonial of my sense of your favours,

vours,

vours, and of my affection. May you live long to reap the native fruits of the useful and delightful studies you have hitherto pursued with so much success.

O rectam sinceramque vitam! O dulce otium honestumque! ac pene omni negotio pulchrius!

I am most heartily your's,

THOMAS SIMSON.

ESSAY I.

Of Muscular Motion.

CHAP. I.

Of the action of the muscles, and what subjects them to the will.

IN this Essay I suppose what Anatomists have discovered, concerning the composition and make of the muscles, to be known; and therefore shall say nothing on that head; but begin to give an account of the motion I propose to explain, in some instances that lead us to a distinct view of the question I am to handle; the neglect of which, in philosophical inquiries, is often the cause of great mistakes and obscurity.

IN that kind of muscles we call *sphincters*, we distinguish three different states they obtain in the body.

A

1st, THEIR

1st, THEIR natural tonic state, or that state they affect and keep at by their natural vigour, when left to themselves.

2^{dly}, A state of distension beyond their natural tone, always owing to some force applied to them.

3^{dly}, A state of contraction beyond their common or usual tonic state; sometimes produced suddenly, by the irritation of some *stimulus*; or otherways gradually, by their own native force, when seldom dilated; from which cause I have found the *sphincter ani* contracted so closely, that with difficulty it admitted a clyster-pipe.

AND thus we find in these *sphincters* the ordinary changes elastic bodies admit of, *viz.* of being either dilated or contracted beyond their more ordinary state; tho' it is not easy to determine what is the middle state in any body, between the first degree of extension, and the first of contraction, or, when a muscle is in a state wherein we cannot call it extended or contracted. Nor do we suppose this middle state to be the true tonic state of the muscle, which always implies some degree of contraction, and must not
only

only in different persons be supposed different, according to their constitution, and strength, but even in different muscles in the same person, according as they have been exercised or composed originally: and therefore, by the true tonic state of the *sphincter*, or any other muscle, we do not mean any precise degree of contraction, but that state or degree of contraction it keeps most easily in the present state and situation of the body.

WE find two causes employed to dilate the muscles.

First, some antagonist muscle or muscles; as the extensors of the limbs extend, by their operation, the flexors, and *vice versa*; and the antagonists, every other where, mutually one another.

AND then, again, the hollow muscles, or *sphincters*, when not directly provided with antagonists, are distended by having some body driven into their cavity, which acts upon the muscle like a wedge; as we find those of the *anus* and *vesica* dilated; though many *sphincters* are dilated by muscles or muscular fibres, as that of the mouth
and

and *pupilla*, which therefore are allowed to be antagonists to them.

Now, whichsoever of these two causes takes place, it is abundantly evident, that they act by drawing or forcing the parts of the muscle they affect to a greater distance one from another, and so lengthen the whole muscle: And we find that all the muscles provided with antagonists, exert themselves in such a manner, that when any one acts upon its neighbour, so as in the operation to stretch it out, the one thus employed is contracted and shortened; as is evident in the arm, which, when folded, has the flexors contracted, while the extensors are extended: and when the arm is extended, these muscles obtain a contrary state; for then the extensors are contracted, and the flexors stretched; though in this case *Borellus* reckons the extensors relaxed; as he asserts, *prop. 139. de motu anim. part. 1.* where he illustrates these alternate states of the muscles; and insists further upon it, *prop. 5. part. 2.* where he argues, that the muscles do not act by their own native force, but some accessory strength superadded to them; and, among several other reasons, he adds,

Quia

Quia quo magis muscoli & eorum fibræ contrahuntur & decurtantur, eo magis flaccescunt, & laxæ redduntur machinulæ ex quibus componuntur: videmus enim machinam tunc maximam vim exercere, quando violenter trahitur, distenditur elongaturque, ut fides citharæ tensæ.

Where he plainly makes the *decurtatio* to be a *relaxatio*, contrary to the plainest observations: for in that state in which the *sphincters* are for ordinary, if we apply any cause to stretch or distend the muscle, we shall find a resistance to the power we apply. And certainly it is by this force the *sphincters* do their duty; which shews, that in that state the parts are firmly knit or compacted together, and require some force in order to make them quit, in any measure, their intimate cohesion, so as to yield to any degree of stretching. Indeed, when stretched, the force by which those parts act upon one another, becomes greater and more apparent. The greater separation of the parts, while their union is not dissolved, gives them a greater latitude to act; and makes their spring to be more bended for it, as in the bow; but when allowed to act in this state,
and,

and, by their action, to recover their more compact and firm state, to reckon then the muscle relaxed, seems not at all proper, except we allow contraction and relaxation to signify the same thing ; whereas a little attention must make us sensible they differ greatly : for example, in the earth-worm or leech, which, like the muscles, are now stretched, now contracted, how improperly should we say, that any of them, in their contracted state, are relaxed, when we see their parts furled and knit together with that degree of energy, which reduced them from the more dilated to the more contracted state.

INDEED, if the muscles, in their contracted state, have any *stimulus* applied to them, and, by its irritation, are made to knit and contract their parts closer together, than they commonly are by their own energy, and, upon withdrawing the *stimulus*, have returned again to their more ordinary state ; I would call this last action of theirs, whereby they returned, a relaxation ; it being so, in my opinion, in a very proper sense ; and is the only case where a degree of relaxation obtains

obtains in a state of health, as far as I can find, the returning from a state of distension being very different from it, and what we call the contraction of a muscle.

HAVING thus illustrated the nature of the three different states I find the muscles capable of, and sometimes assuming, I readily agree with *Borellus*, that the muscles make no observable sudden contraction, till once by force they have been stretched beyond their natural tonic state; as he observes in the proposition last cited. But then I cannot agree with him, that the *actio musculi vitalis non fit vi propria contractiva machinarum fibrosarum*, as he expresses it. It is true, the ordinary force they exert is not sufficient to do all we find them do, to lift and support the great weights we find them engage with. But then, I maintain, they can exert a much greater force, when stimulated or irritated, without the accession of more fibres than they had, or any matter to give these more strength. All that the *stimulus* does, is to make them exert the strength they had. It answers to the corded bow which strikes the fiddle-strings, as we shall shew more fully afterwards,

afterwards, and makes every one of their compounding parts exert themselves in the production of sound ; or, if you will, it is like friction to the electrical body, which calls forth its latent powers, and adds nothing but motion to the matter it contained. And this the *stimulus* cannot do to any purpose before the muscular fibres are stretched, as *Borellus* observes ; and in proportion as they are so, still the more. This stretching raises the spring or elasticity of the fibres, as much as that of the archer's bow is by being bent, and gives them a latitude to contract : and in this case the irritation makes the whole elastic force discharge itself ; as letting loose the string by which the bow was kept bent, at once makes the combined force of every particle in the bow shew itself in producing one uniform stroke or impulse. And what other advantage can we imagine the muscles should gain by being stretched, in proportion to which their force increaseth ?

MR. *Cowper* seems to have had a just sense of this doctrine, in treating of the use of the oblique muscles of the eye. He easily satisfied himself, that the four straight muscles, being

ing much stronger than the two oblique, would keep themselves in a contracted state when not employed, and thereby occasion the oblique to be kept stretched to some degree: so that, as none of the straight exert themselves in that contracted state, wherein they have no latitude to move, he therefore reckons that the use of the oblique, is to pull the eye forward by their contraction, for which they are always found ready stretched, and thus put the four straight upon the stretch; in which case, the mind has an opportunity to make any of them act as she pleases, while she no way affects them in their contracted state.

AND how much would it have cleared the doctrine of muscular motion to us, if he had given the same use to all the antagonist muscles, which certainly they have? The stronger in a natural easy state, when not employed, are left contracted; but the weaker antagonist stretched, which, when brought to contract by the instigation of the mind, does necessarily stretch the stronger, as we noticed above with *Borellus*; and therefore, in fact, one part of the muscles of the

body are contracted, and another kept upon the stretch ; so that the mind cannot directly move all, these which are already contracted being out of her jurisdiction, but are brought under it by means of their antagonists.

WE need not then be surpris'd, that we cannot move the *sphincters*, which have no antagonists in their ordinary state, which is a state of contraction. This the mind cannot do to any muscle, in that state, more than to such *sphincters* ; but if we will try her power over them, when dilated, as they are when any thing is passing them, then we shall find that she can contract them at pleasure, as she does other muscles when stretched.

How unadvised then have those people's labours been, who, overlooking the state of the muscles themselves, have searched for the cause of voluntary motion amongst the obscure recesses of the brain ? In my apprehension, the mind has immediate access to the muscles and muscular fibres, and, in producing of motion, affects them after the same manner with a *stimulus*. No place in children is more secure from the influence of
the

the mind, than the *uterus* and breasts; for in them these parts are not liable to be stretched; but as in menstruating women they are often on the stretch, so then every *stimulus* and agitation of the mind affects them; and, as they are still more stretched in child-bed, they are then still the more easily affected by the same causes. Thus, any violent passion will put a stop to the *lochia*; and a drop of cold water falling upon the body in that situation, will, by the *stimulus* it occasions, produce the same effect.

IN general, whatever parts are made to contract easily by the irritation of a *stimulus*, the same likewise are easily contracted by the mind. This is evident in the case of the heart; which, with every piece of concern, is made to throb and flutter: nor is there any part, even out of the body, that is more easily irritated. How then can it be alledged that the heart is exempt from the power of the mind? I own that the mind is very far from having the absolute direction of its motions: but when we come to speak of respiration, as we shall then shew, that this has a great share amongst the causes which promote the motion

tion of the heart ; so it will be easily understood, why this bowel is not wholly in the power of the will : for then it will appear, that respiration is chiefly carried on by causes which are no way concerned with the muscles, and to which the mind has no access ; and consequently that the heart so much influenced by the respiration, cannot be altogether under the direction of the mind, no more than the respiration itself.

Thus it is evident, that the mind can act upon every muscle, and not command them altogether, when under the power of other causes ; and that they are as easily affected by the mind, as by any *stimulus*. The being dilated, is the evident preparation in the muscles, which makes them so readily answer to any irritation, whether from the mind or some material *stimulus*.

AND this observation lets us see, why most of the muscles are provided with antagonists ; for, the stronger muscles keeping the weaker always in some measure stretched, by this means we have the command of every member that is necessary for us to employ : and the whole body is a curious machine, most artificially

artificially provided with pulleys, whereby to guide and direct its motions ; all of them in so happy and advantageous a situation, that the mind, by its nod, makes them exert their strength, as well as any, whatever, *stimulus*.

AND what more than this disposition of the muscles can be judged requisite in accounting for voluntary motion ? In any instance where the mind employs the members of the body, nothing else appears necessary. Thus, as the *stimulus* increases, so does the force of the machine : for as the weight is which is sustained by the muscles, so is the *stimulus* ; and as is the *stimulus*, so is the contraction of the muscles ; and consequently the force or strength of their action (which is no other but the reacting of the stretched parts in proportion to their being stimulated, which law they have in common with every elastic body) : so that the force of the machine increasing with the weight, the mind has no more to do, to raise a greater weight, by means of the muscles, than a smaller ; and therefore there is no necessity to suppose any new matter to accede to the muscles to accomplish this.

BUT

BUT the force whereby the muscles exert themselves, not only arises from the degree to which they are stretched, or what may be called their latitude of contraction, and from the degree of irritation, but from the natural texture and firmness of the parts. Thus *Richard Goy*, whom *Baglivi* gives account of, in his letter to *Peter Hotton*, had rather the strength of a horse than a man: and whence came this? *Baglivi* tells us his limbs felt like marble or steel; he further observes, that the fibres of a lioness he dissected were gross like spun fiddle-strings, and would scarce yield when pulled; whence he justly accounts for their strength; and herein agrees with the judicious *Van Swieten*, who, in his commentary upon *Boerhaave's* articles on the robust fibres, says, "*quo firmior est fabrica, et*
major elasticitas vasorum laterum, eo validior
est nixus."

THE muscles, then, in a live body, are nervous elastic pulleys; and according as they are more or less elastic,—as they are more or less firm and compact,—as they are more or less stretched,—and as they are more or less
 irritated

irritated by some proper *stimulus*, do always act with more or less vigour.

THE elasticity of the muscles is indeed the foundation of all their force. But, in explaining muscular motion, it seems no more necessary to inquire into the cause of this elasticity, than in explaining the regular and uniform motion of a watch; which takes its first movements from the spring, though its wheels and balance must regulate them: nor is it necessary, in our comments, that we see whence this elasticity ariseth in the muscles, more than how the wool first gained it, of which they make *Duncaster* hose. The workman finds that the wool has originally a great deal of it; that, by twisting it, it gains more, and still more by the particular form in which it is wrought, though he never considers how it is acquired in any of the processes.

AND what a lame account would he give of the firmness and energy of his work, should he tell us its elasticity comes from the spirits of the sheep, though perhaps the wool, first nourished by these, had its first energy from them; which, at the same time, we are by no means able to explain. So that, I say,

say, it seems altogether needless to account for the elasticity of the muscles, or to trace how they have acquired such a power of being stretched, and of rebounding with more or less force as they are stimulated. This is a power we find attending matter in a great many different forms, and what we ourselves trust to in the composition of many machines, whose nature will not change, whatever account we give of elasticity. And thus we find whether *Dr. Stewart's* account of elasticity, or *Bellini's* should hold, that it would be the same as to our account of muscular motion.

Dr. Stewart, in his lectures on muscular motion, reckons, that, by stretching any elastic body, the fluid particles environed with the solid parts, from being spherical, are compressed, and made spheroidical against their natural inclinations; and that, as soon as the compelling force is suspended, their natural powers exert themselves, and reduce the compressed fluid to the spherical form again; and, with them, the distended solids regain their ordinary compactness. *Bellini* and *Sanctorius* supposed the action to depend upon the solids themselves; these, by their account, being

being so disposed that their smaller particles can slide over one another, without losing altogether their contact; and that, in this case, they are under great restraint, by the influence of the parts they left exerting that attraction, by which the particles of bodies are kept in union; and, therefore, when left at liberty, they bounce back to their place again, or, as *Lucretius* has it,

Se ipse in se trahere, & partes conducere in unum.

IN both these accounts, we find the elastic power is supposed lurking in the parts of which the bodies themselves are composed; and that it is the stretching whence they gain the advantage that enables them to exert themselves, without the accession of any new matter to join them in the operation. And as we have shewn that the muscles undergo such a preparation, before they exert their powers, we reckon we have established the fact, which is the true foundation of muscular motion; and this fact gives us so clear a notion of the condition which subjects the muscles to the will, that it adds not a little to the beauty of our theory, which, we hope,

shall be increased by what we have to observe on the action of *stimuli* and the mind ; to which, as a necessary preliminary, we prefix the following chapter.

IN the mean time, I shall put an end to this, by observing, that it must follow from the antagonist position of the muscles, that, in their greater state of indolence, the stronger muscles can only keep contracted by a degree of contraction equal to that whereby it exceeds the weaker. Nevertheless, this state of indolence is not what we chuse to keep the muscles at, when we chuse to rest after fatigue : for then we keep those contracted, which under the fatigue had been most on the stretch. And thus, as *Borellus* observes, *prop.* 143. *part.* 1. when we are obliged to stand long; we do it sometimes on one foot only, which eases the muscles long on the stretch : and we sleep with legs and arms folded, after having them in another posture through the day ; so that sleep rather allows a vicissitude to the active muscles, than a state of perfect rest to all. But the heart continues well, or suffers no fatigue, under a perpetual motion ; because while moving,
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it is as much in the contracted state as the distended; and therefore recruits by moments, what the others do by nights; and thus care is taken that the heart should not be too long on the stretch at a time; which *Æsop* long since found to be fatal to elastic bodies.

C H A P. II.

Of the connexion amongst the muscles, muscular fibres, and membranes by which most of the irregular motions in the body are propagated.

THE nerves having been depended on as the great instruments of sense and motion, Physiologists, in accounting how pain, and a variety of motions, spread themselves from place to place, have contented themselves with pointing out some alliance or other amongst the nerves distributed to these different places; tho' they never took the trouble to know, what the connexion is between the fibres of the same pair of nerves, which should make two places suffer at once from

from it ; or to determine why only two or three, and not all the places served by these nerves, suffered at once when any of its branches were attacked. Perhaps, if the Physiologists had carried their speculations a little further, they would not have been so well pleased with their theory ; since the rise of the nerves, and the different *fibrillæ* making them up, is very obscure, and the source of the bundles we call pairs, seems often as various as the branches themselves ; which must render it not so easy to find where the connexion should ly : nor would it be less difficult to explain how motion of any kind should be propagated along parts the least elastic and moveable. Apprised therefore of this, one ought to try, if there are any more probable means by which such sympathies may be established. The Anatomist is the proper person to guide us here, as in all our searches into the animal œconomy ; and I am confident, that what he has already laid before us, would be an advantageous thread to conduct us, did we carefully attend to it.

Thus we find, that all the membranes of
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the brain are not only closely connected together, but that the chief of them, the *dura mater*, with all its various processes, are in the most stretched state; as Mr. Winslow observes, The large process of the *dura mater*, the *falx*, which, for some depth, divides the *cerebrum* into two lateral portions, is attached for some length at its posterior end, crosses the diaphragm (which separates between the *cerebrum* and the *cerebellum*, and involves the upper surface of this last part as a cover), and keeps it so stretched, that it can support a considerable weight without being depressed; but flattens immediately upon the *falx* being cut through; as this turns loose upon flitting the diaphragm. And as these parts keep one another quite stretched, so likewise they keep stretched the whole *dura mater*, whose processes they are; and all its other processes, not only running variously through the substance of the brain, but by a variety of passages to the external parts of the head: so that by them the whole face, ears, and eyes, &c. are greatly affected, or made more or less stretched, though, by their own structure, they are greatly so; as appears by flitting

ting

ting any part of them in a live animal ; for the wound in that case becomes very wide, and gapes, and thereby discovers how much their parts contract when left at liberty : and the same happens all over the surface of the body ; so that every part thereof is stretched in a natural state. And as it receives portions from all the neighbouring parts, which contribute not a little to its composition, we cannot but be sensible, that this general medium of the skin is greatly fitted for making a sympathy amongst all the parts of the body.

Now, to form a notion, how and what parts are attached to the skin, we must examine the observations on that head : in making which, the accurate Anatomist *Steno* has been very diligent, in his treatise *De pisce carcharia dicto*. He says, *Ex demonstrata tendinum in cute insertione evidens est, quid de membrana adiposa, de membrana communi musculorum statuendum ; voluere plerique esse hæc involucra communia corporis, sed nec panniculus carnosus totum corpus investit cum id generis cutanei muscoli, qui huic pannulo occasionem dedere, tantum in quibusdam locis conspiciantur ; nec membrana adiposa aliud est, quàm adipis col-*
lectio

lectio sita inter prædictas tendineas fibras à musculis in cutem abeuntes ; nec membrana musculorum, communis dicta, unica est membrana, sed ubique tendinum à diversis musculis prodeuntium membranosa expansio, unde fibræ in cutem recedunt : patet inde quid de aliis multis membranis statuendum, scilicet non semper esse illas tunicas partibus vicinis per immediatum contactum firmiter adherentes, sed esse illas persæpè iisdem ferè continuas ob fibrarum à tunicis in partes vicinas, aut à partibus vicinis in tunicas transitum, &c.

THIS we shall exemplify afterwards, in another treatise, from some of the best and more modern authors, where we treat of the coats of the eye : and as it is now fully shewn, that the *tunica adiposa*, as it spreads with the skin, sends off processes, not only between every distinct muscle, but round every fibre of a muscle, so it is manifest, from *Steno's* observations, that the tendinous expansions of the muscles spread with it, and are the constituent parts of it : and thus through the whole body, there is intermixed with very small interstices one continued piece of network, firm and upon the stretch, made up of
tendinous

tendinous fibres, and closely connected with the skin.

THE diligent *Wepfer* found a like connexion in tracing the course of the nerves, as we see in his 8th chapter *de cicuta aquatica*; where he has the following paradoxes. *Primum est ventriculi & intestinorum fibras, addo etiam cordis & omnium muscutorum nihil nisi nervos esse aut proximè ad illorum naturam accedere; certè si quis persequatur cum solertia quadam nervos, musculos subeuntes observabit nerveas fibrillas arctissimè uniri, in unum corpus coalescere. Et licet nervus, musculum transiens, non omnis in illius fibras impendatur; id tamen in vicinis musculis fit, atque eo usque progrediuntur, donec tandem in membranas, adæquatum tactûs organum, absumentur, hacque ratione terminentur.* Which I reckon will be allowed the same connexion that *Steno* attributed to the tendinous fibres; as these terms, of *tendinous* and *nervous* fibres, are very promiscuously used by Anatomists. And what *Wepfer* immediately adds, confirms our assertion. *Non hoc cuiquam absurdum videatur, quod nervi corpora mollia; minusque tenacia sunt præterea minuta, ut hanc ob causam impossibile est tot fibras*

bras in tota corporis fabrica constituere ; molles esse nervos intra spinalem medullam, ut cæteros quatuor sensibus inservientes præteream contentos ; indeque elabentes aliquousque, ultro fateor, at paulo ulterius progressi non solum tenaciores, sed & crassiores evadunt, alicubi ganglia pro majore robore, indultu naturæ beneficæ asciscunt.

By this observation, it would seem, that the nerves are not perfected by the brain, but that they receive additions and a different mould and tempering before they are wrought in amongst the other parts, and assume more the appearance of fleshy fibres, than they had originally ; and thus are gradually assimilated to the other parts of the body, amongst which they are lost ; and, as they pass from part to part, carry along with them portions of the parts thus touched at ; and therefore these compound fibres may be termed tendinous or nervous, as we please ; only let us sufficiently attend to these alliances and connexions, and consider the intimate union that is caused thereby amongst the parts ; and we shall find a better handle whereby to explain their sympathies, than from their having branches from the same pair of nerves.

THIS author, a little before, in the same chapter, had given many other instances of remarkable connexions. *Gula*, says he, *non ita libere transit per diaphragma, quin potius undique superne gulæ, prope ventriculum mediante membrana, cum peritonæo communi connectitur; insuper à diaphragmate reliquo ubi gula illud permeat, filamenta et membranæ nerveæ arctissimè uniuntur, et ulterius aliquosque exporriguntur, atque etiam fibræ ventriculi rectis potissimum coalescunt.*

Lancisus, in his dissection of the heart, finds that its proper membrane is nothing but a piece of close web-work, woven from the detachments which the fibrous parts make, and therefore calls it *tendinea*, as if it were a common tendon to the whole. But not only does the heart send detachments through its own cover, but along the blood-vessels arising from it; and thus the strictest union is amongst all the parts of the body, and no place can be violently affected, but the neighbouring parts must be variously teased and rack'd by it. And thus, if you touch one part of the membrane, the whole is agitated in every fibre: but, besides this general connexion,

nexion, particular parts have particular dispositions for affecting the neighbouring parts.

No Anatomist is ignorant of the manner the membrane of the ear is stretched for vibration, by a fixed *veētis* and muscles to manage it, as are the other bones which at last terminate at the membrane of the *foramen ovale*; whence a vibration is carried through the *labyrinth*, as we shall afterwards shew. And *Valsalva* shews, that the cartilaginous parts of the *eustachian* tube, which is kept fix'd while the muscle of the greater process of the hammer is on the stretch, becomes moveable upon that muscle's contracting, when left at liberty, by the *membrana tympani* being pressed in by the air; and upon that, his new tubarian muscle, hitherto upon the stretch, acting upon the cartilage, dilates the tube by its contraction; and thus the moment the external membrane is touched, the tube gapes, and gives way to the vibrations of the internal air, to increase their force, and make them more distinct.

NOR has Mr. *Ferrein*, in the Memoirs of the *Paris* academy for the year 1741, made it less evident, that there are two tendinous chords

chords along the selvage of the *glottis*, which the actions of the muscles and cartilages of the *larynx* guide and tune, by whose vibrations the voice is formed in all animals: the muscles which raise and spread the *velum palatinum* are always on the stretch, till the tongue is drawn back in swallowing; and then of necessity they must contract, and the more that the *uvula* is irritated by the *bolus*.

AND *Sanctorinus* (art. 17. chap. xi. of his observations) finding, that by blowing air into the uterine tubes, their loose extremity turned towards the *ovarium*, made no improbable conjecture, that a *stimulus* of the vessels turgid on the aphrodisiac transactions, would have the same effect, especially as he had discovered fibres well fitted for the operation.

THE animal machine, then, is so composed, that there is scarce a flexible fibre in it that has not either a sufficient latitude to contract, or that cannot be brought into that state immediately by the action of such as have a latitude; and then these fibres have such a communication, that it is easy to trace their dependence one upon another, from head to foot, by their immediate connexions:
and

and if to this we shall add the power of *stimuli* upon them, we must be sensible that there is not a more moveable machine in the universe than the animal body. And this we propose, from instances, to illustrate in the following chapter.

C H A P. III.

Of the effects of different stimuli on the animal fibres as we have described them.

AS there is scarce an instance of any kind of matter but what can propagate sound; so we may conclude, that there is scarce any but what has more or less vibration when touched advantageously. Mr *Boyle*, in his treatise of languid motions, observes, that there are some bodies, such as bell-metal, which, when put into certain forms, cannot be touched without vibrating or founding more or less; as he found in a strong bell, which was heard founding when touched with the point of a pin only; and in other cases

cases that sound was propagated by very unpromising mediums, as he found by a small striking watch, whose sound was heard and felt through a gold case, the closest of all metals, a shagreen case, and the cloth of his pocket, or whatever else intervened between that and his ear; and how much more are the animal fibres fitted for such vibrations and the communication of such motions?

NOR are there experiments wanting to shew it. Apply a vibrating fork to the teeth, crown of the head, or brow, and the ear shall be greatly sensible of it; so that bones, membranes, and variety of other animal substances, can be touched so as to propagate a vibration. And according as they vibrate, they raise an infinity of different sensations; of tastes, smells, sounds, colours, &c. nor is it to be doubted that every part receives a different shock, as the twitching them varies. Nor is the smart of the shock, or the degree to which it extends itself, proportioned to the force or violence with which the cause acts on the place to which it is applied; for *Wepfer*, in the eighth chapter *de cicuta*, observes, that many cancerous sores, which
consume

consume all about them, produce neither spasm, nor convulsion, nor any great agitation amongst the parts; of which we have an instance in the case of Mr. *Kay*, in the *Philosoph. Transact.* which, beginning in his face, consumed the eye, destroyed a great part of the *os frontis*, *dura mater*, and the whole of the brain, without causing any spasm or disturbance in the other parts; tho' such an effect is sometimes produced by the gentle titillation of a feather, or the tickling of the smooth fingers upon the sound parts of the body; and Mr. *Boyle* tells us, that he was threatened with convulsions from the hairs of his peruke lying on his face when he could not move his hands.

THERE is then a certain way of teasing the well adjusted fibres, which produces the spasms, and makes the convulsions spread. And in this the energy of *Wepfer's* hemlocks seems to have consisted: for, at the time they caused the most terrible spasms and convulsions through the different quarters of the body, they did not act in the stomach with so much violence as the tobacco did; which produced a vomiting, and threw out the roots.

roots. We may compare their singular virtue to that of the small stones which break the *Bononian* glasses, though gently dropt into them, when things much rougher and heavier have no such effect, nor yet the severest blows. *Vid. Institut. Bonon. tom. 2.* A very simple case occurred to me, to illustrate this doctrine. An old woman, who had one of the tusks of her upper jaw hanging loose, by a single fibre, was struck to distraction with the twitches it gave the neighbouring parts; for whatever touched the tooth, immediately struck her in upon the nose; whence a violent pain ran up its ridge, then up the brow, over the middle of the head, down the neck and spinal processes of the back, till it came near the last of them; when the pain was so excessive, that it confounded all her senses, and left her for a moment in a kind of swoon. This had happened for a month, as often as the tooth was touched, till I was sent for; when, by snipping the fibre, I secured her against the process; wherein the spirits could have no share whilst the pain ran cross so many different parts of the body; several ways strictly connected, though

though by no alliance of nerves. Mr. *Reaumer's* account of the striking fibres of the *torpedo*, shews how much they are fitted to cause vibration; each of them is divided into so many small sections by parallel membranes; between which lies a pulpy elastic matter; so that when the longitudinal muscular fibres, making up the sides of the compound fibre, contract, the pulpy matter is compressed, and thus prepared for action; which immediately takes place on the contraction being suspended; for then the parts compressed bounce out with such a smart shock upon the finger touching it, that at once the pain flies up the arm a good length, and causes a most direful sensation, and terrible force, on the chain of particles composing the muscular fibres; so that, for some time, they are benumb'd, and in a manner deprived of their elasticity; not unlike what happens from the shock of electricity, which strikes the member meeting the flying electric matter, either by itself, or combining with those sulphureous emanations, perpetually rising from the body. But, however that may be, it is plain, the manner of the

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shock is that which produces the smart upon the joints, where the muscles which are agitated by the shock are inserted. What is it that makes a person with shattered bones, or even fibres ruffled by wounds, not only gall'd, when lifted, or roughly handled, but that they cannot bear the vibration of the air, from the discharge of cannon, or otherwise? as Mr. Boyle observes in the treatise mentioned, Nothing certainly is more susceptible of motions of all kinds, than the fibrous parts of our body, tun'd and stretched for that purpose, and which occasionally meet with a great many odd dispositions; but none more remarkable than in the case *Van Swieten* mentions, which I shall set down in his own words, from his *Comment. on Boerhaave's Aphorif. vol. 1. p. 35.* *Memini me curasse nobilem puellam qua in nervoso genere nobiliorem nunquam vidi: à minimo sono, à lumine vividiori convellebatur illico, miros motus cum lacerationis sensu in abdomine sentiens; nec ferulacæi succi, nec salutare in his casibus, castorei virus proderant, dum autem fasciis, crura, femora, totum abdomen ad mammas usque firmabantur, remisit statim molestum malum; & datis*

tis dein idoneis remediis, convaluit : per menses tamen sic, instar mummæ Ægyptiacæ, ferè fasciis circumductis vixit ; haud invita cum illico tantum inde sentiret solamen. Now, can we suppose that these bandages interrupted any flow of spirits by compressing the nerves ; in which case they would have done more ill than good, since it would have interrupted both sense and motion at the same time ? But, that they could prevent the small irritation of light or sound from spreading the fibrous agitations in a body very susceptible of them, without any bad effect, is very consonant to what happens in other vibrating bodies, whose vibration is stopt by the interposition of any other body pressing upon them. We have many instances of spreading agitations from the extremities all over the body. Who is it that has not found small blasts of cold air on his legs, when warm, immediately raising spasms or gripes in the belly ? and their continuance makes the intestines exert themselves more, with the muscles of the abdomen, than the strongest purges can do ? as we find by Dr. *Stevenson's* observations in his paper in the 6th volume of *Medical Essays*.
Galen,

Galen, and several other more modern authors, have observed remarkable spasms rising from the very toes to the several members of the body ; and have had observable success in diverting them by ligatures and issues near to the different sources ; as *Tulpius*, in one arising from the big-toe, *chap. 2. lib. 4.* and *Dr. Short, Medical Essays, vol. 4.* from the leg, which had subsisted for a dozen of years together, and which he cured by cutting a small cartilaginous tumour from a nerve, as he reckons, seated pretty deep. I know in these cases it is ordinary with *Tulpius*, to reckon that, though the spasms rise from the under parts, and spread up to the higher, yet most of them are to be derived from the brain. But what is the necessity of this, when we find that they can spread from parts at such a distance up to the brain ? Can we not allow, as in the case I mentioned from the tooth, that they spread from place to place, as they ly contiguous, and are tun'd for it, till they spread over the whole body, and even penetrate to every vessel ; since we know a connexion amongst the parts favouring this, according to what we observed in
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the former chapter. The vapours from the part mentioned by *Tulpius* are quite fancied, and could have no place in the case of the tooth, or that mentioned by *Dr. Short*; both of which shew, that it is not the destruction of the nerve that is so much to be pursued in these cases, (as *Van Swieten* would have it, *Comment. in aphorism. 234. Boerhaave*), as the taking away the *stimulus*: for in the case *Van Swieten* speaks of, the convulsions spread over the whole body, as soon as the irritation reached the region of the heart; and, in the case of the tooth, it passed the head to the back before the swooning. *Wepfer* is very explicit on this head, about the middle of the 8th chapter *de cicuta*; where he says, *Quidam ut hanc compassionem (nervorum scilicet) credulis obtrudant, maxime in convulsione universali seu epilepsia, partium distantiorum læsione subsequente, præviam in nervorum origine dispositionem & apparatus causæ morbificæ comminiscuntur; quidam inde aliquid vitiosi à parte ægra cerebro transmitti opinantur; verum citra apparatus morbificum, circa originem nervorum, epilepsiam excitari aliquando hinc manifestum sit, quod sæpe hac corripiantur, quoad cerebrum & cerebellum*

cerebellum sanissimi; sic adurit illa quosdam à punctura nervorum, morfu viperarum; infantes corrupto lacte & pultibus in ventriculo & intestinis; eandem excitant quoque lumbrici, venena quædam in ventriculo subsistentia, nec ejus pomæria egressa: deinde illa sæpe tollitur causa morbifica ex parte primariò affecta sublata, nullo vel exiguo ad cerebri roborationem habito respectu; vel medicamentis præcipuè ad illius curationem directis. Novi juvenem quendam rusticum ab epilepsia satis truculenta vindicatum fuisse, à vesicatorio toti pedis dorso applicato. Unde symptoma hoc tragædiam ordiri persensit. And, after some further examples, concludes, Communicatio causæ morbiificæ, ejusque ad cerebrum transmissio in multorum ore est, plerisque de viis & ratione qua illuc transportetur, non usque adeo sollicitis.

THIS whole chapter of *Wepfer's* is a true anatomical explication of what we are upon, and confirms greatly, that there is scarcely a part of the body whence an universal disturbance may not arise; and practical authors abound with examples, tho' often not sufficiently attended to; whilst the head is the part only regarded in the cure, and renders the cure
very

very uncertain : whereas we find a well-placed blister, bandage, or incision, to compose the greatest disturbances. The truth is, that often the greatest severity of the scene, does not appear at the seat of the cause, but in some neighbouring part more susceptible of disorder ; as it is often in the gravel, where the stomach and intestines seem most to be affected, and often carry the investigator's attention from the true cause. I was called to an old Gentleman subject to colicks for thirty years, but who never was suspected of the gravel, till I satisfied myself this was the case, from some less observable symptoms, and managed him accordingly the two last years of his life ; though a violent fit at length carried him off, in an advanced age. On opening him, for satisfaction to the friends, we got a stone of 4 ounces in the kidney, worn down to a membrane ; tho' no disorder had ever appeared about the urinary passages. On *November 2. 1748*, I was called to a person under one of the most moving cases I ever was concerned in : A young Lady, in the night-time, was wakened by a slight touch of a colick ; but then a tickling harsh cough
took

took place, which made her force her breathing with the most violent concussion ; and continued so, till convulsions spread themselves over every part of the body, and in turns affected them all ; so that there was not a finger or toe, but was twisted and agitated to such a degree, that she required several people to secure her from destroying herself under the force. During two months we were sure she had not swallowed four ounces of any thing ; for the moment it touch'd her tongue, she was convulsed and tossed, till she swooned away ; nor had she any rest all that time, except some momentary naps, sitting and supported by her friends ; nor for six months more got she any thing but spoonfuls of some weak drink, and that seldom without being thrown into the fit ; till at length she began to pass great quantities of gravel of the softer chalky form ; few of them any thing smooth in the surface, but look'd like the fragments of a large stone that had been beat in pieces with the stroke of a hammer ; for some of it appeared like coarse oat-meal, though a great deal of it was as big as small pease ; and, together with
these,

these, she passed a kind of earthy clay, which spread like plaister on the paper wherein it was put. This continued for some weeks, and she grew daily better, having some days interval, and quite free of the fits; which to me gave a full view of what had so long tossed her. What was observable in her case was the apparent changes the seat of her trouble took; for sometimes the cough ceasing, she had only contractions in her gullet, which threatened to suffocate her; and when these urged severely, she would have pointed with her finger to her arm, she wanted to be bled, and, the moment the lancet pierced the skin, she was relieved; as we had occasion to see by repeated instances. At other times, it took its seat at the stomach with the most terrible pain at the *cardia*, and vomiting; which never ceased, till the severe cough urged her again: some time after, it seized her side, so that it gave her the utmost pain, and threatened suffocation. I applied a blister; and on this it returned to her throat again; nor left her till the lancet was in her arm. Now, what change in the spirits could the putting the lancet in her arm make,

that, in the same moment, her gullet should be relieved thereby? or what change in them did the blister on the side produce? If it should be demanded, what connexion between the arm and the gullet? I answer, that, in persons with such moveable fibres, when they are running together into spasms at any one point, by twitching them in another, the course comes that way, and diverts the pain from the other point: and thus such people have the most quick and sudden fallies of pains, now in one part, now in another; but the gullet seems to be a favourite place, where they frequently centre from every corner. A Gentleman of my acquaintance, greatly subject to these flying spasms, uses to have the attack on the *fauces*, *larynx*, and *pharynx*, so severely, that he alarms all about him, with a fear of being suffocated; bleeding generally broke the force of it, but left him so weak, for a very long time, that he shunned it as much as possible; and then trying volatiles of all kinds, the moment they touched his jaws, his disease was worse. After these observations, I took another method. I kept him sitting in the easiest posture

sture he could chuse, and did not allow him to move hand or foot, or so much as his lip: the trouble wrought down to his feet, and left him sooner, though it was not less severe, than what it had been in most of his fits. I gave orders conform to *Van Swieten's* method, who kept all the parts bandaged, to prevent these fallies.

I am not surpris'd, considering the quickness with which these attacks are made upon one place after another, that some strange fallies of the spirits were suspected for it, by *Willis* and *Sydenham*, and most of the Physicians of this age; though I think it is more natural to suspect, with *Tulpius*, and many others, that certain vapours made the shock; especially when the progress was from below upwards, as often happens. But, when the connexion and disposition of the fibres are considered, and how easily they are irritated in some cases, an attention to those seems to give much greater satisfaction on the head. And thus in my gravelish patient, who was of a delicate make, it will be easily allowed that such a collection in her kidneys was a terrible *stimulus* in such a tun'd machine; though

though she had not time or thought left her to attend to the progress her trouble made; her senses being quite suppressed in the catastrophe. But in other cases, where the persons are not so quickly struck, they observe the progress distinctly; as *Van Swieten* describes, in § 234. *aphor.* in a case he saw, and has often occurred, as we formerly observed; two of which I myself witnessed: *In digito majori, says he, pedis sentitur titillatio quædam, ac si formicæ reperent per partem; ascendit ille motus per crus, fæmur, abdomen, ad præcordia usquè; tunc mox cadit convulsus toto corpore.* And to confirm the course is this way, he observes, with those we formerly cited, that the progress is stopped by ligatures. Can any examples prove more clearly that the brain or nerves are no way here concerned? That convulsions arise likewise from the brain, I am fully satisfied: but then I am no less, that it is after the same manner that they arise from these lower parts. The fibres, which are greatly on the stretch here, as we have described them in the former chapter, allow to be easily touched, and must greatly propagate their

their vibrations; which *Baglivi* has confirmed by experiments, *de fibra motrice*, chap. v. *Si dura mater à dextra pungeretur in omnibus ferè partibus, convulsivi motus excitabantur, in ea præcipuè vehementissimè in qua ipsa pungebatur; sic etiam si pungeretur à leva: generaliter tamen labefacto post meningis puncturam tono, confusio incredibilis in partibus omnibus infernis, tam sentientibus quàm se moventibus nascebatur, primò quidem in capite, deinde in reliquis.* And thence, a little after he concludes; *Inde demum convulsiones, quæ in hominibus graviter capite vulneratis excitantur, in corporis partibus quæ directè vulnere respondent:* so that the convulsions, from irritation at the brain, follow the course of the membranes from the part affected; whereas in palsies, arising from contusions in the brain, the paralytic parts are on the other side, from the contusion or fracture; as innumerable instances shew; which is owing to the nerves crossing the brain, in order to make their *exit* in an easier and straighter course. The palsy, then, deprives the parts of their nourishment, by the injury done the nerves. But convulsions are immediately raised

fed from irritation of the membranous fibres upon the stretch; and as at one time some fibres may be more on the stretch than others, so a *stimulus*, at different times, must shew its force in different courses; and thus it is, the *calculus* in the kidney, *ureter*, or bladder, does not make the pain spread always after the same manner, but according as the fibres are disposed at the time; as the fiddle, which played on, only moves the one tuned unison with it, though many others are equally exposed to its influences.

THERE is nothing more frequent, among our practical observations, than cases where contusions of the head produce vomiting, and again, where disorders of the stomach produce disorders of the head. This I know is ordinarily accounted for from some correspondence amongst the nerves going to the stomach, and those reflected to the *dura mater*. But how much more rationally it is accounted for upon my principles, seems pretty manifest. That there is a constant course of fibres from the stomach up the gullet, and over all the *fauces*, *membrana cellulosa* arising thence, and spreading to the muscles of the face,

face, sockets of the eyes, and *dura mater* as well as to the *pericranium* externally, is uncontested; nor are any parts more upon the stretch than the *dura mater* and its processes: so that we cannot be surprised to find that the first motions to vomit are accompanied with a remarkable vertiginous confusion, while the medicine has been but a short time in the stomach. Many who are more easily affected in the stomach, have this confusion from weaker warm drinks, as tea, especially with honey, which is very apt to fret the stomach and intestines; as I found in a valedudinary Gentleman, who, going into his chaise, after a breakfast of such things, turned very uneasy in it, from the *vertigo*. I being called, and inquiring into his breakfast, easily accounted for the disorder, and secured him against a return, by changing his tea for coffee without honey. Some people are the same way affected from bile in their stomach, or even an empty stomach, when their fibres are very bare and exposed: and hence the charm *Hoffman* makes use of for such as are subject to it, of eating a little bread and butter before they rise in the morning, which I have known

known used to good purpose. But the stronger collections of bile are sometimes able to produce epileptic fits; of this, in my dissertations, I gave an instance, where the fit was preceded by an observable *vertigo*; though at that time I imagined the bile immediately affected the nerves themselves; but the nauseousness spreading through the gullet to the jaws, discovers fully the progress, as the remedy shews the seat of the *stimulus*; contusions and lacerations of the *pericranium* and *dura mater*, spread their disorders again to the stomach, which settle upon fomenting the parts irritated, as we find in our daily practice: and of which *Wepfer* has given instances amongst the practical observations; and *Ruyfch* in his anatomical observations, N^o 60. So that thus weakening the tenseness of the affected fibres, the irritation makes no progress: for, as there are no membranes more bent and firm in the body, than the *pericranium* and *dura mater*, with its processes; so their irritation must propagate disorder to the greatest distances; and since the organs of seeing, and hearing, ly so much exposed to their action, no wonder that from it we
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have such confusions in both these senses; as likewise in the course of the blood under all their ailments; since both the vessels which bring in the blood, and carry it out, are quite involved with these membranes. And hence all the most frightful appearances, and death itself, so commonly attending the disorders of the head: whereas we find that the substance of the brain itself is taken out in spoonfuls with little or no feeling, as we might expect from its want of elasticity and consistence.

WE see, then, by the most manifest examples, what fits the muscles, and muscular parts, to be wrought upon by *stimuli*, and how various these are in their nature and effects; all which attended to, easily account for these connexions and sympathies we see amongst different parts in their sufferings; whereas the reasoning upon this head, from the nerves, is both unintelligible and arbitrary; as there are few nerves in the body, but what you may find have some alliance or other with some other nerve. But more of this in treating of the brain; and, as to some other of the more distant sympathies, we shall see

one considerable rise of them from the mind in the next chapter.

I shall end this, with observing, that the state of the muscles which fit them for action, and their manner of acting, seems to have been obvious to most of the more attentive expositors of the animal œconomy. As to Mr. *Winslow*, who, in 46th article of sect. 3. gives the following *phænomena* accompanying the action of the muscles: the fleshy portion of the muscle then appears harder and more swelled, and the more so, the more they continue in action; nay, it increases by merely adding to the weight or resistance of the part moved; and the motion may be increased, diminished, accelerated, retarded or stopped, and may be made to cease in an instant, and be produced again as quickly; and, during the contraction, the fibres are observed plainly knit, and furled up zigzac-ways, as all painters draw muscles in action. This, I think, should have led him to see plainly what the action of the muscles was; a more compact knitting together of the longitudinal chain of particles, in each fibre, of which the muscles consist, which swells it in the middle,
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and hardens it at the same time : but the quickness with which this was done confounded him, and he could find no agent in the body sufficient for it ; yet we see a simple *stimulus* affects all ; and, as we said, even out of the body, the applying it to any one fibre, makes the whole muscle knit at once, and furl up ; what more quick ? what more efficacious ? And therefore it is manifest, the make of the muscle is contrived so as to be wrought upon in the easiest and most simple manner. Allow then the mind to act in this simple way as a *stimulus* ; and we find that no new disposition in the muscle itself is requisite : by its native make, it is pliant to such an agent, which is all the Anatomist and Physiologist have to observe. And to this reasoning nothing adds more strength, than that we find the increase of the weight increases the contraction. This is a plain increase to the *stimulus* ; for we perceive in a living animal, that the weight irritates more and more the muscle or muscles supporting it, the more it is increased. But as this will be the better apprehended, after we have considered the part the mind acts, we shall not
infirm

insist on it longer here. But I shall conclude this chapter, with observing, that nothing illustrates this doctrine more, than what *Winslow* has observed in the last pages of his treatise on the muscles, and Dr. *Crawford* in the last volume of *Medical Essays*; where they shew, That a just regard to the muscles employed in all the different motions of the body, is necessary in order to investigate, not only the seat, but the nature of the pain under diseases; muscles often having pains very different from what is purely vascular, under their tonic motion, or when in a contracted state. Thus, these who fix the *scapula*, if overstretched and broke by a bruise, or any other cause, cannot allow the action of pronation or supination; for to do this, the bruised muscles strain to put themselves in action, and fix the *scapula*, and thereby quicken the pain; which the ignorant Anatomist is apt to imagine flows some how from the arm, whose action produces it; whereupon, as *Winslow* observes, some recourse is made to indeterminate ideas of some communication between the nerves and vessels of the fore arm, and of the shoulder; which would
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make them suspect obstructions in the vessels, or irritation or strain in the nerves, &c. and, on this foundation, would order the application of remedies to the parts answering to those vessels and nerves; and after a great time employed in the cure, the disease must cure of itself, or perhaps increase and occasion disorders of a worse nature, if not death itself. Thus concluded Mr. *Winslow* against those who went in search of obscure causes, when the knowledge of the co-operation of the muscles would have been a right director to them in their practice. I had a case which confirms greatly what Mr. *Winslow* observes: A young woman, much subject to the *cardialgia*, was seized with rheumatic pains, under which the right shoulder was affected; the *cardia* suffered so much at the same time, that she could not swallow down the least drop of any thing, without hazard of suffocation; and the moment it reached the *cardia*, she cried out, to hold her shoulder-blade, which then had the most acute pain, and, by getting it kept firm, she swallowed with greater ease. What is the connexion between the *cardia* and right shoulder? None at all.

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But, upon shrinking up the shoulders, under the pain of the *cardia*, as we do in most of the quicker pains, the right affected at this time suffered greatly, and was made secure against the pain, by being kept firm. But as the mind was an agent here, such instances come more particularly to be considered in the following chapter.

C H A P. IV.

Of the part the mind acts in moving the muscles.

HOWEVER obscure it is in what manner the mind exerts her faculties, and wherein her being subsists, and in what shape she occupies and is confined to any certain space ; yet, as long as we allow thought to be that wherein her power and strength consist, and whereby she discovers herself, we cannot be at a loss to judge when she interposes in any action.

AND, if we allow contrivance to be the result of thought, we cannot well refuse that all complex machinery, where the different
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parts conspire to produce, by their conjunct operation, some common effects, is most certainly the product of a mind; and that the instruments employed to finish it, when necessary, are all under her direction. But in what manner our mind makes the machinery, reared up by another mind, exert itself, according to the powers lodged in her, is what we have no comprehension of, even at the time we make her exert these powers.

It is not to be expected then, in our present undertaking, that we concern ourselves with those questions, which, by all the more sober writers on the animal œconomy, have been shunned. What we propose chiefly to consider, are the conditions which make the body answer the commands of the mind most easily; and again, the circumstances which seem most to add to the power of the mind in commanding it.

For finding these out, little more is necessary than to give such attention to the state of the muscles, in their action and preparation for it, as to view what real change they undergo at that time.

AND thus, when considering the *sphincters* in their contracted state, and examining them, by thrusting our finger into their cavity, we find, by the resistance they make, that they are not then relaxed, as *Borellus* argues, but in a state wherein they are corrugated, and have their parts knit together; which is most different from relaxation, and what is justly opposed to the stretched state, to which those of *Borellus's* opinion would oppose the relaxation, though this never takes place except in a diseased state.

AND from this it appears, how unjustly the muscles are reckoned to be inflated when protuberant upon the corrugation. This is no more than an accumulation of the parts that were carried diffusively asunder when stretched; and therefore, to prevent mistakes, should be called a reduction of them, in opposition to their former state.

WE have a most evident example of this in the *uterus*, which dilates to a prodigious extent under pregnancy; and then, when free, reduceth itself to its former compactness, in which it is hard and firm. To suppose this reduction done by an inflation of its
fibres

fibres from an accession of some fluid, when diminished so far, when so firm and compact, would be equally absurd, as to suppose it relaxed, contrary to all our senses.

NAY, there are no muscular parts, if left long in the contracted state, without being sometimes stretched, but acquire such a firmness, that they allow not to be easily stretched again ; or, if you force them to it, they suffer the greatest pain in the operation ; and thus the flexors of the limbs, left long in a contracted state, as they are always when folded, acquire a great rigidity, and must be gradually lengthened out again, by proper means ; which shews how far the muscles are from being relaxed in their contracted state.

AND thus it is that parts daily used are easily moved, and more pliable to the causes which affect them, than parts seldom employed ; and therefore it is, that every tradesman has certain muscles he employs, with ease, in his own business, while he finds a tiresome pain in attempting the work of another, which requires the application of other muscles. As we said in our first chapter, then,

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the contraction is the native course the muscular parts run into, while the stretching or dilatation is never obtained in a sound body, except by force ; in the *sphincters* wanting antagonists, by forcing some body, different from the muscle itself, into its cavity, and, in the other muscles, by the help of antagonists.

AND thus, as most of the muscles are designed for instruments to move the different parts of the body we employ in the affairs of life, there are about 500 of them which have antagonists, that is, which can be employed mutually in stretching their fellows ; and only a few of the *sphincter-kind* left without such helps : nor, in the affairs of life, do they need them, since such of them as have no antagonist, can do no service, except when contracted, or, when they have some fluid perpetually at hand which serves, as an antagonist, to dilate them, when their dilatation is necessary, as in the case of the heart.

THIS view of the muscles, makes a plain discovery what situation they must be in before they are employed in any action ; they must, more or less, be put on the stretch, which,

which, in every case, is done as mechanically as we bend the bow, by means of the cord, before we make it exert any force.

NEVERTHELESS the mind, the great agent which employs the muscles, has no notion of the situation of the muscles when she employs them, nor has she any concern about them. It is the action they perform which she proposes; and the smallest degree of an inclination for it, the least act of the will, makes it effectual. Thus, when the arm is folded, and, in that case, we would lift up a weight, the first thing we do is to stretch out the arm, which is done by the extensors, and thereby the flexors are stretched, which are to raise up and support the weight; and this the Peasant does as certainly and expeditiously as the most expert Anatomist. The mind, then, regards not the instruments she employs; instruct her in the action she is to do, and she, by assenting to it, and proposing to do it with herself, accomplishes the same, if within the power of the muscles to accomplish, without any knowledge of the muscles she employs.

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AND thus, if any disposition in the stomach, or the touch of the lips of a child, gives such an inclination to suck, as to make it desire the action, it can be no more strange to find it so readily and neatly exercising that action, than to find it sometime after pursuing, with its eyes, a moving light it has a satisfaction in looking at. In both cases, the simple volition gives it the command of all the muscles necessary to the action.

AND the same way it is, that, in performing a multitude of the most different actions in course, to do it regularly, we want only to have the course made familiar to our imagination, or to have some prompter to direct us in it, and then we go through it as expeditiously as our imagination can follow it.

THUS we reckon, that the address we acquire in walking, dancing, fencing, writing, &c. is more the improvement of the mind than body: by our lessons in these arts, we fix ideas in our minds of the postures necessary in every part of the performance; and as we become more ready and exact in conceiving these, we perform them the more expeditiously and neatly. If we suppose all the parts then equally pliable, as a little use
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makes them, we perform the most complex motions, where the greatest variety of muscles are employed, with the same expedition we do the more simple, when the ideas of the action are equally simple: thus we turn about a wheel, as easily as we move our finger backwards and forwards; and make the fingers in both hands move towards or from the thumbs, all at once, most easily, while we find difficulty to move them one way in one hand, and the opposite way in the other, not from any difficulty in the muscles, which move equally easy to both sides, but from the diversity in the thought, which requires a much greater attention. After the same manner, in viewing any object placed aside, the two eyes are turned by very different muscles; yet it is done with the greatest expedition, because we propose one uniform action to view one object: but if we should place a like object on the other side, and would try to turn an eye to each at the same time, we would find great difficulty in it, not from any opposition in the muscles employed, which move alike easily to both sides, but from the attention requisite to regard two objects,

objects, in such a situation, equally at once : and thus beggars, among whom different pieces of money are thrown, do not run so expeditiously, as they would do to one piece only, from their attention being divided. What intricate and various successions find we in the action of the muscles, and how many act at once, when led by music ; which points out to each its particular part, and leads them uniformly on in the same course. The book lying open, has marks chalking out the road distinctly, and the mind, copying from it, directs the fingers, in the most various courses, along the keys of the harpsicord ; the head and legs join in concert ; the active eyes make the first movement, and the ears are always attentive, examining every step, for which their muscles are ever active : thus almost the whole muscles of the body play, as it were, at the same time ; especially if the player adds fingering to the spinet ; which he has no difficulty to do, and that without any opposition from interfering muscles : all is lead by the same thread, one established tune, which is equally the director, whether marked before the player, or fixed in his memory.

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WE see, then, what a variety of muscles, placed at the greatest distances, concur in the same action ; and that they are never refractory in any action, when the mind is distinct and positive in her commands : and thus the country-dances are carried on, by the direction of music, with the greatest harmony. But, confuse the fancy, by making it follow some aukward irregular course, without a director, and we will be at a loss as to what we are about, and as to the muscles we are to employ, and bungle, in the performance, like frightened sailors in a storm, flying from rope to rope to little purpose : thus we find whence the expedition arises, in moving the muscles, and in accelerating or retarding their motion. Nor is there a muscle in the body employed to keep the equilibrium, but what the mind is directly present with ; for the weight of the parts they support hanging upon them, when the natural balance in any instance happens not to be preserved, gives the mind a sensation that lets her know her duty in the case ; and thereby she is directed how far to reduce the muscles, to wit, till she finds no weight. And as the parts, when poised,
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give the muscles the least stress to retain them in their place ; hence in general the muscles bring them as much as possible to this : but as there are many parts, which, in their natural situation in the body, are not equally poised by their own weight, such as the head, as it is set on the first of the *vertebræ* ; therefore there is an allowance made for this in the muscles : thus, for moving the head, the *erector* muscles are made vastly stronger than those which bring the head forward, and by that means keep the head straight, without great uneasiness : but when the mind is inattentive, as under drowsiness, the head falls forward by its own weight ; and thus shews to us, that when kept straight, it is by the mind's presence, and actually keeping the *erector* muscles contracted by its *Fiat*, as it must do most of the muscles of the spine and inferior limbs when we are standing : so that then the mind actually attends and plies a great variety of muscles, and is led to it by a greater or lesser sensation of pain, which is the conductor to the mind in this case, and fixes her attention to the place where she is to act, though in very different corners ; which
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she would not do so readily, if she had been to project where to apply the instruments, without a monitor, as well as to execute; both which she must do, when she would attend to two different objects at a distance from the body by two distinct organs; which would require a management to be got only by attention and practice; as some people write, and dictate to a writer, and converse, at one and the same time; which requires practice and strength of mind.

AND as the mind is engaged to apply herself, by the uneasy sensation, where-ever it obtains; so, according to the degree of that uneasiness, she exerts herself more or less vigorously; as is observable in a woman in labour, whose expelling muscles act with more or less vigour, according to her degree of pain; a *tenesmus*, or a suppositary, can procure a discharge, which we cannot of ourselves produce; a touch of the spur or whip makes the horse walk firmly, who is apt to stumble; and, in lifting a weight, we make the muscles exert more force than they can do under a less sensation of uneasiness: and thus people are often reckoned to

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act above their strength, and in fact have been found in the effort to do violence to the muscles, by the irritated mind, and occasioned inflammations, strains, &c. Dr. *Mead*, in his accurate treatise on the poison of the mad-dog, tells us, he saw a case of a mad-man, who, by one effort, broke at once all the cords he was bound with, and immediately died paralytic, as if all the fibres of the body had been overstrained, says the Doctor, and torn to pieces. It happens often, when riding, that, upon our horse's stumbling, we exert such a force by our limbs, while we cling to our horse to save ourselves, that we raise the most uneasy cramps; so that, under concern and surprize, we exert a greater muscular force than possibly we can do in cold blood. And we read, in a late transaction of the Royal society, of one *Axford*, who, after the loss of the use of his tongue for four years, immediately recovered it again, in straining violently to cry in a frightful dream; which procures credit to the story of *Cræsus's* dumb son related by *Herodot.* And thus it appears, that the mind when cool and under passion acts as differently upon the muscles,

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as the different *stimulus* of water only warmed and an iron made red hot.

THE whole of our doctrine appears manifest in the case of the *uterus*, which, as we observed, is a muscular part which allows of the greatest distension, and changes its state often after puberty. This bowel, when not distended to any degree, as it is not for some time after the periodical discharge, is as little affected by cold or passion as any in the body; but when the discharge is at hand, or not completed, in which case, its vessels, and with them the body of the *uterus* itself, are distended to some degree; then a drop of cold water on any part of the body or any degree of surprize, raises the greatest confusion, and prevents or stops the discharge; which shews that surprize, or the passions, and a *stimulus*, act the same way upon these parts under distension, as we have said before: this is still more evident in child-bed, when the distension of that bowel is greater; for then a much less *stimulus*, a much less surprize, stops the *lochia*, and produces all the bad consequences attending it.

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By which both the analogy of the operation of a *stimulus*, and that of the mind upon the muscular parts, appears; and likewise that they act the easier, the more the part is distended on which they act, agreeably to *Borelli's* account: and, in many cases, there is such a concurrence of *stimulus* and the mind, that it is not easy distinctly to determine the share each of them has in the action. Thus, when we find the *pupilla* of the eye contracted, upon our facing a greater light, we are apt to imagine that the *stimulus* of light, acting immediately upon the circular fibres of the eye, produceth it; whereas, a small skill in optics may satisfy us, that where the *focus* forms, there the *stimulus* is chiefly felt; and that this sensation induceth the mind to contract the more stretched parts about the eye, to exclude the offending cause. And thus the dilated *pupilla* and eye-lids are contracted: both these parts were dilated and stretched before the accession of the light, and therefore became obsequious to the mind.

WHEN the *anus*, bladder, or *os uteri*, are irritated, if no other part but the *sphincters* exerted themselves, there would never be any discharge

discharge from such a cause ; but, as the *stimulus*, immediately applied to them, causes a stronger constriction, the mind, in opposition to it, reduceth the diaphragm, as much as possible, and the muscles of the abdomen, at the same time ; though, for ordinary, they act alternately, and thereby push open the *sphincters*, and set off the *stimulus* by a superior force : and if any *stimulus* acts more violently, the mind, to overcome its force, musters up all its strength, and, with violent convulsions, tries to get rid of the enemy. What strange convulsions are raised, when a crumb of bread or drop of water falls into the *glottis* ? Not only the diaphragm, and other muscles assisting in making a full inspiration, act at the instigation of the mind, but immediately after it a full expiration is forced by her, as now all the muscles subservient for it are on the stretch, and thereby she studies to carry off the *stimulus* in the greater current of the air : nay, shoulders, arms, legs, and head, though of little effect in the *nifus*, join in it, and shew themselves concerned when the œconomy is in hazard of being overturned.

FOR thus it is, that, in greater cases of danger, the mind herself, being confused, acts precipitantly, and is not confined, in her operations, to what is altogether necessary. Nay, in frights and surprizes, as when alarmed with a thunder-clap, she acts upon every moveable part, and thereby, instead of helping herself, her feet shake under her body, and cannot support it; and most other parts are convulsed; the heart palpitates, and shews that the mind has access even to its hidden retreat; for there is no moment wherein either the auricles or ventricles of the heart are not in *diastole*, and, consequently, may feel the effects of the mind when acting confusedly in the body, under a general consternation.

THE heart, then, like the other parts provided with antagonists, is greatly under the influence of the mind when distended; and that we cannot affect it, when the mind acts coolly, can be owing to nothing but its being under the perpetual influences of other causes, (as shall be shewn when we treat of the circulation) and by them dilated and contracted so quickly, that the mind has scarce time deliberately to interpose; though often,
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in other cases, she does interpose so insensibly to herself, that she reflects not that she has done it. And thus, though every man has the composing of his own features, and assumes a certain posture to his body; yet ask the most of people, and they will refuse they ever had any concern in it; nor does the Philosopher know it, except by a train of observations, which he compares and sets together: He thus finds out that his demure thoughtful air, so different from the *charlatans*, was of his own acquisition as much as the apish turn of the other's face was of his. Nor is it less certain, that the ecstatic devotee, the furious rake, and intriguing politician, have acquired their features, by their ways of thinking, which always have certain muscles, in active form, attending them as their satellites.

THE Philosopher's eye look mostly inward; the devotee's look to heaven with concern; the politician's stare at others at the time he dwells with himself, and therefore has a great mixture in his look; the rake has always the pert oggle in his countenance; yet none of them have the muscles in view which they exercise in their different deliberations.

BUT

BUT as the subject of our thoughts is either some metaphysical idea we suppose existing within ourselves, or some object placed without us, which we can view with more or less freedom, and must attend with some particular address; hence insensibly we fall into the posture most suited to that address; and thereby every person, according to his more ordinary pursuits, acquires a certain mien; though the bulk of people acquire more of this from imitation, from the mien and carriage of those with whom they converse most: and thus, our language, accent, and different phrases, the manner of walking, looking, &c. become peculiar to towns, counties, and nation; the mind, according to the ideas of any action raised in her, more or less performs the same; and as the same action, in different persons is performed by the same instruments, hence it is that certain muscles become conspicuous, and give the same cast to the person's looks and mien, guided by the same examples.

IN a word according to the ideas the mind entertains, however she has got them, she works upon the body. How are we raised
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with prosperity ! how depressed with adversity ! it is ordinarily said in these cases that the spirits are raised or depressed : but in fact it is the mind herself ; for the thoughts are the first things concerned ; and, in consequence only to their disposition, the body is disposed. What is the consequence of the Mathematician's falling upon some agreeable medium to solve some knotty problem ; the mother's meeting with an only son, after many years absence, amidst a course of dangers ; or the covetous man meeting the ore in the mine, where he had buried his estate, though they had been long silent ; yet now the *Eureka* meets the ears of all their acquaintance, and no liquor could have given them such a chearful look, such elocution, expression, and flow of words ? they grasp the hands of all they meet, and fly while they walk ; every aching and pain leaves them, and their blunted appetite now has an edge ; their parched jaws flow with moisture ; nor is there any stop in their breathing. But how contrary is the case of those who have been greatly disappointed ! a flat pulse, forced breathing, dull countenance, interrupted sleep,

achings and feebleness in every joint; and thus the mind most certainly produces in the body effects most similar to those produced by a good diet, exercise, and the generous glass; which for ordinary keep our machinery in trim: and the countenance of a Physician often cures diseases by itself, and may sometimes kill.

It may be justly demanded of the Physiologist, whence this power of the soul over the body?

If once we could determine what was the immediate cause of the disorder, removed by the soul, we should, I reckon, have some prospect of determining the part the mind acted in removing it; and nothing can so much help us to find this out, as a thorough acquaintance with the animal œconomy: for since the question is, what raised, or more or less curbed, some action of the body, or made it difficult or painful to perform it, we must certainly know the instruments by which that action is performed, before we can judge what makes them pliable and easy, and what in any shape disorders them.

UPON

UPON this account it is, that the regular Physician, in tracing what makes us tired or unwieldy in our motions, always examines into the state of the muscles; and, in disturbances in the circulation and respiration, he examines into the state of the instruments employed in carrying them on: for these actions cannot be changed, but in as far as the instruments change in their manner of acting.

BUT it may be said, that as every instrument of motion is animated by the spirits, hence it is that the mind has nothing to regard but them; as they flow, the instruments act.

THIS might be allowed, if the mind was concerned in nothing but the raising or retarding the motions of the instruments; but if, while she does this, she shall at the same time be found to raise a great variety of sensations, as many as are raised by all the different foods and drugs we use, it is not easy to conceive how the spirits, unchanged in themselves, but only more or less accelerated in their motion by the mind, should accomplish this.

AND

AND this power of the mind in raising sensations, and with them the consequences that attend them, is past all contradiction: The sight of an orange gives an agreeable taste, and causes a discharge of the *saliva*: the sight of a vomit or purge will produce the effects which ordinarily attend them when taken inwardly: bread pills, taken with a confidence that they were mercurial, have procured a salivation. Mr. Boyle tells us of a friend of his who set off his urine upon seeing a top run, and of a *Gascoign* Knight who did the same when the bag-pipes played. By all which, I persuade myself, it must be admitted, that there is scarce an action performed by any kind of *stimulus*, but what can be copied and performed by the fancy, or a strong idea of what effects a *stimulus* has produced. I would therefore ask, whether or not we can suppose, that the fancy operates upon one part, and the *stimulus* upon another?

IN our account of the action of *stimuli*, I reckon, I made it evident, that the difference of their operation was from the different way in which they agitated the fibrous parts

parts to which they were applied; and in this sentiment, I think, I follow the opinion of the more judicious of our profession.

Is it not then a natural question to demand, whether or not the fancy, which is led by these *stimuli*, or the notion of their operation, acts upon the same fibres; and, by affecting them after the same manner, produces the same effect?

OR, shall we suppose, that the fancy neglects the organ the other instruments work upon, and applies itself to certain subtile fluids in the brain, and sends them to affect the organ?

IF this last case shall be maintained, then we must allow, that this fluid which we reckon the same in every nerve, as it is touched variously, touches variously the fibres where they land, causing a salivation in one case, vomiting in another, purging in a third, &c. and upon the same sense, produce sweetness, sourness, bitterness, &c. Indeed one and the same bow, upon the same viol, gives us great variety of sounds; but then it is when applied to different cords or different parts of them, or with a difference in the application; which

which changes cannot take place in the spirits confined to their fixed canals, and must land with the same mildness we allow them in the brain; which in no case allows them to act as *stimuli*.

WHEREAS the fancy acting differently upon the same fibres, is agreeable to the powers we have always allowed it; to affect them in a way conformed to the ideas imprinted upon it, which must change as the *stimuli* change whence the ideas arose.

THE question is distinctly this, whether or not we shall allow that the fancy applies herself to the same organ, in making it act after the same manner the *stimuli* had done? for example, if, by taking a bit of orange into our mouth, we bring into it a flow of agreeable moisture, whether or no shall we allow, when only, upon seeing an orange again, the same flow happens, that it did so from the same organs being immediately affected by the fancy in a similar way with the touch of the orange; and thence conclude, the fancy, by its energy, which is so strong and various, accomplishes on the fibres whatever the *stimuli* can do? That it is so, may be made obvious
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to the eye itself; for if you hold a bit of an orange before a child, who uses to be fond of it, and make him gape for it, and then examine his tongue, you will find the organ of taste greatly affected, all its *papillæ* erect above the surface of the tongue, and his mouth filled with moisture; so that you may reckon he has tasted it before it comes his length. And thus we are forced to acknowledge, that the fancy has not only a very certain access to every fibre in the body, but, by having the idea of any particular effect produced by the *stimuli*, does, in fact, make them repeat the same, by its instigation.

THE *stimuli* are thus the touch-stone to discover what are the proper organs for such and such effects, for taste, nauseousness, vomiting, &c. and when other causes, besides these *stimuli*, produce the same effects, to reckon they are applied to any other organ, is to give up the strictest analogy by which we can, and ought to judge, and to leave ourselves without all rule.

IN all these cases it is the strong idea of the effect that leads the fancy, which never concerns herself with the instruments she employs

pleys to accomplish it; though, in every case, we have plain evidences that there are proper instruments for these effects, and that she produces none of them without their mediation. May we not then admit it as a certain and established law, that there is no action that the machinery of the body can accomplish, but what the fancy can make them produce directly, if once she has got a distinct idea of the action?

THAT it is so in the actions we perform by the more distinct muscles, we reckon we have put beyond all question; and that we have a like command over every fibre, capable to be agitated by any *stimulus*, we have given some of the clearest instances; and by them are led to judge of one step the great Author of nature has taken to move us to the particular actions he designed us to perform: he has taken care that for that purpose, on occasions, the idea of the action should be strongly impressed upon our imaginations. The touch of the lips of an infant, new-born, raises in it an idea of sucking, or the inclination to grasp, squeeze and draw with them; and this is attended with
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the exercise of all the muscles necessary to perform it: certain views, certain feelings, and certain smells, excite to venery in different animals, according to the ideas nature has made to attend these sensations; which should make us less surpris'd at what otherways would seem altogether incredible, that the sight of a person deeply coloured in a jaundice, should presently produce that disease; of which I knew two examples in women with child. So that the idea of the colour produced the disease in persons who knew not the seat of the liver, where the change happened, on which the disease did immediately depend: that the sight of such a colour, disguising the whole body, should have influenced the biliary ducts, so as to force back the bile into the blood, is nothing more surpris'ing to me, than to find an infant, tho' blind, repeating the words pronounced in its hearing; what is the connexion between the sound and the organs employed to form it? In no case do we want the idea how, or by what instruments the action is to be done, but purely of the effect that they are to produce, and, by thinking on this, the in-

struments exert themselves, and produce it.

AND thus the fancy often produces great effects against the person's will; as when it turns him sick upon the smell of a tar-rope, which brought to his mind the sickness he had long been exposed to a-ship-board, where that smell predomined; or vomits on sight of white wine, or purges on smelling rhubarb: the idea of the action makes it take place, whether the person wills it or not: and hence the foundation of *Sydenham's* observation seems easily accounted for, That the hypochondriacs are men of genius, if we make the sentence convertible, and assert, that men of genius are hypochondriacs, to wit, men of ready fancy, who pass most in company for men of genius; for such having once felt pain, can easily create it anew to themselves again, and that without design: and, by neglecting pain, or using some diversion to carry our thoughts from it, or by reading our good fortune in the Doctor's face, and thereby satisfying ourselves that we labour under no material trouble; by getting free of the thoughts of it, we actually get quite of the trouble itself.

AND

AND the Physician sometimes finds it a successful stratagem, to free his patient of a pain that has fixed itself, to raise a greater at some distance from it; being fully satisfied of the justness of *Hippocrates's* observation, That the greater pain extinguishes the lesser (*aph.* 48. 2.) by carrying the mind from it.

THUS, to divert a toothach, Dr. *Heister*, in his *Practice of Medicine*, proposes, as an approved remedy, to apply a blister on the joint x between the *humerus* and cubit on the same side; and I have known it often applied to the knob of the opposite shoulder with success: in which cases no connexion of nerves, no derivation of humours, can be suspected as the cause; for when the blisters begin to ruffle these joints, and before much humour has got vent, the inflammation leaves the jaws, greatly encouraged by our attention. And thus in the patient we mentioned before, when her throat was greatly contracted, the scratching the arm diverted the mind and contraction at the same time.

AFTER the same manner we find the sensories, agreeably touched, greatly divert uneasiness and pain; the wearied and faint are recruited,

recruited, while the flavorous wine is yet in their mouth, and sometimes even by its smell; the imagination carries it to all the limbs long before its stream has reached them, and its known influence is thus repeated: the view of agreeable fields gives vigour to the countenance of the sick, and spreads their wholesome look to the most hidden recesses of the springs of life; whereas the sight of our neighbours fears, brings a load on every limb, directs our fancy to their sources in ourselves, and makes the heart to throb. In a word, the charming our sensories has such an influence upon the mind, and its composure, and delights; such an influence in composing the disorders of the body, that in this view, the sensories, in conjunction with the mind, may be look'd upon as the tempering key, which tunes aright every part of the machine. I own it is difficult to conceive, how the rays of light, reflected from a pleasant field, and made to strike upon the organ of vision, should so much animate the whole system; and that other rays, striking the same organ, should have a very different effect; but that it is by the mediation of the mind,

I persuade myself, every Philosopher is now satisfied: and therefore we must allow, that the mind, according to the ideas raised in her, however acquired, acts upon every member, and every fibre; and thus does either disorder or tune them; while it is quite surprising to us, how the various, and scarce sensible, touch of any of these organs, should so variously affect the mind, and the mind so variously again affect the fibrous parts.

WE find that it is easy to calculate what the regular muscles perform when they are made to exert themselves: their position and attachments determine this; and while they exert themselves, we likewise have found that all their parts run closer together. This we see a *stimulus* does directly; and when the mind produces the same effect, it is but just to reckon she does it by the same means; tho' we cannot conceive how the mind touches so as to irritate like a *stimulus*. This is all the mystery! and as no Philosopher has pretended to explain the action of the mind upon matter, in any case, we must be allowed in this respect to stop here with them: to explain this was no part of our undertaking.

OUR

OUR undertaking was to shew the facts, what the mind did in the body ; and to follow as far as we could the disposition of the parts that made the mind obtain the command of them.

NOR could we find a better rule to judge of her power, than first to find what different *stimuli* did ; for as this shewed the things to be practicable, so we found the mind likewise could perform them ; and that it was reasonable to judge that it was by means of the same instruments.

EVERY different word requires the use of different muscles to apply differently the organs of speech : this is done in every nation, however different their language, by children, who do not so much as know that they have peculiar organs destined for that use : and even children born blind speak by the ear, by which they have distinct ideas of the different words pronounced in their hearing ; so that the idea how a word is sounded enables them to sound it over again ; whence this judgment of the fancy, or the mind, in applying herself to the organs so much to purpose, in these cases, is not easily to be investigated ;

stigated: we attempt the thing confidently, and it is done; much as the paralytic man did in obedience to our Saviour, after fruitless attempts for some time before. Nor seems the thing to be void of mystery, however common, that the mind should thus so readily combine the muscles necessary to produce any given sound, whose variety can scarce be defined by numbers. And I cannot give any further account of it, than what I have hitherto given, that the muscles are so subjected to the mind, that when she willeth any thing in their power, they directly perform it, if in health. A distinct hearing, makes a distinct and easy rehearsing: and the mystery in going through all the varieties the different words of different languages require, is no greater, than when we propose to take hold of any thing with our hand; the mind immediately engages all those muscles in the action necessary for it. And on this power of the soul, seems to depend all the wonders wrought by our fancy on the body.

WHEN, for example, the sight of *ipecacuana* makes one sick and to vomit; what is more in this, than that the fancy, by the sight
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of *ippecacuana*, is brought to remember the sickness the drug had caused ; and the idea of this, is the copy according to which she affects the fibres of the stomach. And thus the power we give the mind, is that of being a very exact copier : give her the copy, and she will follow it ; not indeed always upon the first instance, but generally when they come to be repeated : and thus it is seldom, that one dose of a vomit leaves the impression so strong, that the mind can easily copy it ; but repeat the vomit, and the most dull fancies will be trained to imitate : by this means the lesson is better imprinted upon them, and thereby they can be more distinct in copying.

AND according as people have more of fancy upon any other account, they become the more ready imitators ; as most women have in pregnancy, and therefore they go very surprising lengths in this work ; and as their child has very pliable and delicate organs, the effects of their improved fancy come to be very strong and manifest upon the child.

JACOB seems to have been well versed in this piece of natural history, when he set
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the peeled rods before the strong of the flock, and by that means made their offspring ring-streaked, speckled and spotted, which were to fall to his share ; while the feeble were left to *Laban* his father-in-law. Nothing is more mysterious, nothing more certain, than this operation of the fancy !

AND though these less frequent effects seem extraordinary, yet, when considered duly, they have nothing more mysterious than the more ordinary ; as when an attentive child repeats after a master words he pronounces before it : how amazing is it to find the attentive mind compounding the sound the word requires, by the conjunct help of a variety of muscles, of lips, tongue, nose, and throat ; each of them acts a part, tho' they seem as instantaneous in their action, as that of the finger in discharging the fowling piece, when the strickler, cock, flint and powder, act their several parts : the very hearing of the word leads the mind distinctly to each muscle necessary, though she has no idea of their situation, or so much as knows that such instruments are employed. Is this less stupendous, than that the same fancy should irritate

the fibres of the stomach as the *ippecacuana* did, or the tongue and jaws, as the orange does? in both it is the imitation of effects, which are placed distinctly before it, upon the pliable fibres.

THE mind, then, can act upon any fibre of the body, or any part made up of them, which any other agent can affect, if she is brought to have a distinct idea of the effect.

AND since, in many circumstances, the fancy is more lively, or more apt to be touched, of consequence in these she gains more command over the body; and the stronger the object strikes, the fancy must act with the greater certainty.

AND, lastly, the more vigorous and pliable the fibres are to which the fancy applies herself, her force must be more conspicuous.

AND thus we learn the power the soul has over the body, and what must add to and subtract from it. And, in illustrating these points, we persuade ourselves, we have set things in such a light, as to judge, on good grounds, that as the soul produceth no effects in the body, without the mediation of some instruments fitted for that purpose, so she directly

rectly applies herself to these instruments : for since, according to her different ideas, she produceth different effects, where can we suppose she applies herself, but to these instruments which different *stimuli* affect when they produce the like effects ?

AND, in as much as the mother, by her fancy, affects the child as variously as herself, though there is no communication by nerves between them, we must allow that the mind wants not the assistance of nerves for that purpose ; which shall be further illustrated, when we treat of the brain and sensories.

To conclude all I have to say on muscular motion, I must give my opinion (agreeably to that of the learned Dr. *Pemberton's*, in the last paragraph of his introduction to Mr. *Cowper's* treatise on the muscles) that we cannot make a much greater progress in so reclusive a subject, while we are wholly strangers to the principle that causes the parts of matter to adhere together ; and how it comes to pass that this principle should operate with so much force, while the parts of the solid body are yet kept from the most intimate contact they are capable of. How can we know, but
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there is some power in animals that can operate upon this principle, which keeps the parts of their fibres together, and can strengthen the effects thereof upon proper occasions ; so that the particles of these fibres shall be made to approach each other with great force. Thus that learned Gentleman supposed, after shewing the inconsistencies of the vesicular system : and I pretend to have done nothing more, than to have shewn in fact, that the muscular parts do yield and dilate ; and that in this case it is, as the most proper occasion, that the mind makes them return to their contact, or makes them again approach each other with great force, and that without the intervention of any other matter than what they had in their stretched state ; which we see every *stimulus* can likewise do.

IN no case do we see more plainly the process and instruments for it, than what is done in the action of the muscles. In every case we find how they are stretched, and must be sensible what advantage this gives them ; and that their being subject to the will, depends upon their having antagonists to stretch them.

After

After this stretching, the mind finds no difficulty to move any part, in any shape, of which she can be made to have an idea, if the muscles are capable to perform it.

HERE the mind acts upon a machine in the most simple manner, fitted, by its make, to answer her purposes ; she doing no more than the most ordinary *stimulus* does. And this such must admit, who will not allow that the mind acts directly on the muscles, but by mediation of some subtile fluid ; for in that case the muscle acts altogether mechanically, by the assistance only of a material agent employed by the mind ; and therefore the whole action here is mechanical.

THE whole of our doctrine we further illustrate, in accounting for the circulation and respiration, in which the muscles have the chief agency.

E S S A Y

ESSAY II.

Of the Circulation of the Blood.

IN the foregoing dissertation, we endeavoured to shew that it is the natural make of muscular fibres, in a live animal, whence their power arises, of being stretched; and of their recoiling and recovering their former situation of themselves, when left at liberty; that is, while they are in the sound body, they are greatly elastic.—And farther, we endeavoured to shew, that, in fact, they are always stretched or bended before they come to be employed in moving any part; which gives us to understand, that the stretching of a muscle is the great preparation for its exerting itself:—and we have shewn further, that all the muscles commonly reckoned voluntary, are either kept stretched in the body, or can easily be made so by an antagonist that is stretched; in which case, either some irritating *stimulus*, or the mind, by

by its native power to irritate or contract them, brings them into action ;—that is, we shewed how the machinery is fitted to be played upon ; which is all that Philosophers pretended to search after. And the beauty of our hypothesis lies in this, that the most established motions and courses in the body may be easily explained by it, without any further *data* than the structure of the parts, as Anatomy has delineated them : and this we shall further illustrate, in accounting for the circulation of the blood, and the respiration, the two great and immediate instruments of life ; which, in our way of explaining them, will be found to be nothing else than examples of our doctrine in the former section ; and may therefore be reckoned a continuation of it, or additional arguments to shew the justness and certainty of what we there advanced. We should begin with the anatomy of the parts concerned : but, as we have nothing new to advance upon this head, we shall suppose them known, that we may embarrass this treatise as little as possible ; that is, we suppose our readers have before them what the modern Anatomists, *Winslow* in particular, have delivered

delivered on the subject; by whom it is made manifest, that the heart is a very strong muscle, forming two cavities, more or less capacious, as the muscular fibres are more or less contracted;—they communicate not one with another immediately, but the anterior cavity, commonly called the right, communicates, on one hand, with the artery, whose branches spread over every hair-breadth of the lungs, to which it sends the blood it discharges; and, on the other, with the *venæ cavæ*, into which the whole system of the veins, not employed in any secretion, spread over every part of the body, except the lungs, come at length to empty themselves, and thereby supply this cavity; and the other, called the posterior or left, communicates by one passage with the veins of the lungs, from whence only it has its supplies, and by another with the *aorta*, the root or trunk of all the arteries of the body, except these of the heart and lungs. It is through these cavities of the heart the blood has its constant rotation, and is determined in it by the position of the valves affixed to them, and to the arteries arising from them. For the anterior cavity has a broad
tricuspid

tricuspid valve so placed over the passage from the veins, as to give a free passage to the venous blood in it, but does not allow it to return that way ; and the posterior, after the same manner, has a two-pointed valve placed over the passage from the pulmonary veins to the same purpose ; whereas the pulmonary artery and *aorta*, immediately at their rise from these cavities, have each three semilunary valves, making a compleat circle round their cavities, so placed as to allow a free passage from the heart, but no return to it by these arteries. *Cæsalpinus* had a very distinct notion of this course (as we find by the account of it, in his *Cataptron Medicum*, lib. 6. cap. 19.) *Oscula*, says he, *ad basin cordis quatuor posita sunt; venarum et arteriarum principia, secundum Aristotelem; duo sanguinem introducentia, duo educentia, tam in dextro ventriculo, quàm in sinistro; in dextro osculum introducens est ad venam cavam, educentis autem arteria est in pulmonem: in sinistro venæ osculum est introducens ex pulmone, educentis autem est arteriæ aortæ principium, singulis osculis membranæ quædam appositæ sunt, quæ intromittentibus aperiuntur ad ingressum sanguinis,*

sanguinis, clauduntur autem ad egressum; opposito modo in educentibus patent ad egressum, clauduntur ad ingressum, ut continuus motus fieret ex venis in cor, et ex corde in arteriis: though, through all his works, he seems to have but a confused notion of the course in the veins and arteries and their communication; which was left to the great *Harvey* to demonstrate, and thereby to render compleat the whole doctrine of the motion of the blood: for though, after the course of the blood through the heart was established, one would have thought it natural to suppose a free communication betwixt the arteries and the veins; yet the notions, which had prepossessed Anatomists, made necessary the many experiments *Harvey* adduced for it; all which I suppose now established; and, therefore, shall repeat nothing this great author advanced for that purpose. But, supposing the fact, the task I take upon me, is to shew the instruments, and the way they are applied, by which the blood is compelled in this course. There is no Physiologist now, but allows that it is the contraction of the ventricles of the heart, by which the blood is forced into the
arteries

arteries arising from them. But then, the great question is, whence this great contraction, and what, in turns, should make it relax again, or rather, in the terms I chuse, stretch? which I reckon very different from it, as may be easily understood, by my comments in the former Essay. To suppose this stretching to happen of itself, is to suppose a turn in the contracted fibres of the heart most different from what the fibres have in any other part of the body; where it is admitted, after the strictest examination, that the fibres, in a state of health, always affect the contracted state, and become the more firm in it, the seldomer they are stretched. I formerly noticed that when fibres were contracted beyond their tone, by the force of a *stimulus*, that, upon the *stimulus* ceasing, the fibres returned to their natural state of contraction, which is a spontaneous relaxation, or a relaxation by the proper action of the fibres; and that was properly so, as the contraction is spontaneous, when a muscle over-stretched returns to its natural contracted state; and therefore, when we say the fibres affect a contracted state, it must be understood a state of contraction

traction to a certain degree only ; for, when forced beyond this, they affect what we call comparatively a relaxed state. And thus, the animal fibres, like other elastic bodies, can either be made to condense, that is, contract, or dilate, that is, stretch beyond their native tone.—Now, if we say that the heart relaxed of itself, after contracting, then it must be shewn that its contraction was greater than what flowed purely from the tone of its fibres : for, in this case only, it can spontaneously relax ; and then it would follow, in consequence of this, that we ought to shew a *stimulus*, or some other cause of the extraordinary contraction, so as to account for the action of the heart ; which some imagine they have done, when they observe that the heart is supplied by the eighth pair of nerves passing to it between the *aorta*, and pulmonary artery. But why should the nerves of this pair occasion a more violent contraction than those of any other pair ? and if they do it to the heart, why not to all the parts to which they send off branches ? amongst which are many of the voluntary muscles, particularly those of the *larynx* and *os hyoides* : and if it be allowed, that
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the contraction is to no greater degree than what its natural tone gives it, then there can be no natural relaxation; and whence, in that case, the *diastole*?

FOR this, some have advanced, that there is an extraordinary relaxation occasioned by the compression of the great cardiac *plexus* of nerves, lying between the two large arteries, at their rise; but the authors of this reason have been too fond of it, when they have neglected *Morgagnus* and *Vieussens* observations, that sometimes that *plexus* did not take this rout at all to the heart:—*Winslow's* account, in his anatomy of the most ordinary course of it, is, that the chief filaments run in the cellular substance behind the *aorta*, as well as between it and the pulmonary artery, so that all of them would never be compressed; and that these filaments serve the auricles as well as the body of the heart, so that the auricles would be relaxed with it, which would prevent their contraction which takes place when the ventricles are in their *diastole*. Since, then, the eighth pair of nerves, with its associates, serve promiscuously voluntary and involuntary muscles, membranes, glands, and bones, we can
succeed

succeed nothing in our reasonings, from the specialities in this nerve, to account for the specialities in any of these parts ; nor is there any part whose action is less capable of being explained by the obscure nerves, than that of the heart, which is purely muscular ; and how a muscle acts, we have explained above : the only thing in debate concerning the heart is, what stretches it, or what causes the *diastole*, under which the fibres are distended beyond their natural tone, and consequently must be under the influence of some foreign power.

ALL authors seem satisfied that the *apparatus* at the entry of the ventricles, is somehow adapted for pushing in the blood ; and, with *Hoffman*, *cordis modum sequi vasorum modum* ; that the heart is contracted more or less strongly, or more or less frequently, &c. according to the strength and frequency of the push of the venous blood ; that is, that its *systoles* were determined by it ; and yet they could not be persuaded that the venous blood was strong enough to dilate the ventricles ; for, if this was allowed, there was nothing more wonderful in the contraction of the ventricles of the heart, than in that of any *sphincter*.

sphincter.—To illustrate the case of the heart's *diastole*, we shew the *apparatus* for pushing the blood into it; and, then, the experiments which shew that the *systole* is in consequence of this.

ANATOMISTS and observers seem to have determined very indistinctly the parts which act and move conjunctly in pushing the blood into the heart. By the modern debates, concerning the size of the ventricles and auricles, one would believe that it is the general or prevailing opinion, that the auricles only supplied the ventricles; whereas, if we attend to the spaces bounded by valves, we shall find that not the auricles only, but, with them, a great tract of the neighbouring vessels, at once supply the ventricles: for, upon the posterior side, *Ruyfch* has shewn us, in his 13th epistle, that the pulmonary veins unite before the ventricle, and make up the greatest part of the auricle, or at least one cavity with it; and, at the same time, we know that there are no valves between this cavity and the branches of veins opening into it; nay, nor between the pulmonary arteries and their veins, the first valves that we meet being the semilunary, at the rise of the artery from

from the anterior ventricle: what, then, in the time of the *systole* of this ventricle, can hinder the blood from flowing, in one continued stream, through the pulmonary arteries and veins to the left auricle, and thus from filling them all at once? For, as the blood does not move in separate parts, or in a body like a ball discharged from an engine, but like the waves of the sea, which follow close one immediately upon another, it is probable, that the blood has reached the pulmonary veins, or rather the auricle, before the ventricle has done contracting, or exerted its full force, in discharging it self into the arteries: nor is there any thing to hinder this progress, since all the passages are open, unless it be some little blood left in the veins after their last supply to the posterior ventricle, which must necessarily be pushed forward. So that, I say, the blood, upon the contraction of the anterior ventricle must move all at once, in arteries and veins through the lungs towards the left auricle; and, consequently must all at once distend and prepare all these several vessels to push their contents conjunctly, or with one united force, into the posterior ventricle; which they do

do upon the anterior ventricles ceasing to act, or its recovering its contracted state : and as this represents to us both the ventricles at the same time, precisely in the same state, so, from hence, we see, that their action must be synchronous ; and the same must be understood of the action of the auricles, which here appear both of them distended, whilst the ventricles are contracted. But that nothing of this could possibly happen, unless the vessels of the lungs did all of them act conjunctly, is very apparent ; for if the anterior ventricle pushed the blood only into the pulmonary arteries, and these arteries into the veins and their appendix the auricle, which can never act separately ; in that case, whilst this ventricle was acting, the posterior auricle would, at the same time, be likewise acting ; which is impossible. I conclude, therefore, that the pulmonary arteries, veins, and posterior auricle, do all at once receive their supplies and discharge them again : and, had this been attended to, how plain would the course of the blood have been ? and how many idle controversies about the dimensions of those vessels prevented ?

FROM the same way of judging, we must allow, that it is not the anterior auricle, by itself, which immediately supplies its ventricle, but with it the whole tract of veins unseparated from it by valves; and thus we must allow, the whole superior *cava* to be as one cistern with the auricle; we meeting no valves till we come to the axillaries and jugulars, at whose rise *Fabricius ab Aquapendente* discovered them, as *Eustachius* did in the inferior *cava*, immediately upon its passing the diaphragm: so that here we have a pretty large cistern to supply this ventricle, and of a much larger capacity than the ventricle itself. And that all of it acts conjunctly in filling the ventricle, is agreeable to an observation of *Wallæus*, in his letter to *Thomas Bartholine de motu chyli*; where, speaking of the motion of the *cava*, he says, *Motus autem ille venæ cavæ propè cor evidentissimus est; ut plurimum eum quoque in vivis canibus observavimus toto illo tractu ab hepate, & à jugulo ad cor usque*, that is, thro' the space we have mentioned. Now, the question is, if these venous parts, with the auricle, are capable to dilate the ventricle by their contraction? for if they are, then we

see

see the instruments which naturally prepare the ventricle for action ; as the antagonists of the muscles not hollow do extend, and prepare their fellows ; and if we examine facts, they seem greatly to prove it . Thus every thing which accelerates the venous blood, or its return to this last receptacle, immediately before the ventricle, hastens and enlarges the *systole* of the heart ; or, as *Hoffman* observed, the motion of the heart is determined by the vessels supplying it with blood : by this failing, the person becomes faintish, with a languid pulse, if not a compleat intermission of it, and swooning.—The pulse too is more or less full or frequent, according as the respiration makes more or less impression upon the abdomen.—In a person standing, it beats about a seventh oftener than when sitting ; at which time the abdominal muscles lying loose, do not so much assist the diaphragm, in pressing the blood returning by the abdominal veins ; which likewise is the cause that women after child-bed are quite faintish, if not girded ; and such as are tap'd for a dropsy ; and that the *Scythians* bore hunger longer and easier when girded than other-

otherways ; as *Aulus Gellius* tells us, from *Erastistratus*, in chap. 16. lib. 3. of his *noctes Atticæ*. But the girding must not be over strong, as I found on trial, otherwise the circulation will be quite stopt ; whereas the small preffures increase it ; as we find, from *Mr. Hales*, in the experiments where he made the largest evacuations in dogs ; for when, by them, the pulse was quite sunk, a small preffure on their belly at once raised the pulse, as muscular motion does, by which the venous blood is hastened to the heart. What can we imagine more decisive in any question, since the heart shews more or less force, and acts quicker or slower instantly, according to the force of the venous blood upon it ? for whatever virtue we reckon in the animal spirits, if they change their way of acting, in consequence of the venous blood moving quicker or slower, the motion of the heart must be changed prior to that of the animal spirits. The great *Harvey* observed the course at the heart most distinctly, in opening live animals ; as we find in the 4th chapter of the circulation, where, from his observations, he concludes, *Sic prius desinit cor pulsare, quam auriculæ,*

*riculæ, ut auriculæ supervivere dicantur, pri-
mus omnium desinit pulsare sinister ventriculus,
deinde ejus auricula; demum dexter ventriculus
ultimò reliquis omnibus cessantibus & mortuis
pulsat usque dextra auricula, uti ultimò in dex-
tra auricula vita remanere videatur. Et dum
sensim emoritur cor, videre licet post duas aut
tres pulsationes auricularum aliquando quasi ex-
pergesfactum cor respondere, & unum pulsum lentè
& ægrè peragere & moliri. Sed & præcipuè
notandum, quod postquam cessavit cor pulsare,
adhuc auricula pulsante, digito super ventricu-
lum cordis posito, singulæ pulsationes percipiun-
tur in ventriculis; eodem planè modo, quæ ven-
triculorum pulsationes in arteriis sentiri antea di-
ximus à sanguinis impulsu nimirum distensione
facta, &c.* If the action depended on the
nerves, what should make the auricles move
longer than the ventricles? but if on the
blood, we must allow, that as the posterior
parts of the heart are supplied from the an-
terior, that these must first fail; and even
the anterior ventricle before its auricle, since
it is supplied by it. So that what *Harvey* ob-
served was as reasonable, on our supposition,
as that the mill-wheel should decrease in mo-
tion,

tion, as does the stream which makes it move; and that at length it should stand still while the stream was moving, though too weakly for it. And thus he observes, that the motion first began in the umbilical vessels, and thence to the auricles; and at length to the ventricles; *Capite ultimo Exercit.* And, in the same chapter, he observes that the auricle is always proportioned in strength to the ventricle in different animals, *ad impellendum et implendum*; than which nothing can make it more evident, that the ventricles owe their distension, or *diastole*, to the force of the venous blood returning to them; and thus we find how the ventricles of the heart are brought to that stretchedness or degree of tension, we reckon a preparation for muscles to make them exert themselves; every observation confirms it; and the most obvious *phænomena* we meet with every day, argue for it: so that there can be no objection against this doctrine, but the plainness of it.

In our arguing, we have obviated the objection, that this course we have established is a *circulus in causis*; for we have shewn, that, without the assistance of respiration, the ve-

nous blood did not return with sufficient force to fill and distend the auricle, to prepare it to act upon the ventricle: so that here is a new force perpetually superadded to the returning blood: This we find in fact to be a *sine qua non* in the circulation: by this, and the action of the arteries and veins themselves, while in a state of dilatation, the anterior auricle, and thoracic parts of the *cavæ*, are greatly bended; for they are dilating all the time the right ventricle is contracting; and thus they are in their greatest strength, when the strength of the ventricle is spent; and then they make their push according to which the ventricle is more or less dilated; which of necessity makes its push in its turn: and as the whole thoracic part of the *cavæ* joins with the auricle, the impression they make on the ventricle must be great: every part of this larger bounds contracting and giving an impulse to the fluid; so that the *momentum* with which it acts on the ventricle, must be made up of what results from this compound pressure, and so make up the loss of what each part wants in strength of the parts of the ventricle; and, as it contains more than
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the ventricle can receive in a state of health, it never returns to its greatest degree of contraction, having still more or less blood in reserve, and contracts only so far as it is able to make the ventricle yield or recede from its natural tone ; so that each part of the cistern acts from a greater stretch than the ventricle, and must of consequence in this respect do it with greater vigour ; and thus we see, that necessarily, when the auricle acts faintly, the ventricle must do so likewise, and *vice versa*, according to what we find to be fact: but the chief thing to be regarded, in the course of the action of different parts of the heart, is, that when the auricles have lost most of their force, by their contraction, the arteries have done so likewise ; and thereby the resistance of the semilunary valves to the action of the ventricle is diminished ; and consequently the *diastole* of the ventricles can subsist no longer: and thus the *systole* takes place with such a push from every quarter, as the propped wall falls downward, by forcing away the prop ; for it is manifest, that except these valves make resistance, the ventricles could not be dilated at all by the blood ; since they
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make up a part of the enclofer where it is contained ; and therefore we may judge of the force necessary to support the ventricles, by the resistance they give ; which is considerable, when the arteries are full and press their blood against these valves : but when the arteries subside, which they do against the time the ventricles are full, the valves can make no resistance at all ; and thus the fluices are opened, and the ventricles begin their *systole*, sooner or later, according as the blood is received from the arteries. And this shews, that as the quicker return of the venous blood hastens the motion of the heart, so any stop to the discharge of the arteries, must retard it ; and whether or not the fleshy pillars, agitated by the stream, adds a *stimulus* to make the ventricles brisker in their motion, I leave every one to determine, who has considered how certainly the touch of a pin does this.

OUR doctrine, then, of muscular motion leads us to an easy explication of what is acted at the heart, and lets us see that the auricle is the moderator and bender of the ventricle for motion: and as we have shewn this in the anterior auricle and ventricle, so it holds in the posterior;

posterior; for when the anterior auricle has so far reduced itself in contracting, that it can affect the ventricle no longer, as it must do in its course of contracting, by which its action becomes weaker and weaker, then the ventricle, urged weakly by the auricle, and but little resisted by the valves, exerts itself, and causes a general dilatation of the arteries and veins of the lungs, with the posterior auricle, which had immediately emptied themselves into the posterior ventricle; so that the moment they are emptied, or rather have their blood diminished only, they are again distended with new supplies, and prepared to urge the ventricle before them, which at the same time has immediately discharged itself into the *aorta*, and arrived at its weakly state, when the source whence it is filled is in the greatest vigour; just as when one wave spends itself, another is following it with new vigour, and keeps up a perpetual flux; or, as the great *Harvey* justly says, in his 5th chapter, *Nec alia ratione id fit, quàm cum in machinis una rota aliam movente, omnes simul moveri videantur.* Besides that, as the lungs are under the continual pressure of the air, both in
inspiration

inspiration and exspiration, this preffure must add greatly to the force of the blood in dilating the posterior ventricle; as we shall fully illustrate in the following treatise. So that it is manifest, that the respiration, both as it acts immediately upon the lungs, and mediately on the lower belly, is a great cause of the motion of the blood and of the *diastole* of the heart; which is the chief thing to be investigated, in order to account for the circulation. And it must be observed, that as I have argued, that through the lungs the motion of the blood in arteries, veins and auricles, is uninterrupted, both when the arteries are filling from the anterior ventricle, and when discharging themselves again; so the same takes place in the *aorta* and veins communicating with it; for nothing can hinder the veins from receiving supplies from their arteries, even at the time these are a filling from the heart; and the same supplies are necessarily continued, when the arteries are in their *systole*: so that there is a constant stream into the veins; as we find the stream to be equal in them in venæsection; though the arteries, on their contraction, are greatly exhausted,

exhausted, as is the thoracic cistern of venous blood after its contraction : and thus the bounds between this and the arteries, supplying the veins, must be reckoned greatly loaded when the arteries are in *systole* ; for then the thoracic cistern is likewise in *systole*, and therefore there must be an accumulation in the vessels between the two ; though at other times there is still a course into it. And from this view of things we reckon, that the whole of the circulation in the larger vessels is fully shewn through all its changes, and the reasons of it ; though in the *vena portarum* it must have a longer circuit, and probably in some other veins from their make.

BUT however plain I have made the action of the heart, and however evident it seems to be that the blood forced in upon it is the cause of its *diastole* ; yet, when we take a fuller view of things, something more admirable must appear to be in its motions, than we have brought into our account. The hearts of frogs, pigeons, and many other of the lesser animals, in a manner dance and leap when cut from their bodies warm. My Lord Bacon, in his *Hist. vitæ et mortis*, tells
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us, that he saw a criminal's heart, when torn from his body, jump up and down more than a foot high for some minutes; as we find most of hearts repeat their contractions, separated from their bodies, when prick'd in any one place: but does this argue any thing against their contracting with more or less force according to the distension or stretch made of their fibres by the venous blood? This we see as clearly as we do those other experiments, and cannot therefore but allow it equal credit: nor can I see that any thing more can be argued, from the motion of hearts separated from the body, than that they are most nicely set for it; so that the smallest *tremor* sets the whole a going, like *Memnon's* harp, or *Van Swieten's* patient, with the sunbeams. It is obvious that vegetable and animal fibres, of the softer make, immediately upon being separated from the course of their nourishment, lose much of their compactness of texture: their lesser elementary parts, by losing their cement, lose so much of their cohesion one with another; and thus, of themselves, they obtain a latitude to contract or move: and in this state it is, that a *stimulus* makes

makes them contract, and affect their former degree of cohesion ; tho' they cannot keep it, for want of a proper cement provided by nourishment. And most of the nicer and more obscure powers want some incitement to rouse them ; as we find the electric does not appear till roused by friction : and why should it appear more strange, that the attraction among the lesser parts of the fibres should likewise require some incitement ? This the air does to parts not formerly exposed to it, for some time, after the death of the animal ; when that fails, the touch of a pin ; after that, warm water ; and when this fails, the touch of a hot iron. So that when the weaker *stimulus* fails, the stronger and more penetrating can do it : than which nothing can argue more strongly, that all consists in the mechanical operation of the *stimulus* upon a machine well set for it. What the operation of a hot iron must be upon such a corded elastic piece of work as a muscle, is not difficult to imagine : one fibre running through it, to which the rest are some how or other linked, when corrugated, which is the native effect of heat on such fibres, must agitate the whole ;

whole ; and, from the counteractions among so many fibres as are there combined, repeated vibrations must happen before the first shock ceases : warm water acts the same way ; and a pin may be allowed the like operation, though it acts upon lesser bounds. In the instance formerly mentioned, the touch of a pin could make a strong bell found, by making all its parts vibrate ; and why not agitate a whole muscle, one of the nicest corded machines we know, and which can be played upon by the rays of light, as we said before ? How should we reckon it so strange, then, that a heart should bounce and play, knitting and relaxing again, while vigorous with its native powers, and exposed to the influence of such *stimuli* ? A man sings over an empty glass, and makes it tone to his tune ; and shall the fire appear enchanting, when a heart bounces from it, and thereby only shews its corrugating force ? Warm water again immediately checks the motions of a fish's heart, and cold sets it a moving ; as *Hoffman* often observed, *System. vol. 2. p. 33.* This shews how they are set for different shocks : and thus Mr. *Hales* reckons the difference

ference in different *menstrua*, is owing to the difference of the shock they give different bodies. But, be this as it will, it does not affect our observations, that muscles must be on the stretch before they act; and that in proportion as they are stretched, if the cohesion of the parts be not dissolved, they act the stronger; on which the whole doctrine of the circulation depends. And, as *P. Borellus*, in the last of his first century of observations, has observed, that not only the *mimosa*, but several flowers contract all their parts, by touching one very slightly, this mobility, in well-adjusted machines, should not appear so odd; especially, as he further observes, that, by exercising them a little this way, they lose their delicacy, and seem not so pliable to the touch; not unlike the hearts, which stand it for a few trials; though there are others which can be kept in play very long. All depends upon the original structure and vigour of the parts: the same way the *dura mater* gives over its action after repeated punctures, as *Baglivi* observes; so that the vegetable and animal parts, of a delicate and easily changed structure, have that soon resolved, and put out.

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of tune for action, merely by exercising them : but, by rest, and the recruits they have from nourishment, while in a live state, this is again restored. Thus likewise we find, that upon the destruction of the nerves, every part in the body becomes paralytic, as well as the muscles. So that these surprising motions which continue, for some time, in parts separated from the body, serve rather to confirm than contradict our doctrine ; as they are very strong against those suppositions, which make an immediate flow of spirits necessary to bring the muscles to action. An eel's heart beating an hour in an exhausted receiver, as *Mr. Boyle* observes, shews an immediate flux not to be so necessary ; and, even after a second hour, some degree of heat set it a going ; which shews, that some fishes are touched with heat, as well as cold ; and is a plain proof, how the fibres of different creatures are differently disposed for motion, and to propagate it differently, in the same persons, according to their state of health. Upon the whole, one cannot but rest satisfied, that contraction is the native disposition of fibres in a live and healthy animal, and relaxation

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xation in a dying and dead animal ; and that a *stimulus* to any one part, makes the relaxed parts through the whole muscle regain their contraction for a moment, as the constant flow of the bile keeps up the peristaltic motion in the guts ; and vomits and purges produce convulsions in them. And thus it is but natural, that the *sphincters* and heart should, in languishing animals, be found relaxed and open, though their *diastole* is not their natural state, when they are in vigorous health. And thus the reason likewise appears, why particular fibres are seen contracting in the shambles, some time after the animal has been hung up ; and the hearts of some animals cut into several morsels, do nevertheless shew a *systole* and *diastole*. Now the fibrous parts are separating in course ; but, retaining still some of the uniting force natural to them while in life, the *stimulus* of the air can as certainly affect them, while endued with any degree of it, as it does the violin tun'd unison with another, by which the air is modulated.

P. S.

P. S. Along with this treatise, I must recommend the reading of one upon the same subject, by *Jos. Weitbrecht*, in the 6th and 7th volumes of the *Petropolitan Commentaries*, where there is a most distinct account of the progress of the circulation in different receptacles and vessels; and seems only deficient, in not having observed the use of the valves bounding the *cavæ* within the *thorax*, which make that portion of them, with the auricle, a distinct cavity, as much separated from the abdominal *cava* and its branches, as the *aorta* is from the left ventricle of the heart, and suffers a distension and contraction like the arteries, according to *Walleus's* observation, as we observed above. And, in a paper we laid before the Philosophical society at *Edinburgh*, in the year 1739, after we had investigated, in a human subject, *Eustachius's* valve, according to *Winslow's* method, in the *Parisian Memoirs* anno 1717, an attention to this valve shews, that the thoracic portion of the *cavæ* and *aorta*, have their action synchronous, but not the intermediate veins; whereas all the arteries and veins of the lungs, with the left auricle, are filled together, and
then

then discharge themselves at once, in restoring themselves after a considerable distension, and by the assistance of respiration, as Mr. *Weitbrecht* allows ; though he seems to have had no notion that the *sinus venosus* before the right ventricle had the same advantages, as we have shewn above ; and therefore seems to attribute their distension to a vacuity in them, upon relaxing somewhat after contraction : the whole of which goes upon suppositions for which there is no foundation, as we have shewn above.

E S S A Y

ESSAY III.

Of Respiration.

THE cavity of the breast is bounded by the ribs, joined behind by the *vertebræ*, and before with the *sternum*, and filled neatly up, in their interstices, with a double series of muscles, lined with membranes; and thus form a very close barrel, though not cylindrical, being much more contracted above than below, where it is closed up very neatly by the diaphragm, which is a broad strong muscle, stretched cross the trunk of the body obliquely, from the *sternum* downwards, and meets the spine at a very acute angle; and though it lets pass the gullet and many of the larger vessels, yet all is made close by the *pleura* attached to them on one side, and the *peritonæum* on the other. The two first ribs ly more horizontally, between the *sternum* and spine, than the rest; and though they let pass the wind-pipe, and
gullet,

gullet, with many vessels; yet, by muscles, ligaments, and the *pleura*, the cavity of the breast is quite closed up here; so that the whole cavity, examined within, is found smooth and entirely lined with the *pleura*, made firm by a concurrence of bones, ligaments, and muscles; and, consequently, the whole of the inclosing walls must be quite close and firm.

THE parts contained within it are, the heart, and the lungs, appended to the wind-pipe, together with the nerves, and blood-vessels which pass through it, and a gland placed at the uppermost and fore part of the *mediastinum*; all of which are far from filling up the cavity in its enlarged state, when the lungs are not blown up.

BUT, before we consider the action of these parts, it will be necessary to consider the fabric of the lungs, and the course of the blood-vessels through them.

THE wind-pipe divides into two large branches about the fourth *vertebra* of the back; one to serve each portion of the breast, as it is divided longitudinally by the *mediastinum*: these are immediately subdivided into smaller branches,

branches, until they are brought to the greatest subtilty, and, at length, become membranous, and are expanded into very small and thin vesicles; all of which are so combined, as to make up clusters quite contiguous; and out of them there are three lobes formed in the right side; and two in the left, possessed by the heart, and made less in itself, by the *mediastinum*, inclining somewhat more this way, in its descent: so that the cartilaginous wind-pipe, with its cartilaginous branches, and the vessels appended to them, make up one vesicular mass, whereof all the parts communicate with the wind-pipe, by their distinct conduits, and are envelopped by the *pleura*, which externally connects their convex surfaces.

THE pulmonary artery entering the lungs near the first division of the wind-pipe, sends branches all along with its branches; and, at length, spreads its extremities over the vesicles, forming a regular net-work by their inosculations; the veins, rising from them here, keep by the same branches of the wind-pipe, till they form their four large heads joining the left auricle; and, except by these vascular attachments, the whole lungs hang quite

X quite free, by the wind-pipe, in the cavity of the breast, lying, when unblown, close upon the heart, but, when inflated, spreading to all the corners of that cavity ; though they become not contiguous to the sides of the breast, the inclosing wall ; since air passes the lungs, and must therefore ly between them and the *pleura* ; as Dr. *Hales* has evidently shewn, in 112th and 113th experiments of his vegetable statics ; and may be found by any one that will try to blow up the lungs, which he will find impracticable to keep distended, however fast he ties the wind-pipe, after blowing them full, except he repeats the distension till the lungs become quite rigid and stiff, and so support themselves by their own firmness ; which is a manifest proof of their being pervious, though not greatly so, they subsiding very slowly : and Dr. *Hales*, in his experiments, has observed, that it is only by a few passages they transmit air.

BUT, to understand the action of respiration, we are first to consider the state of the lungs, and cavity of the breast, in a child not born : in him the ribs are greatly depressed, and the diaphragm is thrust up to the third or fourth rib,

rib, as I have found by examination. In this case, then, the diaphragm must be extended greatly beyond the length it would have if lying straight between the different parts to which its fibres are insert, as we have described them; and the ribs in this posture, lying spread to as great an extent as their articulations allow, the muscles between them must likewise be greatly stretched beyond their tone; in which state they never remain without force, as we shewed in treating of the contractile fibres, and with them every other muscle must be stretched, assisting to raise the ribs: and the lungs thus confined are found so compact, that they will sink in water; which they never do after their having been once blown up.

SUCH, then, is the situation of things in the cavity of the breast. And as for the external force that overcomes the natural tone of these muscles, and that detains them contrary to this their natural tendency in that state of violence; this, without doubt, in the case of children yet in the womb, can be no other but the weight of the atmosphere pressing upon the integuments of the mother's belly; and

thereby communicating its superior force to the *uterus*, and so to the breast of the child : for as the wind-pipe and *bronchia*, not yet inflated, can afford no balance to the external air, whereby the muscles that raise the breast might be relieved from the pressure they are under; those muscles, while the ribs accommodate themselves to the small contents of the breast, cannot but come to be stretched, and continue in this state of violence, unless they were so rigid and strong as not to yield to the whole strength of the atmosphere; which can at no rate be pretended.

THE next thing we have to consider, is, what happens to those muscles at the birth. Upon this event, no sooner comes the child out of its close confinement, so as to be exposed to the outward air, but, this elastic fluid immediately pervading every open passage, the nostrils, the mouth, the gullet, and, particularly, rushing into the wind-pipe, and cartilaginous *bronchia*, a power now enters the breast equal to the whole weight or force of the atmosphere; which cannot, therefore, but relieve the intercostals, the diaphragm, &c. from that outward pressure they are under :

der: for, as it is the natural disposition of every muscle to contract itself, and not to quit its contracted state, without great resistance, it is here to be considered, that, of the whole force of the atmosphere pressing upon the muscles employed in raising up the breast, it is only a certain portion of that force that keeps those muscles stretched, whilst the rest is spent in answering the resistance that arises from their contraction: so that the air introduced into the breast, being equal to the whole force of the atmosphere, cannot but prove greatly superior to that part of it which stretches those muscles; and thereby, setting them at liberty, it puts it in their power to exert their native force, to contract themselves, and so to elevate the breast, wherein the outward and inward air come to balance one another. Here, then, we see, that from the outward air rushing into the wind-pipe, and cartilaginous *bronchia*, the breast is heaved up; and, of necessity, while this is doing, (which is done in a moment) the subtil fluid is still penetrating farther, and reaching the vesicles; it blows up and expands the lungs,

lungs, as it fills up every other cavity to which it can have access. But, besides this mechanism that so far contributes to the raising of the breast, the mind likewise may be conceived herein to lend her assistance, as she may thereto be incited, by a new sensation at the breast, occasioned by the run of fresh air into it, and by the new current of blood forcing its way into the lungs, whose difficulties ever after awaken greatly the attention of the mind. Thus much for the first inspiration, and how the breast comes thereby necessarily to be raised.

Now the breast thus raised, its capacity, in all its dimensions, is greatly increased; and therein the lungs, now inflated, having full room to dilate themselves, the blood (which heretofore, without touching the lungs, had passed from the *vena cava* to the left auricle and *aorta*, partly by the *foramen ovale*, and partly by a vessel lying between the roots of the pulmonary artery and *aorta*) finds a free passage through them; and comes at length to be confined to that course we described when treating of the circulation. And considering that the blood, now spread among
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the vesicles of the lungs, must be diffused over a vast surface, no less, by Dr. *Keil's* calculation, than five times the whole surface of the body; and that at the same time it is impregnated with a degree of heat, superior to that of the sun in the dog-days, as we shew when treating of the blood; one cannot but allow, that the evaporation of its volatile sulphureous fumes, with which it abounds, must be very great through the whole extent of the breast. As therefore the air in the lungs, and every where through the breast, now overcharged with sulphureous fumes, cannot but thereby have its elasticity considerably spoil'd and broken; so this, of course, greatly diminishing that inward force or balance, by means of which the intercostals, and other muscles, were enabled to contract themselves, and so to elevate the chest, the outward pressure of the atmosphere, now superior in power, must again prevail; and, by depressing or stretching those muscles, very much lessening the cavity of the breast, the inward effete feeble air contained in the lungs, &c. is forced to give way, and to rush out: and herein we see the first expiration.

BUT

BUT again, now that the lungs are emptied of air, and if any remain in the vesicles or *bronchia*, it has lost its spring; from the nature of fluids, it is impossible, but the vigorous external air, having nothing to oppose it, must rush in again along its former course, and heave up the breasts, and inflate the lungs; till, by losing again its elasticity amidst the fumes that arise from the sulphureous parts of the blood, it loses again the balance; and, by the subsiding of the breast and lungs under the pressure of the atmosphere, is again forced out, or made to expire, and so makes way for another inspiration. And thus the machinery is carried on, till the animal comes to breathe out its last; so that, by an inevitable necessity, inspiration and expiration succeed to one another, at longer or shorter intervals, according to the force of the rising fumes, the strength of the air, and the vigour of the muscles, &c.

Dr. *Hales*, we find, experiment 108. *Veget. Stat.* was not able to breathe 240 cubical inches of air above a minute; for then he was not able to blow a bladder, into which he breathed,

breathed, more than half full ; and consequently the lungs would keep equally flaccid, there being access to no fresh air to play upon the lungs ; both that in the bladder and lungs being thus weakened : but though he had forced a breathing for a minute, yet, in less than half a minute, he found he did breathe with difficulty. And, in fact, we find, that, in the 20th part of a minute, the fumes have so far destroyed the air, as to leave room for a new inspiration ; people in health inspiring about 20 times in a minute ; and therefore, after that, if the air, once inspired, is not changed, or a freedom left for new air to succeed, the respiration must always become more and more uneasy, and at length incapable to balance the external air so far, as to allow the muscles, for enlarging the *thorax*, to exert themselves.

AND thus we find that it is the air that plays the whole machinery of respiration ; though, by the doctrine of animal motion by the spirits these should have enlarged the breast before the air could have entered its cavity : but what should make any new course in them for that purpose, upon the birth, is not to be

be imagined. What we have advanced, is built upon certain facts, and makes the action of the muscles depend on the access of the air to the breast; and ever after, upon a supply of fresh and vigorous element, not to be had on the tops of mountains, or stagnating caves, or places where sulphureous fumes prevail, whether arising from the bowels of the earth, the bodies of men, &c.

Dr. *Langrish*, by his experiments upon brutes, seems to have added much to the strength of these arguments; for, by forcing in sulphureous fumes to the different cavities of the body, and by keeping the whole body involved with them, except the lungs, the animal suffered little; but when forced thro' the wind-pipe, killed it immediately: so that the sulphur had no bad effect, but where it prevented the action of respiration; though the author imagined it was by killing some unfelt *æther*. But since the unactive air in the lungs is still attended with this effect, and that in an exhausted receiver the same misfortune shews itself, there is no need of such a supposition.

By

By the whole argument it appears, then, that the muscles of the breast are, by the force of the atmosphere, as much opposed in their tone, and put on the stretch, when the air is destroyed in the chest, as the *sphincters* are in their tone, by the bodies driven in upon them occasionally. And thus we see how such as have the organs of respiration weak, or have a difficulty of breathing upon any other account, feel so much the changes of the air. It is upon the air that the exspiration depends: it is the principal antagonist to these muscles which dilate the chest; if it languishes, the exspiration must be faint, and consequently the inspiration must return the sooner; that is, there will be a quick and faint respiration. And if we will suppose a faulty blood, not much abounding in volatile sulphureous parts, we must allow, on our hypothesis, that, in this case, as the internal air would be but slowly killed, so there would be a difficult inspiration, and a great oppression at the breast, from a rarefaction of air not killed; and the external atmosphere would be too weak an antagonist, and fail in depressing the breast

and stretching the muscles. And how far the swelled veins, and stomach, and a general sense of straitness over the whole body, (which asthmatic persons so ordinarily complain of) shew the cause, I leave every one to judge: to me they greatly argue the want of that volatility in the blood, or attenuated sulphur; and by this the air is not only felt too strong in the breast, but in the stomach, and every vein; whence all the asthmatic's uneasiness; for which an infusion of *sal volatil. corn. cerv.* and *succin.* with sulphur, was a great remedy of *Willis's*, though he had not adverted to this theory.

THE whole of this doctrine is so manifest from *Dr. Hales's* experiments, that one would be apt to suspect that it was the chief thing he had in view to establish from them: but though he never makes any conclusion to that purpose, yet he is very positive, from his 111th experiment, that there is no vivifying spirit carried along with the air, causing that sudden recruit of life, spirit, and strength, we find instantly arise in languishing cases, from the admission of fresh air; and that all this happy sensation is from the fuller dilatation of the lungs, and a brisker circulation following

following upon it : but, lest the experiments he made had not been convincing to such as had long dwelt upon the treasures the air conveyed with it, he seems, in the 114th, to have contrived an *apparatus*, to shew, that nothing was necessary for all these surprising effects of a free respiration, but the blowing up and agitating the lungs ; for when the air was so effete, as not to do this of itself, by pushing it by means of a bladder appended to a dog's wind-pipe, he made this air, under whose influences the dog quite languished, cherish and revive him again, by its mere mechanical action. And thus opens a different view to us from what we had, of these cases where the air kills directly, from losing its elasticity ; and shews a cause very different from what obtains in the cases where poisonous exhalations introduced to the blood kill more or less slowly, without regard to the respiration.

AFTER taking away the cherishing virtue of the air, it must be natural to demand, why all this *apparatus* to introduce it into the body ? why such a delicate cartilaginous membranous *sac* to receive it, such walls to secure this ? and why should the whole mass of blood pass in review

review before it? This, indeed, at first view, would look as if the blood received here some perfecting stroke: and we may persuade ourselves it was not for nought. And so many having engaged to shew at great length the chief design of respiration, discover how sensible Physiologists have been of the importance of this *apparatus*. Some have thought a mixture of the air with the blood was of absolute necessity. But why a particular provision for this, which is certainly done in the common course of the chyle, where there is nothing to hinder it? and therefore air must associate and go along with every drop of it, as it does with every liquid it meets; for all abound with air, and thus mix more safely with the blood: for Dr. *Langrish's* experiments shew, that air cannot safely be admitted directly to it, (*Vid.* his last experiment upon sulphur). Nor does the mixture of the new admitted chyle with the old stock of blood, and the attenuating its particles, combining too much in the veins, seem a sufficient ground for this *apparatus*, as some would have it; a work the force of the heart and arteries are so well fitted for. What shall we
then

then assign as a sufficient task for it? To dilate the ventricles of the heart, by adding to the *momentum* of the blood forced in upon them; as we hinted, in accounting for the action of the heart, when treating of the circulation: and thus to prepare them for a vigorous contraction.

By innumerable observations, we find, if the force of the respiration is not felt upon the returning blood, that the circulation stops at once; as was manifest from a few of these we adduced in our treatise upon that subject: by which it would appear, that the respiration was the true antagonist to the *systole* of the heart. We shewed this in the case of the right ventricle; and if it has such a force mediately by the abdomen, it must certainly still more directly have it upon the left ventricle, for which the great *apparatus* of the lungs is so observably formed. These hang loose in the cavity of the breast, and have either effete air squeezed from them, or fresh dilating them; in both which cases, the numerous capillary arteries must be pressed by these different actions; and the sum of all must squeeze the blood directly upon the left ventricle,

tricle, as we took notice in the treatise of the circulation.

Now, some have made this force extravagantly great, and others again would have it nothing at all, and adduce their calculations to shew it. But, these calculations being accommodated to certain hypotheses, the accuracy of the hypothesis is more to be regarded, than that of the calculation. The facts adduced for *data*, are what should be first examined; and these, perhaps, rightly viewed, may determine the case, without any calculation. Thus, in our former essay, we noticed, that if by any means the force by which the diaphragm recovered itself in inspiration, was diverted from the *cava* passing through the abdomen, that the action of the heart was suspended, and would give over altogether. Now, the force of the diaphragm is proportional to that by which the air rushes into the breast; for it is bended by the pressure of the atmosphere on the abdomen, and contracts in proportion as that is carried off; and this again is in proportion to the force of the air entering the *thorax*, which has the balancing the external air. But though this shews us, that the air must enter with a considerable force,

force, yet there are more direct observations to shew it.

DR. Hoadley, in his treatise on respiration, p. 15. observes, with others who have made perforations into the cavity of the breast, that the lungs act with a great deal of violence upon the orifice; and again, that when a trocar was forced in between the *pleura* and lungs, they scarce could get it to stay, because of the violence with which the air in that part of the cavity urged it; which shews how much the air was pressed betwixt the breast and lungs; and that it was the air which pressed, he proved, by observing, that when the trocar was taken from the *cannula*, and an exit given to the air, the *cannula* lay easy. It is true, the dog's agony added greatly to the force of the muscles employed in respiration. But yet these experiments shew, what must be the effect of the easiest respiration, that it must more or less compress all parts within the breast, especially the lungs themselves, which ly between the pressures of the air in their cavity, and what they have transmitted to the space between them and the *pleura*; for the force of the exterior air cannot exceed

exceed that of the internal: and therefore, since this shewed itself so much on the trocar, the internal, or what acted in the cavity of the lungs, could not be less; though in expiration its force appears small at the *fauces*, where a great deal of the force is lost by the air spreading itself into nose, mouth, and gullet. A person into whose wind-pipe we had put the *cannula* of a small trocar, breathed out a considerable *sibilus* through it, till a most threatening *angina* went off, and, upon holding a candle to the orifice, after he began to breathe pretty freely by the *glottis*, he blew out the candle at once, and shewed us that the air enters and passes again with a considerable force, though not observable at mouth or nose. And, in this case, the pressure of the lungs must be very great: for, in the *Hessian* bellows, and such machines, we find a vast force raised by the pressure of a very small pillar of a fluid communicating with the fluid in the bellows; and if, instead of such a pillar, we would make a small bladder communicate horizontally with the bellows, we find that the pressure of two fingers on the bladder, would sustain 100 *lbs* at least upon the bellows,

bellows, such is the effect of the pressure in these cases. And thus we see, by the plainest instances, what the effect must be of pressing the blood in the pulmonary artery and its branches, and the pulmonary veins and their branches, betwixt the air on the different sides of the lungs. All this pressure, as we have shewed in the treatise of the circulation, must land directly upon the posterior or left ventricle of the heart, and force its *diastole*. And thus the use of the lungs appears in a most open view, and that their importance is no less than what we allow the circulation to be; which we see depends upon it directly, and must be strong or weak as the respiration is; according as the most thoughtless spectators find and acknowledge: and it seems very strange that every one should acknowledge, that the violent strainings in respiration accelerate the circulation, and directly shorten and overcome the *systole* of the heart; and yet will allow nothing to the more ordinary respiration.

AND, by this account of the use for which respiration is employed in the animal œconomy, we easily see, why an animal who has once

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breathed,

breathed, and who shares not of the pressure of the mother's breathing, does instantly suffer in a place where it cannot breathe: with the breathing the circulation stops of necessity.

So that the problem which *Harvey* delayed to solve, and many since attempted to no purpose, appears now plain, when facts are fully attended to, without any comment. The respiration then presses every vessel in the lungs and in the cavity of the breast, except it be the heart included in a cavity by itself; and therefore the respiration must be allowed the great antagonist to the heart, and with it the great instrument of the circulation of the blood.

THE judicious Botanist and curious observer of nature, Dr. *Houston* (who had his degree in medicine from us, and spent much of his time in his younger days in this place) exhibited to the eye, most of the *phænomena* which help us to judge of the force and nature of inspiration and expiration; as we find in his paper N^o 441. of the transactions of the Royal society; where he observes, in a dog whose skin and intercostal muscles he had separated

parated so as to leave the *pleura* entire, that, in time of inspiration, or when the fresh air was forced into the cavity of the breast, it pressed likewise upon the *pleura*, now bared, and made it concave: so that here the force of the air was distinctly seen on the *pleura*, not supported by elastic air within; whereas, if the air had not been changed within, it would have always so balanced the external air, that it should have made no change in the *pleura*. But in expiration, he could scarcely call it convex: and no wonder, when now the ribs, by falling down, were greatly more separated, and kept the *pleura* more tense; for otherwise it would have appeared rather more concave, as the diaphragm is in that case: and therefore the only time the *pleura* can be observed concave, is when inspiration is near its height; that is, when the breast is pretty much raised, and the ribs furled together: for then the *pleura* must be loose, and, as inspiration is not completed, the external air must press on it still, as it does through the *glottis* upon the lungs: but in the turn from inspiration to expiration, the loose *pleura* may be somewhat convex; for
then,

then, upon the air within being at once destroyed by the fumes from the lungs, spread to their greatest extent, the vigorous atmosphere without, in conjunction with the muscles assisting in expiration, now in the greatest vigour, being greatly distended, must act with a brisk *nifus*, and force up the diaphragm, and down the ribs: and as thereby the inactive air is squeezed on every hand, the *pleura*, while loose, that is, while the ribs are not greatly depressed, must rather appear convex; and the whole lungs, which appeared through the transparent *pleura*, must disappear, and the redder diaphragm come in its place; as was conspicuous in the above experiment; though in this case, upon the first contraction of the breast, if we slit through the *pleura*, some parts of the lungs would force out at the orifice; they being pressed every other where by the internal air; as in Dr. *Hales's* experiment, they were greatly pressed by squeezing the bladder, though the air in it was effete; but in inspiration again, they are so far extended to the other parts of the breast, that they are drawn back from the orifice. Thus it was that Dr. *Houston* imagined

imagined the lungs were extended while the breast was contracted, and *vice versa* ; tho' it is quite otherwise. And thus I reckon the turns in respiration are accounted for, and their true causes made obvious ; as likewise its primary use. I shall only further observe, that it is probable, upon the first access of the air to the breast, that, before it is enervated, it rarifies by the heat, and thereby at its entrance gives a sudden shock to the lungs.

SINCE, therefore, the first dilatation of the breast depends wholly upon the muscles employed to that purpose, being originally dilated beyond their natural tone, we find, that the respiration can be only explained by the principles of muscular motion we established when treating of that subject. And thus we find, that the two chief actions in supporting life, depend on the muscles acting uniformly after the same manner.

THERE is no doubt but the lungs are subservient to many other purposes, for speech, &c. ; and that the cooler air, fanning the lungs, and most of the *pleura*, may refresh such as are oppressed with heat ; as the laying the hands or feet in cold water does. But these

these advantages we at present pass over, proposing to treat of the primary use only.

WE have an experiment of Dr. *Musgrave's* and Dr. *Hook's* to our purpose, in Mr. *Lowthorp's* abridgment of the *Philosoph. Transact.* vol. 3. p. 65. 67. Dr. *Thurston*, says Dr. *Musgrave*, asserts the chief use of respiration to consist in maintaining a motion of the blood; but the arguments he produces to make out this assertion seeming to me insufficient, I pitched upon the following experiment, which I hope will be decisive of that matter. I took a middle-aged healthy dog, and, having freed the *trachea* from the adjacent parts, cut it off just beneath the *pomum adami*, and turned the loose end outward, and with a cork stopt up the *trachea*; some few violent struggles succeeded, in which the *sternum* was raised as in the deepest inspiration; and thus he died, two minutes after every motion had quite ceased: when his breast was opened, I found the *arteria pulmonalis*, the right ventricle of the heart, with its auricle, and the two great trunks of the *cava*, distended with blood to a great degree; the *vena pulmonalis*, left auricle and ventricle of the heart,

heart, in a manner empty, not containing more than one spoonful of blood: and hence he concludes, that respiration promotes the passage of the blood through the lungs; and that it is the principal use of respiration. And indeed this is generally the case, however the creature dies. What Dr. *Hook* advances, in the former page, still argues stronger to this purpose, though he thought otherwise; he laid the breast open, and the heart denudded of the *pericardium*, and, by means of a double pair of bellows, kept the lungs quite distended, and furthered the blood through them, by the repeated blasts; which were no sooner intermitted, than the dog fell into agonizing fits; so that nothing but the motion of the heart, supported by thus acting on the lungs by alternate blasts, sustained the life. He indeed argues, that the blood moved in the lungs without the blast; because then, cutting a bit of the lungs off, blood issued out: but this was owing only to the parts subsiding on the blood's having a passage made for it, though thereby it had not a sufficient force to dilate the heart; and therefore not fresh air, but air driven with a sufficient force, was necessary for life, as was
manifest

manifest from Dr. *Hales's* experiment; for when all the surface of the lungs was prick'd and furrounded within and without with air, as in Dr. *Hook's* experiment, how could fresh air be wanting?

COLUMBUS, in his 14th book, where he has a collection of the experiments made on dogs while alive, says, *Si arteriam asperam inter annulum et annulum secueris, et arundinem immiseris; si eam ori admoveris, et buccis inflas pulmones illico attolluntur, et cor ipsum amplexabuntur; et paulo post pulsus immutabitur, se ipso major factus, quo viso sat scio obstupesces.*

I shall end this Essay, by answering an objection of the learned *Frederick Hoffman* against our doctrine; though a great many observations in his works favour it greatly. In the preface to the third part of his 4th vol. he acquaints us, that he and his friends observed often, that the lungs were quite full and inflated with air in those who died of suffocations; and therefore argues, that the circulation could not be stopt in them for the want of a due dilatation; and, consequently, that the inflation of the lungs does not promote

promote the circulation. But I alledged before, that a species of the *asthma*, and perhaps of the worst kind, might depend on the want of a due quantity of the more volatile and sulphureous parts in the blood: in which case, there could not be any expiration, for want of fumes to destroy the air within the breast, and no counter pressure to promote the blood; so that the dilated strong air would rather cause a suffocation than prevent it, by resisting the blood's access to the lungs; though, I suspect, in most cases where the lungs are not destroyed by ulceration or putrefaction, they may be found generally inflated after death; as are the intestines, since the same cause must affect them, that is, the rarefaction of the air not destroyed by fumes; which are suppressed in the corps: and thus it is that the eyes look glazed with humour in a dying person, when the heat does not make it fly off: and by ducking animals several times into water, before they are kept down, they are much longer before they are quite suffocated; so that dogs and cats, who die in two minutes when kept in the water unprepared, by preparing them

continue 10 or 12 minutes alive, and divers a quarter of an hour, from the chilness of the medium in which they are: so that, by cooling the blood a little, and lessening the fumes, the air is not so soon rendered uselefs in the breast, and the creature so easily drowned: and thus, in the receiver, where one pigeon lives two hours, two put in together live only one; and the mercurial gauge rises something upon the death of the first. (*Institut. Acad. Bonon. tom. 2. part 1. p. 340.*)

IN a word, attending to the nature of the fumes of the body, as Dr. *Hales* has shewn it, and the influence they have in respiration, and what this has on the circulation, opens new prospects to us of some of the principal agents which carry on the chief parts of the animal œconomy; and on whose greater or lesser energy the greatest revolutions must happen there: and thus the understanding of them must tend to the knowledge of diseases.

I have only a word to add further, occasioned by an objection lately made by some of my friends. They observe, when an animal dies in the receiver, the air has not become

come so weak as it is on the tops of some mountains where people remain without sudden death. True; but tho' in such heights the air is greatly weakened, yet it must be considered, that it has a free course from the breast; and access to it again; which makes a reciprocal impulse upon the lungs, though not so strong as when the air is more vigorous; which is not the case in the recipient, or when we breathe from a bladder only, whose sides check the spreading wave in expiration, and intercept any return from a distance; for as soon as the whole air in those small enclosures is warmed, it loses all force, being in a perfect state of stagnation; so that after expiration, in this case, there is no air more vigorous, than what is contiguous to the lungs, to force its way to them, and to renew the pressure, and to balance that of the external air which had forced the expiration: and that it is the want of this alternate pressure, seems to be demonstrated from the supplying it mechanically; as we observed from *Dr. Hales*: and for the same reason it is, a candle won't burn after the air in the recipient is equally warmed; for then
nothing

nothing blows upon it, all is at rest about it; as little or nothing blows on a fire exposed to warm sun-shine, or under cover with another fire: but on the tops of mountains, the weak chill air without the breast, must keep up its influence within the breast upon the changes there, though these are not so great as where the air is stronger.

ESSAY

ESSAY IV.

Of the Human Blood.

AN attentive consideration of what the more ingenious and diligent observers of the animal *phænomena* have laid before us, promises to give light to those things we seem to inquire after, with the greatest curiosity, in the human blood.

It is feldom that any thing red, or that can be suspected to be blood, is found in an egg not hatched, which is made up of two observable humours, the yolk and the white : nevertheless, before any motion appears to our eye, or the *punctum saliens* has discovered itself, the blood is observable. *Quantum*, says *Harvey*, *ex accurata inspectione discernere licuit, fit sanguis antequam punctum saliens efformatur. Exercit. 51.* And *Malpighius*, who observed the motion of the heart much earlier than *Harvey*, (that is, against the fortieth hour ; whereas *Harvey* seems to have observed

ved it only between the third and fourth day), could not determine with himself, whether the heart or blood was first seen; though he saw the heart long before he was sensible of its motion, since he had discovered its make even before the thirtieth hour; as he acquaints us in the appendix to his treatise of the egg.

FROM both their authorities, then, the blood was formed before there was any apparent motion, and was, in *Harvey's* judgment, endued with the vital heat. Yet we are not to suppose there was no motion about the *cicatricula* before that time; since, before that, the appearances in the umbilical region were changing greatly, and the vessels were observed swelling: but then, as it was not manifest, except by the effects, it could never be so strong as to cause an attrition, which, by its force, would warm and fire the humours to the deep colour of blood. And what should make us insist upon so violent a cause to produce blood, when we find, by the most gentle motions in the fluids of plants, liquors produced of all manner of colours and tastes? And certainly these early times

times *Harvey* and *Malpighius* took to consider the rise of the humours, were the most advantageous : then we were taken to nature's own laboratory, to see the processes she used in bringing each humour to perfection. Here we find, by their observation, that the simple white of the egg, by the gentle heat of incubation, became, in the umbilical vessels, first yellow, then of the rusty iron colour, and at length red. Nevertheless, we must not imagine, that, without the vascular system, this would have happened ; for we find, in fact, when the egg is not cock'd, or the embryo grows not, as frequently happens, that the hatching heat turns this radical humour of the white into a fetid dark *serum* : so that the action of the imperceivable vessels upon this *serum*, or rather the mixture from different vessels with the heat, is the great cause of the change ; and as vessel and vessel is brought to action, and bowel formed after bowel, so the animal abounds in a multiplicity of fluids of most different aspects ; as many as you could have produced in a spot of ground equal to the compass of our body, by throwing into it as many different seeds as
it

it could have supplied ; and that in a very similar manner, to wit, by the operation of different vessels upon one and the same fluid : much, therefore, after the same manner as different plants work differently upon the crude juices of the earth, does the different vessels of the animal work upon the simple juices of the egg ; and thence ripen and produce every fluid found in the animal body. But as no Philosopher has yet shewn the peculiarities in the root of the betraw, which makes it turn all the juices into the dark red, while the rhubarb makes them yellow, and the dentilion white, or, in a word, accounts for the colour of the juice of any one plant : while the different plants, among them, yield an infinite variety of colours, no more can we expect to give an account of the animal fluids as they change among their different vessels. This is the prerogative of the Supreme Being, who made the animal, and could calculate its growth from the first atom he contrived as a proper root or element for it ; who could limit every part to a certain degree of extension, consistence, &c. and fit them to receive certain liquids to be thrown out of the body as
useless,

useless, or to form new ones, to be employed for certain purposes, in helping the animal functions: so that, as we cannot determine every change of a vessel, attended with a change in the fluid, or observe the smaller vessels frequently uniting, and, by their compositions, forming fluids, we never can calculate the ingredients entering into the composition of the mass in the larger vessels, or these fluids peculiar to some branches from them.

Let us then be content to observe the product of the divine machine, as *Harvey* and *Malpighius* were; with whom we say, that the blood is the product of the animal elaboratory, which works first upon the simple fluids of the egg, and then upon the food the riper animal takes: but as this food is in a greater state of crudity than the first nourishment was, we find a gradual mixture of animal juices provided to digest it, or assimilate it to the animal juices, before it is admitted to the mass, while it is passing through a very long tract of vessels to it; as is known to such who have at all considered the animal œconomy: and against the time it comes to

the last part of this tract, it is formed into one homogeneous white fluid, not unlike, in all appearances, to milk, which falling drop and drop into the blood returning to the heart, is lost among it, and, after a few courses with it, is found quite of a piece with it: and thus the blood, in perfect animals, is daily recruited.

AND though, considering this accession of new parts to it, and what a discharge there is daily of so much of the old stock by the secretions, we should imagine, that, in short intervals, there would be a total change of the blood; yet we have strong arguments to satisfy us that this does not happen: for not only does it keep paternal infections, after the greatest changes in the mass, through a long tract of years, but we find that it is susceptible of the small-pox, till once it has got a depuration by the infection; and that, after this, no infection of that kind takes impression on the blood: and therefore, we may conclude, that part of the first stock is still permanent with it; and that by it is supported its most distinguished property of heat, which is absolutely necessary for all its functions.

ctions. And thus it was, that, at first, nothing was wanting to bring to action the *stamina* of the embryo, but heat; which succeeds equally, whether communicated from the mother, or an adventitious fire; since, in *Egypt*, hatching succeeds by the heat of an oven, as much as by the mother's heat; and I have by me a young crocodile, preserved in spirits, produced aboard a ship from the egg, kept in sand, exposed to the hot season in the *Mediterranean*: and therefore, we must be sensible, that the first heat, which begins the animal life, has nothing in it, but what is common to fire in general. But then, the great question is, what supports this in the riper animal, we find always glowing with a like heat, independent of any external cause. All animals borrow their heat at first to kindle their humours; but once set on fire, their heat never goes out again, as long as life exists; which made *Harvey*, in his book *De calido innato*, name the blood, thus warmed, *Lar familiaris, calidum innatum, sol microcosmi, ignis platonis; non quod ignis communis instar, luceat, & urat, & destruat; sed quod vago & perpetuo motu, seipsum conservet, nutriat, & au-*
geat.

geat. It is the true vital fire, which never can go out, without carrying the life with it ; and therefore by it we judge of a person's being living or dead.

IN eight different persons Mr. *Amontons* examined by the thermometer, the greatest heat was 9, and the least 2 lines above 58 inches ; which was a very small difference in the spirit-thermometer he used ; though the pulse of the highest only beat 66 times in a minute, when the lowest beat 68. *Memoires de l'acad. à Paris* 1703. so that the beats of the pulse did not correspond to the heat. And the same author agrees with the *English* author he comments on, that the greatest height the human body could raise the thermometer to, was not out 59 inches, while at *Paris* he reckoned the solstice heat only above 58 ; so that, by his account, it did not exceed the human heat. And, in *Fabrenbiet's* thermometer, Dr. *Martin*, who was most diligent in his experiments upon this head, found his own heat, and that of several others, raised it between the 97 and 98 degrees. Yet several of our domestick animals raised it between 100 and 103, and fowls between this and 107 ; whereas, in *Italy*, the greatest
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sun's heat was about 89 only, though in an extraordinary season 91; and in *Holland*, observed by *Muschenbroek*, the length of 94: and, even under the *torrid zone*, as was found by those intrusted by the *French* academy, the sun's heat keeps still inferior to that of the human body (*Vide de calore animal. cap. 1.*) and consequently to that of most of our domestick animals, and fowls, which exceed that, according to the above observations. The difference among them and that of man, is not at all great; and probably is chiefly owing to the difference of their integuments, which are more apt to foment heat than our naked skins: and thus the fowls exceed that of the woolly sheep, whose cover yields in warmth to that of feathers, though it exceeds any thing we can contrive, even when we borrow from them; for we cannot implant what they contribute into the skin itself: and *Dr. Martin, prop. 9.* found the urine warmer than the skin. And thus we have a very great presumption, from this equality in the heat of animals, that it chiefly arises from the ingredients of which the blood is made up: for to suppose that it arises chiefly

chiefly from attrition, by the action of the blood against the vessels, is giving up all the observations made about it; that it differs nothing in the infant from what it is in the labouring servant, in the delicate girl, in the lamb, in the straining ox, &c. as Dr. *Martin* has observed in the above treatise: for nothing can be more different than the force and fulness of the pulse, and consequently the attrition in all these different animals, and in these of different ages and sexes of the same species; and yet the heat is the same; nay, the urine, though long stagnating in the bladder, is not less warm than the blood. We must then look upon this heat as the product of the different ingredients of which the white of the egg is composed, as they are wrought by the different vessels and the heat conjunctly. And it seems now agreed upon, that the ferous part of the blood has the principles of the red mass, but only wants to be further manufactured by repeated circulations and compressions, and longer concoction by the heat: and thus, if, soon after a meal, a person is let blood, you will find that much of the ferous chyle separates from the mass, which

which would not be seen some hours after. And if we attend something accurately to what happens to persons of good stomachs after a large meal, we shall be able, distinctly, to judge of the *phænomena* arising from the mixture of the new chyle.

WHEN these begin to dine, we must suppose the intestines, and even lacteals, drained; then eating heartily, in a short time, these vessels are supplied largely, and thence a very great run of new chyle into the veins and arteries, that is, of crude materials; which so far suppresses the heat of the glowing mass: and therefore, as the new mended fire gives less heat, there must of necessity be a suppression of the animal heat for some time; which is found by a chilness immediately spreading over the whole body, and with it an indolence, especially in the winter, when the external cold contributes to chill the mass; and now the fire, and the easy-chair, is sought, till once the blaze gets up, and glows in all the features, and often ends with a degree of moisture: and the person thus affected, we reckon most healthful, and upon good grounds, because it is first the indication of a good digestion,

gestion, and then of a hearty meal, which happens not to the invalid.

WHEN therefore we advance, that the blood is of much the same degree of warmth in most of the more perfect animals, it must be understood, when it is in its most perfect state in them: for *Sydenham* has long since acquainted us, in his epistle on hysteric symptoms, *Quod non rarò notabilis quædam externarum partium refrigeratio, symptomatis his omnibus viam quasi sternit, et plerumque non nisi paroxysmo finito depellitur: quam quidem refrigerationem haud semel isti ferè, quâ rigent cadavera, parem comperi, pulsu nihilominus rectè se habente:* in which case, to be sure, the thermometer should have subsided by their touch, as it does under the cold of an ague, according to Dr. *Swencke's* account; who, in one person, found that then his thermometer, which was of a piece with Dr. *Martin's*, did not rise above the 60th degree, though in another to the 87th, but in time of the great heat to 104, and of the sweat to 100, and when all was over, 95; so that this animal heat, so equal in persons of health, differs greatly in the same person under diseases; but

but in none more than in persons under the *chlorosis* or *febris alba*, who have scarce the colour of blood, and yet recover it very fast by bitters and steel, with exercise, and especially by the use of the bark : these are subject to very feverish warm fits, though for most part to cadaverous chilness. So that in them, and the aguish, there is something resembling the course we observed in people of health after a hearty meal ; an extraordinary heat after observable chilness and coldness : and whether or not it is owing to a like cause, a great proportion of crude matter, intermix'd with the mass of blood, that checks its heat, till it be digested and assimilated to the mass, I leave every one to judge from the *phænomena*.

THERE is another vulgar observation, which seems much of a piece with what we have advanced, and to depend on a like reason. If one has been very warm or sweating, and is immediately exposed to the cold, he first has a feverish horror, and then the feverish heat of more or less continuance : what more probable reason can be assigned for this, than that, after the external vessels have

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been

been much evacuated by the force of the heat, they come suddenly into an absorbent state, and introduce a flow of crude juices, which stifle for a moment the heat of the mass. Or this may be accomplished (as Mr. *Hales* would have it, (*append. hæmast. obser. 4.*) by suddenly chilling the humours in the dilated vessels of the surface; as he supposes to happen to those who sit long in the open air: for though, says he, in that state, we may not be much sensible of any cold; yet on our first moving, whereby the motion of our blood is also accelerated, we are then immediately sensible of chilness all over us, which is, doubtless, owing, adds he, to the very cold surface-blood's then running in greater plenty among the next adjoining inner vessels, which, being much warmer, are then sensibly affected with the sensation of the much colder blood, from the surface of the body; or rather, as we were saying, stifles the heat of the mass, and produces a great coldness through the whole body, as we reckoned the greater flow of chyle does. And the effects of it, in all these cases, are most manifest; for on making urine at that time, we find
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it quite limpid; so that none of the sulphureous fumes are then raised and carried off with it, so plentiful at other times; and a breathlessness is felt, on the want of them, at the breast.

WE may understand, likewise, how a single drop of water, upon the warm surface of the body, should diffuse a chilness over the whole. For, as we observed in treating of muscular motion, all the fibres of the skin are on the stretch, and with the same *impetus*, by which the *stimulus* of the cold drop contracts these it touches, we knit and contract all the rest; this is a copy inducing us to ply the rest after the same manner; and thereby there is a general push of the surface-blood in upon the mass, which is not felt when flowing slowly, and mix'd in a small proportion with the mass. And thus, sudden fear, attended with a strong contraction of the external parts, may chill the mass.

BUT though I would argue, in some such cases, for the stifling the flame and heat of the blood, by a run of crude or chill'd humours overpowering it; yet I am far from imagining that this is always the case: for any thing that will intercept the blood from going
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to the extremities, produces a like feeling; being so far in the same circumstances with the gangrened limb, through which no blood moves at all: and thus we can never be surprised to find a cadaverous chilness, when the pulse quite disappears; as happens upon great loss of blood, or other evacuations continued, so as to drain it greatly: or any other cause by which the circulation is weakened; as the abdomen being in too relaxed a state, or the whole solids weak, as in the *chlorosis*, &c.

BUT yet there is certainly still something more mysterious in the sudden productions of a cold chilness in some cases; as in these hysteric disorders *Sydenham* mentions, where, with the coldness, the pulse continued good, and consequently the motion and attrition took place, tho' not the warmth; and what we shall suppose in these cases, is not easy to imagine. But, as natural history furnishes us with a variety of examples, (as we find by *Dr. Martin's* collection, in his 20th proposition on this subject) where the ingredients of mixtures, of themselves, produce heat and cold, we may justly suppose that the mass of blood sometimes meets with some
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such ingredients. I shall give only one example, from Mr. *Boyle*, where we have instances both of heat and cold produced in an instant, (his works, *vol. 5. p. 97.*); salt ammoniac, cast upon oil of vitriol, gradually produced a seeming effervescence, with great noise and store of froth, which more than once was ready to run out of the vessel; yet the mixture was cold both to the touch and thermometer; then throwing this into three or four times its quantity of cold water, it turned so warm, that the glass was held with uneasiness. Such instances as these would persuade us, that when heat is attended with effervescence, yet it is not the necessary consequence of it, since cold arises likewise along with this, and that cold is produced from certain mixtures; so that in such as are subject to sudden chilness, if no evident cause casts up, it is not absurd to suppose, that in a diseased body, where the humours are always changing, some of them may suddenly chill the mass, tho' such a cause must always be very obscure.

BUT, from the whole of this history of the causes of the productions of heat and cold

cold in general, and the cases of the human body where they are produced, it is abundantly evident, that bare attrition can never be admitted as the cause; and is still more evident from examples we have in fevers, of very great heat and drought, and the reddest urine, with a scarce perceptible pulse; of which (this very season, *June 1750*) I have had many examples, where I extinguished the heat with diascord and claret; which always turned worse, by drinking water and watery things; and even with *crem tartar*, which I find a great charm in most inflammatory fevers. One of these patients, who had been tossed with anxiety, heat, and drought, for three days, made me feel his fore-head, while I could scarce feel his pulse; and it felt no otherwise, than if I had held my hand close to the grate of a large fire. The claret raised his pulse, extinguished his heat, brought moisture to his parched palate, and a digestion to his urine; periodical sweatings accompanying the change for some days, as it did for ordinary this season, tho' he kept weak and giddy for some time after, in spite of the bark and claret.

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AND as we find, according to the constitution of the season, fevers of different degrees running out to different periods, and many of them attended with eruptions of different aspects and different courses ; what can be more certain, than that, under these different *phænomena*, the humours are in a most different state, undergo different agitations according to it, and at length have discharges of different natures ; especially since we find that the matter so discharged, applied to some sound bodies, produces a like course to that by which it was produced, while there are others not susceptible of the contagion ; as in epidemic diseases, one species of animals are affected, and not another. Can this be by any other means, than the infectious matter mixing with, and working upon the mass appropriated to it, and thereby producing an increase of heat, &c. ? And if an increase of heat accompanies these agitations, by which so many forms of matter are cast out of the blood, and so many other new appearances made ; why should we be so backward to allow the action of smaller particles of matter in the blood among themselves

selves to be productive of heat? If we had any instance of pure water, by being agitated, receiving any degree of heat, we might imagine the blood wanted no more. But as this has not as yet been shewn, and we have the plainest instances, even in the body, of a change of mixtures causing more or less heat, we have all the reason in the world to allow, that it is the nature of the parts making up the mass whence the constant heat of the blood is supported, and whence its greatest irregularities are to be accounted for. There is no doubt that the motion contributes to it: but we have shewn, that it does not rise and fall with the motion: and therefore motion here does as little, as pressure to a dunghill or undried hay, without which they do not heat, whereas it preserves what is dried; and consequently, not the pressure, but the juices of the grass in a moist state, kept so close as to make one part act upon another, produce heat. And thus the circulation mixes and presses to the same purpose juices fitted to act upon one another when in contact, and which seldom but heat, even after death, when the chilness of death is over; which

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new heat is remarkable even amidst the greatest heat of the atmosphere around ; for then the air in the body, enjoying its elasticity when no fumes act, swells in every vessel, and causes a very close pressure of the juices, and hence they kindle : and, in the greatest health, if you keep two parts of the body contiguous, they heat and scald. Nothing is so active as the different parts of the blood. The perspiration, or any other part of it, kept close upon the animal body, is apt to propagate itself. Itch produces itch, pox the pox, and, in many cases, infected perspiration, the disease whence it was infected. Is it any thing strange, then, that the warm blood should bring the chyle into the same degree of heat, after being contiguous with it for some time, since most of it is animal juices, and the rest fermentive juices of vegetables ? All of them have the principles of heat in them, and very soon warm when kept close together, especially in a warm place : and though the hot-bed, after coming to a certain heat, gradually cools again ; yet it would never do so, if recruited perpetually with new materials of a like nature, as we

find the blood to be ; which yet can be long preserved with no recruit in some cases, without losing quite its heat : but then it preys somewhat on the body ; which turns parched and dry in these cases, but not putrid, as has been supposed : as we found in the case of the young Lady mentioned in the first Essay ; who, after fasting compleatly two months, and living sparingly for six months more, under the severest exercise of her muscles, nevertheless had no stinking breath, no high-smelled urine ; this, amidst all these severe agitations, keeping quite limpid, and she herself rather cold than warm, though her pulse was generally full. So that, in her case, we had the strongest attrition I ever had an instance of ; but no extraordinary heat, no sign of putrefaction : the more sulphureous parts were much spent in her, and she seemed to have no recruit, but what accrued to the mass from the cellular stores laid up in health, or from the air. And, in the young man of a good firm constitution Dr. *Martin* speaks of, *prop.* 18. the heat decreased four degrees on two days fasting, from the want of new chyle, and not from a less quantity of blood.

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Therefore, not the strength of circulation, but certain mixtures with the blood, seem the great cause of putrefaction in it; as the daily recruit of wholesome food keeps up the ferment and heat. And hence, in prisons, ships, and hospitals, not well air'd, the most putrid fevers are found, especially when the season is sultry-warm: and many sores do not shew their worst till laid open, and an access made to the air to work upon them, as in cancers, gangrenes, and several others. Nothing, then, seems more susceptible of contagion, more disposed to be wrought upon, to be agitated, to ferment, than the blood: nor is there any fluid that shews more different products, as we have already observed, than the blood does under these courses; and medicine must be greatly defective, while we are defective in their history. The antients laid themselves out greatly to observe the periods and crises both in acute and chronical diseases, and to assign the marks of the more or less promising, to teach the Physician when and how far he should interpose; and Sydenham, with great sagacity followed the example. But the extravagancy of Chymists, in introducing what was observed only in their phials
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and retorts, whereby to judge what passed in the body, brought this method greatly in discredit, and made way for the Mechanics to establish their empire, which was not able at all for the government: and therefore it cannot be surprising that the commonwealth of medicine flourished so little under their absolute authority. Mechanics, then, and Chymistry must be joined, if we would see and judge of what passes in the body: and we must be sure of supposing no power, no active matter, to be employed, but what in fact has been discovered present; in which case we shall enlarge Chymistry in its bounds, and Mechanics, by introducing under them many things found in the body. But we must beware of establishing any thing found with Chymists and Mechanics as part of the animal œconomy, which we have not been able to trace in the body. All things from analogy, must be introduced with the greatest caution. We must see the instruments we bring into our operations so distinctly, as to be able to describe them; and then we may be sure we impose not upon ourselves or others. And thus, after the trials made of the heat of the

the blood, we are confident of its degree, and of its equality in the most of men in health ; and, by the same trials, we find how it varies in diseases, and what *phænomena* go along with its changes : and to it, and the matter it works on, we attribute both the quantity and nature of the perspiration. Since the heat of the blood is greater than that of the sun in the dog-days, and the blood itself at least twice more volatile than water, as we shall find afterwards ; and as nothing is more porous than our skin, the evaporation must be very great ; and as, by many experiments, this evaporation is found inflammable, it gives us a pregnant proof of the nature of the whole mass ; that it is a bituminous fluid, seething constantly with a degree of heat about half that of boiling water, according to Dr. Hales's calcul, *exp.* 10. *Veget. Stat.* and Dr. Swencke's, who makes boiling water 212 in *Farenheit's* thermometer.

THIS heat, then, must have different effects on the concoction of every different humour according to its nature, and as it lies more or less near the larger streams of the fixed mass ; and hence its use in the body must be various,

various. To this in particular we must refer the assimilation of the chyle to the mass; the turning the acid fixed salts to the volatile neutral, as we find them in the urine, (*Vide Dissert. on the urine*), and in the mass itself; so that there is here a true chymical change, and with this change the sulphureous or oily parts are greatly exalted. A friend of mine, to satisfy himself of what *Hoffman* and *Swencke* advance upon this head, setting blood and water in similar vessels, equally filled, in the same window, found that not above a fourth of the water was evaporated, when an half of the blood was gone; that in 48 hours it was reduced to an extract, and in 72 to the consistence of glew; and this, dried to a cake, and powdered, according to *Mr. Boyle's* observations, flashes like rosin through the candle's flame; so that the whole mass seems to be most volatile and sulphureous. And, in our treatise of respiration, we have observed the effects its fumes have upon the air admitted to the chest, and that no such thing as respiration could be without them; at the same time, the air in every other cavity and vessel is kept at under, which otherways, by
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the degree of heat that acts upon it, would burst every vessel ; as it does in some degree in the corpse, when there is no check by fumes.

AND the nervous juice evaporating in every bowel, by the same heat, must make a great demand upon the brain ; as the evaporation by the leaves of plants and trees makes demands upon their roots, according to Dr. *Hales's* observations. And thus, all along the pulpy substance of the nerves, we see a necessity of a perpetual run of the nervous juice, which we cannot conceive should happen upon any other supposition : and thus the heat of the blood is as necessary to promote the nervous juice, as that of the sun to bring the juice of plants into action. But if the brain, the source of the spirits, is drained, then the heat has no right materials to act upon ; and hence every part turns languid, though the heat is in vigour. And thus it is we are disposed to rest and sleep, and continue so, till the brain is furnished with stores for the service of another day. And, from the same reasoning, we understand why sleep accompanies the greater degrees of cold : and,
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on these views we must allow, that *Harvey* could not have given the blood a juster character than the *sol microcosmi*.

I have often observed, that people subject to periodical fits of the *mania*, as a prelude of the fit approaching, have complained of a weight and fulness about the *hypochondria*, and of a more intense redness in their urine, which, at the height of the fit, after lasting some weeks, came to be as dark as that of claret; and going off yielded a copious dark sediment, not unlike what we find under the jaundice; which confirmed the notion of the antients to me, that the seat of the disease was certainly about the *vena portarum*, and the vessels immediately communicating with it; and that the blood there suffered great changes; which was confirmed by these medicines only being successful in removing the illness, which chiefly operated on these parts; whereas the cephalic medicines shewed no good effect. Now the question is, what force the blood or humours in these parts, of whatever nature we shall suppose them, could have in disturbing the mind, in turning its state to a state of vision,

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to hear, see, and feel things so different from what actually passes before them or is transacted, as happens in many other cases. To judge of them, we shall take some of the most simple examples, where the cause is certain, and the remedy. One of these I take to be that of getting drunk. Let a person be fuddled with spirits, how does it change his thoughts? he raves, and becomes a madman; pour into him some draughts of water to dilute the spirits, and extinguish their heat, at once he is himself again. Wherefore it is manifest that, in this case, it was the fiery sulphureous blood whence the heat and all the disturbance arose; and that, by augmenting the quantity of the watery parts, the heat was extinguished, and the wild fancies with it; while we cannot easily suppose that the nervous juice was changed. But how shall we determine whether blood in this overheated state, immediately by itself perverts the fancy, and leads the mind in a train of errors; or whether it first acts upon some sensory more intimately connected with the soul? For my part, I cannot find why we should reckon the mind worse to be affected by the

blood of itself, than by some sensory disordered by it; especially as we find it certain, that the mind of the mother affects the child in the womb, though there is no communication of nerves between them: and though we have sensories appropriated to form certain ideas, as of sound, light, and colours, &c.; yet I know none for sense and reason; tho' if there were any, we could not but expect, they should be as complicate and conspicuous as the others. That all the senses by which we have certain ideas excited, are disturbed with the blood, there is no doubt; and this certainly must confuse the mind greatly: but how from this a man turns more pensive, frolicksome and furious, should converse with persons not present as if in view, &c. cannot be explained from any change of the senses: and therefore though the mind falls into some mistakes from the senses, yet this thorough perversion of the mind, must be from some other source: we must allow, while the house is in a flame, that the mind is bewildered in the smoke; and that as it is intimately joined with every link of the muscular fibres, so it is with every drop of the fluids, and has
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certain ideas from every different motion in them; fries with the bile, with the *saliva* of mad creatures, and turns stupid, morose and senseless, with a less volatile mass. The unmanageable bull, perpetually roaring with fury, upon checking the mildest secretion of his body, and what lies at the greatest distance from the brain, becomes the obsequious and mild ox. I don't pretend to be distinct in this affair; but would study to say so much of it, as to fix the Physician's attention to it; since, by rectifying the mass, and being attentive to other places than the head, in such disorders, it is possible we may come to have a greater command over them, than has yet been imagined. For I have often found, that, by the easiest methods, I have composed such disorders; when the green withes to tie them, or the whip to chastise them, with blisterings and cuppings of the head, had been idly applied.

TAKE all the effects of the warm blood together, then, it must appear a very mysterious fluid: its streams accompany every nerve, and facilitate the course of their fluids; and thereby invigorate every part of the body:

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on its stop, all strength and nourishment stops, the parts gangrene, &c.; by its fumes, the machinery of the breast plays and changes an hundred ways, the air shews different powers within every cavity and vessel; and we have just said how much they affect the fancy: no wonder then that *Harvey* could scarce imagine it different, not only from the vegetative, but the active directing soul itself, as we find in his treatise, we cited, *de calido innato*. But what he and others have said, only shews, that there is something more wonderful in it than has yet been discovered distinctly; and that a further attention to it, may greatly enrich both the theory and practice of medicine, beyond what the mechanick Philosophers will ever be able to make out.

BESIDES the sulphur which remains in the blood after calcining, *M. Vincentius Menghinus* mentions a great portion of iron particles, especially in the human blood and quadrupedes, some in fishes, and fewer in fowls; how much these contribute to support the heat of the blood, I leave such to consider who

who know the ingredients in the *thermæ*, though vegetables abound in them likewise. *Vid. Institut. Bonon. part 2. vol. 3. and Medical Essays, vol. 2. art. 6.*

UPON the whole, we may make the reflexion Galen has, *edit. chart. vol. 10. de Hirud. cap. ult. circa fin. Nam sæpius in anno venam secare haud expedire arbitror; quod una ex sanguine vitalis excernatur spiritus. Atqui si hic copiosius absumatur, tota moles refrigeratur, et omnes naturales operationes deterius perficiuntur.*

FOR a particular answer to their opinion, who deduce the heat from attrition, I must refer to Dr. *Stevenson's* excellent treatise on the heat of the blood, in the *Medical Essays*. I have said nothing of the globular form the lesser particles of the blood have been observed to move in, by microscopes, and to which it resolves itself: I reckon the blood has this form in its compounding parts in common with most fluids; which Mr. *Lewenboeck* would have overlooked in the blood, if he had not discovered it before in the yeast of wine and ale; as he acquaints us in the 2d epistle of his works; though they form
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more regularly in the blood, as they do in every oleaginous fluid; Sir *Isaac Newton* having observed the attractive and refractive power of bodies, to be greater or less, as they partake more or less of sulphureous oily particles, with which we have shewn the blood to abound. What seems more nearly concerned in its history, is the perspiration and urine, two secretions on which its right state greatly depends, and which help to form just indications concerning it; and therefore, to complete its history, we shall subjoin some account of them.

Of Perspiration.

THIS seems to be an evacuation, without any particular *apparatus* for it: at least every porous body is subject to a like discharge from similar causes, that is, from heat, and a supply of volatile matter; and no body can be more porous than the animal, *M. Lewenhoeck* having calculated, in the space of an ordinary grain of sand, no less than 125,000 of them; which there is no reason to suppose to be the extremities

extremities of regular vessels, but the interstices along their sides ; at least we find, that the inward surfaces of the cavities of the body, and the surfaces of the bowels they contain, have the same perspiration which strike our smell, upon the cavities being laid open, while a cloud of vapours arise from them, and they instantly absorb liquors injected among them : nay, we see upon bruises, that the blood under the skin is gradually absorbed ; and, according to an observation of *Galen*, cited by *Mr. Boyle*, in his 6th chapter of the porousness of bodies, blood extravasated in fractures, where the skin had not been rent, penetrated it so as to appear upon the dressings. Whence we would imagine, that from every side the skin was permeable ; as the same Gentleman found the bladder, by putting salt of tartar well dried into it, and tying it up when quite free of all moisture ; for in that case, he found, when the bladder was left in water, the salt soon dissolved ; and even sugar managed the same way, though it dissolved slower. As *Hippocrates*, then, long since asserted, the body is every way permeable, and, as it would seem, perforated, as is every

every vessel : for how can we suppose membranous and fleshy parts not to be porous, when we find the hardest bones, and ivory itself, to abound with them? as is shewn by particular experiments in Mr. *Boyle's* essay we have mentioned. The body, then, abounding with fluids, every fibre, though not vascular must be moistened by them through and through, as a string of hemp or lint will be, if you dip but any one part of it into water, especially in a warm place.

AND thus we consider the whole body as one porous lump, sapped in its own fluids, and glowing with 96 degrees of heat, according to *Farenheit's* mercurial gage, when not chilled by external cold or disease : in which view, we must be sensible that it must perpetually emit clouds of steam ; and, agreeably to this, it is found in summer, if one sits near a white wall, enlightened by the sun, with his head new shaven, that the steams shall be discovered by the shade on the wall. And, from this account, there are three great causes of this perspiration, the heat, the quantity, and the volatility of our humours.

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NONE can doubt but the matter perspired must always bear a proportion to the heat ; and, consequently, cold on the surface of the body must check it considerably ; heat being the known cause of raising and carrying off steam from fluids, as Mr. *Hales* has shewn by repeated experiments in vegetables. If this had been adverted to, we should not have had so much talked of the effect of cold closing the pores of the body. Let the pores be as open as you will, there must always be heat to raise the steam ; and that will always find pores to favour its course.

WE took notice, when treating of the blood, of its great volatility in respect of water ; so that we must look upon it as favouring a great discharge when exposed to heat ; and that according as it is more or less crude, or as it has had supplies that more or less favoured its volatility. And thus it is observed by Dr. *Keil*, and others, who have made statical experiments, that though in those who live uniformly the perspiration keeps something equal ; yet it is found very different in different persons, according to their temperament, age, food, sleep, exercise, and season

of the year ; and all these, either as they change the heat, or more or less promote digestion, and a just quantity of fluids ; agreeable to which we find the whole of Dr. Keil's observations.

THUS, in *aph.* 15. he tells us, the perspiration is in proportion to the heat in the same circumstances : agreeable to which, he found that the greatest summer perspiration through one day, was double of the least winter perspiration, as in *aph.* 17. : that coming out of the hot bath, an hour's perspiration was not less than 24 ounces, *aph.* 25. ; whereas sitting in a cool place, it was not above half an ounce in that time, *aph.* 23. and, by heat and exercise, only four, and sometimes less, *aph.* 21. : so that heat and moisture joining make the greatest ; whereas chaffing the skin made no change, *aph.* 33. : and though bathing promoted greatly the perspiration, yet drinking small liquors did it not ; and therefore perspiration in the first case was certainly owing to the more external parts retaining much moisture, which the heat soon dispelled again.

AND

AND as it rises by heat, and consequently exercise, and every thing causing heat ; so it does by certain foods, some supplying more, and some fewer volatile parts, which recruit the mass more whence the perspiration flows : for since we found, in our essay on the blood, that it was greatly more volatile than water, it will be more or less so, as it abounds more or less with water, in regard to its other parts, or any other thing less volatile, or curbing what is volatile. And thus Dr. *Keil* observes, that, by eating oysters, he perspired less than when he eat nothing at all. But, more particularly, the tables which Dr. *Rogers* of *Cork* published, shew, that, even in summer, with the advantage of heat, lettuce, mushrooms, melons, cucumbers, purslain, diminished the perspiration a third, as did the rest of the slimy, watery, vegetable kind of food : and it is greatly diminished likewise by pork, new cheese, bread not well fermented, ryce, as it is by soles, eels, oysters, and fish of a like nature ; while it is greatly favoured by well baked and fermented bread, fresh eggs, honey, mutton, partridge, woodcock, plover, turkeys, capons, pullets, and the like, wines
of

of ripe fruit, well wrought ale, &c.: so that there is the greatest odds in it, from the *pabulum* with which the blood is supplied.

IF, then, constitutional asthmatic patients are made so by a defect in their blood, by not having store enough of volatile parts to keep it under the elastic air in the vessels, as we suggested before ; then we see what air they should chuse, and what food. But to bring this to a further demonstration, many more experiments must be made with this view.

WE shall close up this treatise, by confirming what we observed before, of the great volatility of the blood in the sound body, from an experiment we have often repeated ; that the shirt through which we perspire odds of a pound in the night-time, gains not one grain of weight in that time ; nay, not after being worn three days and nights together : so that the perspiring matter must fly quite off even through our cloaths.

Of the Urine.

IT is abundantly evident, that, in general, the secretions are made in vessels where the red blood does not enter, though we know that many of them are thicker and more gross than it is; as the cystic bile, *semen*, *mucus narium*, *cerumen auris*, &c. But all these acquire their thickness after the secretion in the finer vessels; and it may be presumed, that the nearer any secretory vessel is to the greater artery, and the less diminished in its wideness, that the secretion should be less changed from the qualities it had when carried along with the mass: on which account, it is not a little probable, that the urine has changed but little from the state it was in before the secretion; and therefore is one of the most proper standards to judge of the state of the mass.

THE emulgent arteries, we find, from inspection, are the largest branches of the *aorta*, and separate from it by an acute angle; and though, upon entering the kidney, they suffer great circumvolutions in their branches,
which

which are every where reflected into veins, so as to allow all the red and weightier parts, keeping the *axes* of the vessels, to return ; yet we know, that any extraordinary shock forces in red blood even into the secretories and excretories ; that injections penetrate the same part, which is not found in the other glands : and therefore it is justly presumed, that in so patent a way, and so very short, small changes happen to the passing fluid ; and consequently the urine may be looked upon, not as transformed, but as the part of the *serum* which coheres the least with the mass, while what coheres more, passes with it by the veins ; the small distance from the *aorta* and openness of the vessels not favouring their separation : whereas, where the course of the red blood is much retarded before it reach the secreting vessels, as in most of the other glands, the mass of itself will resolve, and take on it the serous form, as when extravasated ; for then, when kept in a moderate heat, it resolves almost quite into *serum*, though not in the cold, as Dr. *Swencke* observes : in such cases, then, the secretions are made from the resolved mass, while the urine is from the
more

more loose and unfocial *serum*, which had not united to the mass, or had corrupted by its long service. And thus we find how this organ is fitted to cleanse the blood of what was useless and pernicious : whereas the other glands change parts of the mass into liquors of different natures, as the service of the body requires : these are made to change ; that only to separate.

AFTER this view of the organ, by which the urine is separated from the blood, it cannot appear strange, that the urine should have been so much consulted, both by the antients and moderns, to form a notion of the state of the blood : for as it is the immediate offspring of the *serum*, very little changed, by which we may rightly judge of the stock ; so it has in it all the most heterogeneous parts which are not so apt to associate with the mass. Thus the bile, which, after its formation, acquires a very different consistency from the blood, and degree of acrimony, when denied passage to the intestines, runs off in great quantities by the kidneys, and makes the urine look as if it had got a mixture of claret, though the cloth dipp'd in it
looks

looks yellow, and causes immediately a very copious sediment ; a great proof that the sediment is made up of heavier parts, which do not so easily assimilate to the body of the urine. The same way, let a man have the course of his perspiration stopp'd, by being in a cold damp *medium*, and we will see the sulphureous parts that should have gone by it, changing the colour of his urine : so that its stramineous colour shall now, even in the stream, appear, when running, changed for one of a much deeper tincture ; and, catched in a glass, shall soon become of such a muddy clayish look, as when tincture of castor is mixed with any simple water ; with which it does not so intimately mix, as the castor had done with the spirit. Now the castor is a fat or sulphureous animal substance, and of the same volatile nature with our perspiration ; and shews greatly that *phænomenon* of our perspiration confounded with urine. The *stimulus* of this retained perspiration in the blood most ordinarily raises a fever, as in the urine it causes a *miçturitio* ; and then this fever an increased perspiration, which is always proportioned to the heat : and with it
not

not only the more volatile parts fly off, but every thing that is more fluid; so that the blood is thereby greatly deprived of the watery parts, the mass rendered thicker, and the *serum* less in quantity, and of consequence must yield less urine, which will therefore continue longer in the passages exposed to a greater heat. And thus new colours appear in the urine; for now it gains, according to the degree of the fever, that degree of intenseness in colour, *Bellini* observed to arise in urine according to the evaporation of the aqueous parts by heat, till it comes the length of the colour of red strong ale; which it has in the higher fevers. Thus we see in what shape the stopp'd perspiration at first changes the urine; though the after-changes, in consequence thereof, arise from the fever, and too great a perspiration: so opposite are the changes happening in the body from one and the same cause! And thus, according to Dr. *Swencke's* observations, if blood be let in a very cold place, it has no *serum* separated; in some small degree of heat, by degrees the *serum* separates fluently; if in a place near to the heat of our blood, of 92 or 94 degrees,

the *serum* separates in a small quantity, till it putrifies; but in a degree of 48, it coagulates; and raised to that of boiling water (212) $\frac{7}{8}$ of it fly off in vapour; so different are the effects of heat in the different degrees thereof. So that *Bellini*, very justly, after putting it to the trial, made the evaporation by heat, the great cause of change in colours happening in the course of a fever; and confirmed it greatly, by shewing the first colour gradually recovered again, by gradually diluting it in water; and when the urine is thick, and increased in toughness, we find no sediment; and therefore reckon it and the blood, whose interpreter it is, to be then in a state of crudity or indigestion: but when our drink, for which there is a great demand, incorporates with it thoroughly, so as to dilute the whole mass, and render it quite fluid, then the urine is so in proportion, and with its pale aspect, and copious sediment, shews the approaching change in the fever; and the same fever, in different persons, for most part, takes the same time to shew this; which shews, that crudities, according to their causes, require limited times to digest; and would
argue,

argue, that, besides stopp'd perspiration, there must be a variety of specific causes, which procure epidemic fevers, or that vitiate the blood. But, in any of them, we find seldom a resolution without the signs thereof appearing in the urine; which shews how much the humours are affected in such disorders: and as we find the effects of stopp'd bile and perspiration in the urine, so it is not to be doubted, but every other secretion stopp'd, causes gross parts to regorge into the mass, and supply the urine with heterogeneous parts, which will subside: and thus we find, under any swelling or tumor, where-ever it is, the urine always with an observable sediment; as blood let in the same case generally shews the gelatinous tough surface; and consequently every new disposition in the *serum*, which furnishes the urine, always makes it shew a new face, and for most part a sediment, occasioned from the blood's not having a free course, under which only it digests into an equal homogeneous mass: *pus* too, drawn up into the mass, and not easily mixing with it, has got vent by the kidneys, as do small liquors taken

taken in great quantities, which makes them not easy to be assimilated and incorporated with the mass.

BUT then the vessels of the kidneys, under some diseases, manifestly change their dimensions; and in that case it cannot be supposed that they should act as in their natural state: thus, after long habitual drinking, especially of the weaker liquors, a *diabetes* takes place, under which the milder part and less diluted of the *serum* passes, and very soon exhausts the person; as I saw in one, after long stoppage of one of his kidneys by a stone, who passing about half a pound every hour, was in two days exhausted in spite of the most astringent medicines. By a violent agitation of the blood, under severe exercises, blood itself has been forced this way: and under convulsions, or even the milder contractions of hysterics, nothing but the more watery parts will pass. And thus we find how the urine changes with the mass of blood, and with the vessels of the kidneys.

BUT further, a great many changes can happen from other operations on the organs concerned in the forming and transmitting
the

the urine. Dark water, as tinctured with foot, named ordinarily moss-water, generally attends a stone in the kidney, and arises from the oozing out of some blood from the smaller vessels grated by the stone, and heated along the passages; as the blood from the upper parts of the intestines loses its colour, and becomes black, especially if from the liver, when it has the name of *atra bilis*. But a stone in the bladder has generally a slimy urine from the *mucus* of the bladder, if not pure blood, when the attrition is greater; and the pain in making water is at the beginning, and sometimes at the end; whereas from an ulcer it continues all along, and you have *pus*, blood, filaments, &c. according to the state of the ulcer; to be known from the preceding symptoms, and the present appearances. In forcing a sweat, either from exercise, warm bath, or medicines, you have urine like what we observed to arise from tincture of castor; and from being abroad in the cold, at first we have the watery and pure, as under convulsions; though afterwards what arises from stopp'd perspiration.

As

As to the chemical productions from urine, *Boerhaave* has shewn trials in his *Chemy* he made on urine passed 12 hours after neither eating nor drinking: this urine, he informs us, had nothing acid in the taste or smell; and these things which turn acids reddish, made no such change on it; nor did dissolved salt of tartar raise any agitation in it, nor the most alcalescent spirit of *sal ammoniac*: and even the urine of a person 12 hours after he had been drinking Rhenish wine, and ale something turned, and used vinegar to what he was eating, and eat summer fruits, shewed no sign of acidity in it; as it did not in sickly girls living on milk and acid vegetables; nor did any sign of the *alkali* discover itself by the addition of vinegar, limonjuice, spirit of nitre, of salt; nor did it make green the juice of plants, as all the *alkali's* do: and this was observable even in the urine under inflammatory diseases, long retained, and made in a small quantity: and he had occasion to examine urine which had been suppressed 120 hours, which yet discovered nothing of the alkaline nature, though he found it in another; and allows, that when
urine,

urine, on any account, is made to putrify, that then it turns alcalescent. But then this is not in the natural state. The salt of urine is therefore a neutral salt, and with it is joined some sea salt, that never changes in the body. And thus we find that urine is a part of the changed and digested humours of the body, which have acquired a nature peculiar to themselves, when retained a competent time. All of this history is confirmed by Dr. *Brown-Langrish's* experiments upon the urine, in which he has used great diligence; for in a great many trials made upon urine from persons under fevers, he could not, before distillation with a strong fire, find any appearance of alcalescency, except in his 4th and 5th experiments; and even in this case the appearance was very small, tho' the heat had been extreme, as well as of a long continuance: but he acknowledges it was a singular instance, out of a great many under ardent fevers, where he could not find another; and concludes his observations, that, in his 5 trials on the urine of a young woman, where the fever was so high, the urine became more and more impregnated with saline and sulphureous

reous parts, in proportion to the abatement of the bad symptoms, till at the *crisis* it contained more than double the quantity it did before; which discovered a plain digestion and resolution of the mass, too much coagulated, or closely combined, under the strength of the fever, when examinations made on the mass, and urine, would have shewn a great difference of principles; the urine, in that case, having a small share of them. And thus we find, in most of these cases where Dr. *Langrish* examined the cohesion of blood in his patients under fevers, that the urine was limpid, while the *serum* was deep coloured and pungent, and the blood strong in its cohesion. In others it was indeed otherways; particularly in his last case, where the urine was lixivious, and the *serum* exceeding pungent, and of a deep bilious colour, and there was a vast cohesion in the mass: but, as this was in the 13th day of the fever, it is possible it might be under some remission: for, in some of the worst fevers with remissions, I have seen urine, which in other cases would have promised well, attend the worst turns; at one time with the fullest sediment,

diment, and the next limpid without any at all, having the appearance of many partial *crises*; but, in the mean time, carried off the patient. From these observations, it may be allowed, that the urine gives generally a good indication of the state of the blood; and that, with an ardent heat, limpid water is a great indication of a strong cohesion of the mass; which continuing, kills the patient; but digesting under the actions of the body, and suitable drinks, resolves at length, and gives an agreeable *crisis*. The whole of the processes in the case, shew that it is the humours which cause and support a fever, and must alter, therefore, greatly according to that state, or according, if you will, to the infection. For as an hundred things may infect, so we may have an hundred different fevers, where the course and times of digestion shall be most different; which confirms greatly the history we gave of the blood.

As to the particular situation the kidneys have got, if we consider that the bile is the sharpest of all the secretions made from the blood returning from the spleen, stomach, *pancreas*, *omentum* and intestines, we may see

the reason why neither salts nor sulphur was to be separated from the blood that was to supply it; and therefore the separation of the urine would have been disadvantageously made before the bile, or what supplies it; and it would have been as disadvantageous to have had blood unpurged to supply the spermatics, whence the mild balsamic *semen* was to be separated; and therefore, immediately after the emulgents, the spermatics arise.

E S S A Y

ESSAY V.

Of the Brain.

IN the former Sections, we have considered those actions which properly deserve the name of the VITAL in animals; those actions, I mean, which are immediately employed in carrying on the circulation.

BUT as, together with such actions, the Physiologists generally consider that of the brain, we shall not dissent from them in the method: for though we did not find any necessity to consider the brain as having any direct influence in moving any of the parts concerned in the circulation; as, in our opinion, it has not in moving any other part; yet as the vigour of the whole body, and consequently that of the parts we have described, depend so much on the brain, that for the most part they suffer immediately with its misfortunes, we shall give it a place among the parts immediately concerned in the vital actions;

ons ; for the consideration of which we have destin'd these essays.

THE firmness of the walls with which the brain is invironed ; the sudden and fatal effects which frequently attend its disorders, particularly in stupifying, and otherways distempering the mind, to appearance ; and then again the life and spirit diffused over its frontispiece, the face, and the number of sensories round it, which seem, as *Cicero* says, as so many avenues leading to the soul ; have greatly persuaded Philosophers and Physicians of its excellency and dignity : though I suspect much, that none of them as yet have discovered truly where its excellency lies ; and that, in attempting to shew it, the opinion of its mysterious powers has so prepossessed them, that they have been carried beyond both Anatomy and Philosophy in their speculations. Whereas, if they had allowed themselves to have been conducted by Anatomy, the only sure guide in explaining the animal œconomy, they would have found nothing but what is simple and plain, and most conform to what they meet with in the other quarters of the body. For my part, at least,

least, I can find nothing, nor can I learn that others have found any thing in the whole extent of the brain, except the vascular and fibrous productions of the blood-vessels, as in other glandulous parts, and the membranes necessary for their security and convenient disposition. What more than this has ever cast up to *Willis*, in all his scrutiny with the knife? what more to *Malpighius*, however laborious with his glasses? what more to *Ruyfch*, with his subtile injections? to *Morgagnius* and *Winslow*, though provided with *lyncean* eyes, and minds scarce to be imposed upon? All these great and laborious Gentlemen agree in the uniform structure of the constituent places of the brain; though in different parts they are disposed differently, as are the parts of the most uniform bowel we find in the body.

IF our investigators had found any various machinery about the brain, formed so as to shew the smallest appearance of different organs, they might have been indulged the liberty of imagining, that one part was subservient to memory, another to judgment, &c. But for them, with that great Naturalist Dr.

Hook,

Hook, to suppose in the brain some kind of *Bononian* phosphorus, to receive the impressions of the light from the eyes ; and in another place vases or bells, like what *Vitruvius* mentions to have been placed in the antient theatres, to receive and return the sounds more vigorously, is making our fancy to constitute the brain, and a plain disregarding of what it is in itself ; which, as I said every Anatomist allows to be as simple in its structure as any other gland, and as uniform in its parts.

IN its different parts, I acknowledge, this homogeneous substance of the brain is differently disposed ; but no where in such a manner, that one can be led to suspect that any of its parts are employed as any particular machine or instrument whereby to convey to the mind any particular perception or sensation, or make its access easier to move the other parts of the body. This difference in the situation of the several parts of the brain, seems plainly calculated for the safety or convenience of such a bulky mass. Thus the *cerebrum* is in one repository, the *cerebellum* in another, and the spinal marrow in a third ;
though

though they communicate one with another, and their substance seems quite similar. But as the *cerebrum* was still too bulky for so soft and incoherent a substance, exposed to violent shocks, we find it still parcelled out into lesser parts, secured some how from the shock of their neighbours. Thus we find it separated into the anterior, posterior, and lateral lobes: but the middle part being still too bulky, it is most artfully disposed of, made hollow in the more central parts, and vaulted, and divided by a middle partition, and arched where it terminates at the posterior end; and the floor of this vault is emboss'd with various risings, allowing vessels of different kinds to run among them, and a variety of conduits or drainers to the whole, while under all these different forms the matter seems quite the same; for, except the blood-vessels, nothing is found among them but the cortical and medullary substances common to every other part of the brain and spinal marrow.

AND thus I am as little solicitous to find, why the *glandula pinealis* is left solitary, as I am about the *lobus parvus* of the liver: nor
am

am I more solicitous about the *corpora striata*, *thalamus nervorum optitorum*, and *quadragemini* of Mr. Winslow, than those of the brow, chin, cheeks, mouth and nose, which indeed add to the symmetry of the face, but could not but be similar, since the parts on each side are the same, as are those of the different sides of the commissures of the brain; and things being thus similar on each side of the brain, can there be a stronger argument that they have a common use? and that they are not subservient to different faculties of soul or body? In which case we certainly should have found parts in the brain as different in their aspect and structure, as the kidneys, liver, *pancreas*, stomach, &c. which fill up the abdomen.

AND how unaccountable is it, that we should imagine that the nerves do any particular office in the glandulous part of the brain, whence they arise, when we see them so equally distributed to the parts without? and are equally formed out of the medullary body, made from the collection of the medullary parts, arising from the cortical throughout its whole extent?

WHEN

WHEN every part of the brain, to the best of our observation, concurs to form those cords we call pairs of nerves, and the rest of the medullary part which joins the spinal marrow; to imagine that the brain has any other use, than to supply them, is to run out of sight of land, without helm or compass, and give ourselves up to wandering and roving. I allow, that with the brain the mind is generally in great disorder: but this, I have reason to suspect, arises from its affecting the mind no otherways, than the other parts of the body are found sometimes to do; though I allow, from its make, and the sensibility of its membranes, and the manner the blood-vessels are involved with them, while all of them are so compactly packed up within the rigid scull, that more violent disturbances to the œconomy, and thence to the mind, do more frequently and easily arise from this, than from any other part. In these circumstances, a slight compression near any of the more considerable blood-vessels, while entering or passing from the brain, must cause a very great disturbance: for, should the blood be prevented from en-

E. e tering,

tering, the continual impulse it receives from the heart, must expose the neighbouring vessels to great violence, while the brain itself is defrauded : and, by intercepting the return of the blood, the brain at once must be quite compressed, and all its fluids quite damm'd up and stopp'd in their course : and such a stoppage in the course of the humours, makes the mind always disappear ; and as this takes place prior to, and more easily than a general compression of the nerves, we have more reason to suspect it for the more ordinary cause of such disorders.

WE have already, in our treatise on muscular fibres, observed, that epilepsies and convulsions are the native product of the irritation of these fibres, while nothing of the kind happens from pressing, stimulating, or even tearing and cutting the cortical and medullary parts of the brain ; and which, when done to the nerves, is never known to produce any thing but a palsy of the parts they supplied. And we find, that any thing which stops the circulation, where-ever applied, produces a kind of apoplexy, attributed for ordinary to a compression of the brain ; and indeed,

indeed, when its seat is elfewhere, it is not attended fo much with the noife in the ears, the confufion in the fight, &c. which are reckoned concomitants of the difeafe, and arife from the fituation of thefe organs; which fituation likewise makes their effects laft longer, and prove more dangerous: the fcull yields nothing, and therefore the fmalleft fwelling of the parts within, makes an univerfal compreffion of longer duration, than when perfons are ftruck down by violent attacks on fome other part, the *ftimulus* of a loofe tooth, &c. It is certainly very rash to land every diforder upon the brain, where the mind is affected, without any proof. When we turn chearful with a glafs, we muft reckon the brain firft invigorated, though the fatigued find its effects before it has well reached the ftomach: nay, we often find a brisker air, an agreeable fmell or profpect, do the fame; for a well-pleafed mind has generally a body pliant to its will and humour, and does not regard the fmaller achings.

THE reverend Dr. *Hales* brought a dog to life and vigour, by preffing effete air into his lungs, fo as to diftend them; and I have found

found the soul disappear, in a person when discharging his hydropic water, as oft as the tags of the belt, with which he was swath'd, were left loose; as I observed when speaking of the circulation: and in every instance where the circulation fails, so does the man; on which account the inspired writers seem to have placed the life of the animal in the blood. Our mind never appears in a dead machine, as it is for the time, when the blood stops; and more or less, the more or less it is stopp'd in its course. The weak person, with loose fibres, has no soul at all when the mercury falls, or the hygrometer indicates moisture in the air; so that the well tempered air would seem to be his life; tho' a closer view shews, that it chiefly arises from the effects it has first on the lungs, and by them on the circulation; to which we must attribute any change in the nervous juice, if then any happens to it; as, we reckon, we have illustrated in the former treatises on muscular motion, the circulation and respiration. The forming a right notion of these, must discover to us the share they have in the œconomy, and what changes in the mind happen upon

upon their changes ; and help us to restrict the brain in its dominion, which seems to have usurped the authority of most of the other parts, without a just title.

IF what, I reckon, I have put in a pretty clear light, shall be admitted as just, that the access the mind has to act upon the muscles, depends much upon the disposition of the muscles themselves ; I mean, upon their being stretched ; it must be very superfluous to seek any further preparation from the nervous juice ; this must make us look, as we said, upon the muscles scattered over the whole extent of the body, as the different strings of a musical instrument directly to be played upon by a *stimulus*, or the mind : and to make the mind do it by the mediation of the nervous juice, in which we find no fitness for the mind to act upon it, nor know the laws by which it should move, to any purpose, when touched, is to involve ourselves in obscurity, after distinct prospects had been opened to us.

Cartesius's whim, that all the nerves centered in one point, where he confined the soul, is now sufficiently exposed by anatomy, which
could

could never countenance the supposition. But what have we put in its place? nothing at all we can venture to describe. Two or three, of late, have indeed pitched upon the *corpus callosum*: why, they tell us, this never was destroyed, without incapacitating the mind to act in the body; and here there is a great confluence of the nerves from the different sides of the brain. But how fond have they been to grasp at the *hypothesis*, when they would not consider, that great numbers of these employed about the voluntary muscles, have no connexion with this *corpus callosum*, at least immediately; these, for example, of the extremities and spine coming from the spinal marrow; all which parts lose their power of acting, upon the diseases of the spine, as much as others on the diseases of the head.

BUT, further, their assertion, that the destruction of this part is attended with an absolute loss of the mind's authority over the voluntary muscles, is not agreeable to fact. *Wepfer, histor. apoplex. 14. schol. 2.* observes, that this, with many of the adjacent parts, were ulcerated and torn in appearance, and yet the senses were entire, immediately before
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the person's death, though formerly he had raved. And *Tulpius* and *Marchettis* supply other examples; and *Ridley*, *observ. pract.* 34. *Galen* is positive he saw a young man cured in *Ionis*, wounded in one of the ventricles, *de usu part. cap.* 8.; and, after making experiments, he argues, that the anterior ventricles suffer less by wounds than the rest. *De placitis Hip. lib.* 7.

Now, as *Lancisius* and *Peyronie* have given a great number of instances, where every other part of the brain has been destroyed, without destroying the senses or the action of the muscles, we must acknowledge, that there is no one place of the brain necessary for the senses and muscular motion.

THE learned Professor *Diemerbroeck*, in the 5th chapter of his third book of Anatomy, argues much to my purpose; for, after citing the different opinions of the seat of the soul, he concludes, *Verùm omnes dictas opiniones admodum dubias esse constituit experientia, ita ut nihil ferè certi possit discerni, tam de loco in quo facultates illæ peraguntur, quàm de modo quo peraguntur; multa enim exstant exempla à Nicolao Massa, Carpo, Fallopio, Viga, Ariæo, Angenio,*

genio, *Andrea à Cruce, Petro de Marchettis, aliisque præstantissimis practicis notata; quibus è magnis vulneribus capitis notabiles cerebri portiones prodire et rescissæ sunt, integris manentibus modo dictis principibus functionibus.* To these he himself adds some considerable examples, and at last cites *Kerkringius* for an instance, where, in a boy of five months old, no brain was found, but a slimy water in place of it; and therefore calls the story in question: for though he allows, that every part by itself might be dispensed with, without the loss of any of the faculties of the soul, yet he would not grant, that these could subsist entire, when the whole brain was wanting or destroyed: in which opinion *Bidloo* so far joins him, as to call *Kerkringius's* histories, and *Le Clerc's* to that purpose, unaccountable fables, as *Morgagnius* observes (*adver. 2. animad. 35.*) who at the same time confirms what *Kerkringius* and *Le Clerc* have advanced, by his own and his friend's observations.

By an impartial inquiry, it would then appear, that no bowel is more frequently mutilated,

tilated, and even quite destroyed with less injury to the œconomy than the brain.

THE Hon. Mr. Boyle tells us, in the 1st exertion of the 2d part of his treatise on the usefulness of Natural Philosophy, that after cutting off the head of both the male and female fly, parents of the silk worm, they engaged in copulation; and that the largest tortoises live many days without their heads. And we find, *Philosoph. Transact.* N° 226. p. 439. that a pigeon, having its scull emptied of its brain, and filled with flax, searched for food, and did all the actions of life: and dogs lived sometime, now wanting the *cerebrum*, now the *cerebellum*; but not without both, except by blowing up the lungs: and who can but suppose, that, in larger animals whose blood-vessels are much larger than in the lesser, such operations should carry greater danger along with them, and require greater caution in managing, from the loss of blood only? So that the difference of the effects in them does not at all argue that the brain is more necessary to the one than the other; and the less, that we have so many examples in the larger animals, of their keeping up their

vigour and life after the loss of the brain; as we observed above. To which we may add these instances *Ridley* gives in the last chapter of his treatise of the brain, and what *Bartholine* cites in the 91. *obs.* of his 6th *cent.* and *Bonetus sepulch. sect. 1. obs.* 86; amongst which we have the history of an ox's brain quite petrified, seen at *Sweden* by good judges; as there was one at *Padua*, by *Bonetus's* account, *Medic. sept. sect. 4. cap. 4.* and one at *Paris*, as is narrated in the Memoirs of the academy 1703, which was so vigorous before it was knock'd down, that he escaped several times the slaughterer's hands. I shall add one of a cow, well attested in this country, no less remarkable than any of them, in a supplement to this treatise. Mr. *Kay's* case, narrated in the *Philosoph. Transact.* N^o 277. p. 169. is one of the most remarkable I have met with in the human kind: a cancerous ulcer began in his cheek, eat out his eye, and through the *os frontis, dura mater*, and continued so long, that gradually the whole brain was spent; so that when he died, nothing was found in the skull, but about a spoonful of black putrid matter, and yet he
lost

lost no sense, or the motion of any part, nor had he any convulsion or spasm: it was certainly a great chance, but that the destruction of some large vessel should have carried him off long before the whole brain had dissolved; but, where nature does the work, it often happens, that such hazards are evited. And thus so many children born without the brain, who are otherways entire in all their parts, especially the nerves, as *Morgagnius* particularly observes in the instances we referred to: and thus likewise ossifications and petrifications of that bowel, without any apparent loss or disorder to the other parts; whereas the Anatomist would have had difficulty to have done the work, though he goes a greater length often, than the current accounts of the way the brain is employed can admit of.

Is not the brain of use, then, since it can thus be dispensed with? No doubt it is; but we find many parts occasionally dispensed with, which nevertheless are of undoubted use, as the spleen and kidneys, &c.

WHAT shall we then allow for its province, since both sense and motion subsist without it? Nothing but what I have already hinted at,
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the keeping stores for the equal and ready supplies of nourishment promiscuously to every part.

To shew why I entertain so singular an opinion, I must shew how far it is fact; and then how the parts are supported under the mutilations and total absence of this bowel, as must happen in the cases we cited above: for since we allow these cases of sufficient force to overthrow the current theories, of sense and motion being derived from the brain, it is hard to conceive why they are not reckoned so likewise, to shew that the immediate nourishment of the parts cannot depend upon it.

To understand the true state of the nerves, I must refer to the account we gave of them, when speaking of the distribution of the fibres, in the 2d chapter of the first Essay; where we shewed, from that diligent investigator *Wepfer*, that the nerves have every where an accession of vessels as they pass through the body; so that they rather increase in bulk, the farther they have run from the brain, than diminish: and from these communications and accessions they have,

we

we must be sensible, that they must be supplied from every part of the body as they pass ; and the more, the more their supplies from the brain are intercepted. This allowance we are obliged to make from *Morgagnius* and *Vallesnerus*'s observations, and that of several other accurate Anatomists, that, in these cases where the children were born without brains, their nerves, through the whole extent of the body, were nevertheless as large and well grown, as in the ordinary cases where the brain was entire ; which can never be accounted for, except by allowing, that when the brain is defective, other parts can supply the nerves.

AND thus we find a very great caution used to prevent the nerves being starved under the greatest losses ; though we must be sensible that the more sudden destruction of the brain is not so easily supplied ; for it may easily be supposed, when the parts communicating with the nerves supply other parts, that they will contribute little for them, when kept full from the principal source, the brain ; and consequently if this should be destroyed, it would take some time before the by-streams would

would change their course, and give a sufficient allowance for the nerves. We find this in the arteries themselves : if at any place we tie a principal branch, as is done in the operation for the *aneurism*, it is some days before the pulse be found below ; that is, before the smaller branches allow such a free course by them, as was by the larger. No wonder then that it takes a much longer time before the nerves get a sufficient recruit, from the very obscure vessels which supply them, after their exit from the brain ; and that the brain when suddenly destroyed, should leave the nerves in such a starved state, as to make them useless, and that death should follow upon the operation : whereas, when the brain turns corrupt, or hardens gradually, there is a demand made upon the lesser storehouses, which get time to gather and increase as the demand rises ; as happens to the tree which stands between two other trees, and has its branches on each side made to inosculate with theirs ; when the inosculatation is completed, you may safely raise the roots of the middle tree from the ground, and let them hang loose in the air, for it will have sufficient recruits from the neighbour-

neighbouring trees ; which it could not have till it had been joined to them for some time, and thereby made the course easy through the new channels.

AND the method of cure in palsies, by strong friction, urtication, and other forms of *stimulus* applied to the parts affected, shews how much the new course may be improved by topical medicines, when the advantages of the first are lost. *Vid. histoire de l'academie Royale à Paris, obs. anat. 5. ann. 1741.*

BUT nothing seems better fitted to let us know the changes the nerves are capable of, than the observations by P. P. *Molinellius* in the *Bononian* commentaries, *vol. 2. p. 2.* who gives us great reason to suspect, that either too many nerves have been tied at once, when the animal died by that means ; or, in other cases where only one part was affected, by tying the nerve serving it, that they had not given the animal time to recover its loss ; which he found it did in length of time : for though, upon tying the cardiac nerves upon one side, the dog was not a little disturbed in its motions at first ; yet four on whom he made the trial, recovered against the 20th day after

after the operation. And as to the loss of the motion of the part, upon tying the principal nerve, he denies it absolutely, having seen the contrary in severals on whom the operation for the *aneurism* had been performed; and therefore gives this remark upon it, *Quo tempore in homine nervum constringis, eo doloris vim planè majorem is percipit, quàm si arteriam tantum devincias; dolorem verò major aliqua sensus ac motus jactura consequitur: atque hæc tamen brevi evanescent; idemque curationis exitus, ac si penitus abfuissent: quod si aliquando contingat, ut qui arteriam simul cum nervo ligaverint, noxam observent aliquam non contemnendam, ii videant porro ne nervum pungendo læserint.*

IT is certain, that many misfortunes happen, in the course of experiments, that arise from other sources, than what we at first imagine. What we have advanced, seems indisputably to shew, that not only the work of particular nerves may be supplied by the neighbouring branches, but even that of the whole brain, by the supplies the nerves receive at the other parts of the body: and as this happens in fact, it demonstrates sufficiently,

ently, that the principle which determines the motion of the muscles cannot be seated at the brain. And what other can we imagine to be the design of every part having nerves from so many places, but for its security upon the loss of one or more of its branches, as most parts are served with arteries from different quarters? how many different branches of nerves serve the eyes, how many the heart!

THE next question which arises from our doctrine of the nerves, is, what determines the flux of the animal spirits by them, for which there was always supposed some power in the brain? Which leads us to shew the particular advantage of the doctrine advanced above.

As far as I can yet understand, there are no instances of impulse forcing a fluid, however subtile, into the lesser or capillary vessels: the attraction of the sides of such vessels, upon the small quantity which enters them, seems to prevent this; and therefore, though we find every where such vessels employed by nature in her works to convey fluids, yet we find no where that impulse is trusted to im-

pel them, but some other method. And thus we find that plants and trees have their roots spread thorough the inactive earth, where the juices have nothing to impel them: nevertheless, these juices are often found rising in the plant with a very great flow, and even to the tops of the highest trees; as we find by Mr. *Hales's* experiments, who demonstrates that they rise in proportion to the surface of their leaves, and the heat applied to them. Whence it is evident, that it is the emptying of the vessels at the one extremity, that makes them take up or absorb the fluids at the other. It is certain, that the vessels of an animal have this power: inject a thin fluid into any of their cavities, and open them after some hours, you shall find it gone. And Dr. *Keil's* experiments shew, that the whole skin has this property; as we observed when speaking of the perspiration. And what vessels can be better fitted for this than the pulpy, porous nerves? and as the whole bowels and their vessels seem to be made up of them, by what we observed from *Wepfer*, and what other Anatomists have observed, the perspiration of these bowels must
empty

empty them most certainly, and thus make a demand upon the fluids communicating with them : so that the warmth of the blood, which supports the perspiration, must keep up a constant flow by them ; as much as the heat of the sun upon the leaves of the plant, supports their perspiration, and the rising of juices by trunk or stem, and, lastly, the absorption by the roots.

THUS it is we suppose every part to make a demand upon the brain by means of the nerves ; and, of consequence, every part must share in its stores, in proportion to its expence. There is no need of any arbiter at the brain to judge of its wants : every part of necessity judges and demands for itself, and will make a demand on the lesser store-houses, when the principal fails, if allowed time to do it ; as was shewn above.

By this account of things, then, the brain seems to be the great repository of the purer and more active part of the blood, designed for a recruit to all the parts of the body promiscuously, where-ever the nerves are distributed ; that is to say, for the bones, cartilages, nails, membranes, glands, &c. since they seem

to have an equal share of nerves. And, consequently, if all motion and sense are managed and formed by particular organs, fitted to that purpose, (as we have shewn particularly in the muscles, and are to shew immediately as to the senses), and these organs are again supported by the nerves in common with the other parts of the body, then we must see, that both sense and motion must fail, by a total interception of the nervous juice; and this without allowing that the nerves are the immediate springs of either of them, or that by them the soul has an immediate communication with the organical parts, distributed at greater or lesser distances from the brain.

WE must likewise allow, from this account, that heat is of equal importance to both sense and motion, as what the nerves are, since their fluid cannot move or be conveyed to any of the parts of the body without it: and thus extreme cold, and want of nourishment, must equally render useless the organs of sense and motion, and both of them cause irresistible sleep.

THIS

THIS new doctrine concerning the use of the brain, and its being so passive in the animal œconomy, I have ventured to publish with the greater confidence, that, in my first Essay, I have shewn, that, in the performance of muscular motion, the muscles themselves were fitted to qualify one another for exerting their powers, and subjecting them to the influence of the mind, and thereby left no objection from that quarter : and further, that the connexion of the fibres, and the influence the mind exercises over them, promises fair to account for these sympathies among the different parts, in their movements and sufferings, which use to be attributed to some imagined alliance among the nerves : for though in many cases of the most violent convulsions, the pain causing it arose from one point, and observably made a regular progress from it through the body, till it quite overwhelmed the person in the storm ; yet, in other cases, the pains seem often, *per saltum*, to attack the parts most distant one from another ; of which we gave examples, where parts most disposed for pain and contraction seemed to be their ordinary seat :
but

but something which carried the attention elsewhere, made a short translation of it, as the scratch of a lancet, or a blister, which *Morgagnius* calls *clavum clavo extrudi*, in his *epist.* 13. *art.* 7. concerning *Valsalva's* writings; where, and in the neighbouring articles, he has much to our purpose; shewing, that, for all the currency of these opinions of the sympathy of the nerves, yet the most diligent Anatomists do not agree, if the correspondence is by the arteries or nerves; as in that famous experiment of burning the ear for the toothach; where he acquaints us, that *Diemerbroeck* attributed all to the searing a branch of the carotid, while others found from that operation no benefit at all; and when they did, I would have made it the *clavum clavo*; of which I gave formerly examples, in applying blisters to the knobs of the shoulders. And I shall conclude this with one from *Morgagnius*, in the place I cited; *Sanè aliquâ ejusmodi ratione evenisse crediderim, quod, me olim, studiorum causâ, Bonnoniæ commorante, in quadam virgine tentatum est, quæ non ita pridem à cephalæa liberata, in alterius temporis dolorem incid erat, quotidie mane rede-*
untem,

untem, acerbum adeo, ut clamare, delirare, ad extremum sine motu & sensu concidere, & quatuor ipsas horas sic jacere virginem cogeret: huic, aliis omnibus præfidiis irritis, vir ille qui medicinam faciebat, (quæcunque illum ratio moverit), duos ex eodem latere superioris maxillæ dentes, quantumvis sanissimos, evelli jussit: quibus evulsis, dolor non amplius rediit. How such effects should follow from such operations, I cannot think difficult to imagine, after considering the particular tension necessary to make the smallest touches shew themselves violently; and how certainly their effects cease, on intercepting or otherwise diverting any flux upon the part, upon which the periodical tension depends: and thus I have seen a single snuff cure the *catalepsis*; and the mind likewise loses her intention on the change of scenes, as we just now observed.

It now remains, that I survey the different sensories, so far as is necessary for our present argument: concerning which still greater liberty has been taken, in making the nervous juice move backward, on the smallest touch we feel, at the greatest distance from the brain
to

to the supposed common sensory there: a supposition that nothing could make us allow, but the greatest prejudice! What should make the juices run back from every point of the body, to which we are positive they have a constant flow?

APPEN-

A P P E N D I X.

Of the Senses.

C H A P. I.

Of the senses whose organs are more obscure.

THE manner in which most Physiologists have spoke of the organs of touch, placed, as it would seem, over the whole skin, would persuade us, that they believed they were pure nerves, no other ways formed than what they were at their first rise from the brain ; as *Boerhaave* seems to reckon these serving the organ of smell, equally distributed through the whole *membrana sneideriana*, lining all the *sinuses* communicating with the nose, (*Inst. art. 495.*) ; and as most indeed seem to reckon these of taste, the stomach, *penis*, &c. But what *Ruyfch* observes, *art. 5.* of his first *adversarium*, that the nerves did not end less variously than the arteries, should have given a suspicion that they suffered considerable changes in their course ; especially joined with

Wepfer's observation, that in fact they increased in their progress : this shews, that the nerves are join'd with other filaments, with which they form the composition we call the extremity of the nerves. And thus it is, that tho' most of the lesser organs of sense have only the appearance of *papillæ*, to form the sensation, as over the whole skin, some part of the *membrana sneideriana*, (*Sanctorin. obs. anat. art. 11. p. 91. 92.*), the tongue, *penis*, &c.; yet these are all different: for it is agreed by observers, that these of the tongue are *capitatae*, (*Heist. anat. vol. 2. p. 20.*), those of the stomach much less; so that we find them denied by some, (*Ibid. not. 9.*): and these of the fingers, though larger than at the other parts of the skin, yet appear only pointed eminences, (*Vid. Ruysch, fig. 17. annexed to his epistles, Epist. prob. 1. fig. 14. thes. 10. fig. 3. t. 3.*): they are flat again at the breasts, as they are at the *penis*, (*Idem. thes. 10. N°. 34.*) I had occasion to see those at the tongue to the greatest advantage in pulling a tooth; upon scarifying the gum, the tongue was besmeared with blood, and then, on pulling, the man contracted his tongue so much, under the pain,

pain, that the *papillæ* appeared eminent over its whole surface, of a white colour amidst the blood, and of the bigness of a small pin's head, so thick, that the whole tongue appeared checquered: here each *papilla* appeared as big as any of the branches of nerves at its entry to the tongue; so that together they must have exceeded greatly all the simple nerves entering the tongue, not only for sensations, but the use of the muscles and other parts; and consequently the *papillæ* must be something else than mere nerves; as must be the nails and many other parts, we, in a loose way of speaking, call nervous; while they differ greatly from one another in appearance, consistency, &c. I could easily go in with *Wepfer's* opinion, and others of the moderns, who suppose all the parts originally from the nerves, if we still allow them to be nerves, while increasing in bulk by the accession of other parts: but this allows some kind of vegetative nature in them, and carries us quite from the common notion concerning the nerves: for example, what idea should I give of the upper half of a goose's bill, if I should say no more of it, but that it was a nervous part,

part, because *Wepfer* traced a branch of nerves from below the eye, which increasing in bulk in its progress, was quite spent upon this part, and seemed to make up the whole of its substance? and what answer should I have, if I should demand, why such a share of nerves to this part, which has so little use for any extraordinary sensation, and has no motion amongst its parts? which is likewise the case with the glandulous parts, and the bones, whose involving membrane has indeed a very quick sense, as likewise the internal; but the nerves running through their substance, nothing remarkable this way: and therefore not the nerves, but stretched membranes have the sense. It is more than probable, then, that the *papillæ*, which form certain sensations, are something else than pure nerves, and that they differ greatly amongst themselves; and thus the same thing, such as *ipecacuana*, or a rose, &c. applied to them raise a most different feeling; which we would not expect, if the *papillæ*, at nose, tongue, stomach and skin were pure nerves. The different feeling, then, from the same object, applied after the same manner, argues a different organ, and other parts

parts than pure simple nerves; as is most evident in these more enlarged sensories of hearing and seeing, which nature has so enlarged, that we can view their various parts, and judge from them more distinctly, what share the nerves have in the sensation; and therefore we shall be more particular in our account of them.

C H A P. II.

Of the Hearing.

NOTHING can be more remarkable than the *apparatus* at the ear, first, for introducing the air to advantage, by its external parts; and then to communicate its shock to the internal, by the parts which lie between the two.

THE entry is very patent, and has several ridges raised round it, directing the more parallel waves of the flowing air into it, which combined by the narrower body of the passage, are thus landed advantageously upon the membrane, laid obliquely cross its internal

nal extremity: between this membrane again, and that which opens into the internal ear, there is a small chain of bones, lying in the most moveable posture imaginable, cross the empty space, called the *tympanum*, lying between the external and internal ear. This *tympanum*, from the extremity of the external tube, covered with the membrane we have mentioned, to the small oval membrane, that lies immediately above it, and covers the entrance into the internal ear, is not more than a sixth of an inch, which we may call the wideness of the *tympanum*; and in circumference, about a third,

THE chain of bones does not lie directly cross this passage: but the first lies parallel to the larger membrane, at the extremity of the external tube, which is called the *membrana tympani*; and that in such a way, as to have its smaller end, like the extremity of a short pin, involved in the duplicature of the membrane, from the circumference to the center; while its head, formed like that of a club, placed without the circumference of the bony circle, to which the membrane is attach'd, is articulated to the body of the next bone
lying

lying on it, as an hammer on the anvil; and therefore Anatomists give them these names. The anvil lies likewise parallel to the membrane with its two legs; one of which runs so far over it, and parallel to the handle of the hammer. To the extremity of this, a bone, in form of a stirrup, is articulated, by means of a small oval bone, distinct from both, and not exceeding, in bigness, a small millet seed: the broad end of the stirrup enters an oval passage, which leads to the *vestibulum*, involved in the duplicature of the membrane, which covers that passage; and thus stands perpendicular, from the leg of the anvil, to the upper side of the *tympanum*: these four bones then lie in some kind of zigzac course cross the *tympanum*; articulated and fastened with ligaments one to the other; so that nothing can be more vacillant. And thus we find how the smallest motions of the air must be felt upon the membrane covering the passage into the *vestibulum*; which now we must describe, with the parts it leads into.

THE *foramen ovale*, in which the stirrup is placed, opens into a small cavity, almost round, which scarce would admit a coriander

der seed, called the *vestibulum*; having three canals exterior to it, and the *cochlea* lying on the interior side: the length these three parts take up, is not two thirds of an inch; and the canals open into the *vestibulum* by five passages, two of the canals uniting into one: and one half of the *cochlea* opens likewise into it; but the other is joined to the membrane covering the *foramen rotundum*, which is another passage into the *vestibulum*, from the *tympanum*, lying something more inward and backward, but not so high as the oval. The *vestibulum*, canals and *cochlea*, taking up a large half of the *os petrosum*, at its rise, by one name are called the *labyrinth*; all of which is covered with a membrane we reckon the internal *periosteum*; and the two passages, from the *tympanum* to the *vestibulum*, are covered both with it, and the external *periosteum*, which lines the *tympanum*; but the internal is so little fix'd to the sides of the canals, that *Valsalva* took them for cords running through them: but *Winslow* allows these to be no other than the *periosteum*, which easily recede from the bones when a little dried. This membrane is always greatly moistened

ened, and in infants looks mucilaginous. The *cochlea* is divided into two distinct canals, by a duplicature from it, one of which, as we observed, opens into the cavity of the *vestibulum*. The vibration of the first membrane, then, to which the air has access, must, by means of the small bones, land upon the lining of the *foramen ovale*, and by that means communicate to these different linings of the three different cavities to which it is connected; and in themselves always on the stretch, and of different lengths and flexures: so that, as *Valsalva* observes, according to the touch, some of them at one time, some of them at another, will be made to play, and, on different occasions, combine differently, to form different sounds; and thus among them raise an infinite variety: so that we can be at no doubt, that this internal ear is a corded instrument, played upon by the air, as *Memnon's* harp was by the sun-beams.

HERE then, without all doubt, the instrument is played; but the question is, whether it is heard here, or in a distant apartment: the most of Anatomists alledge in a distant apartment, at some common sensory, to which

every particular sense sends its observations; the *papillæ* at the toes, though touched only with the stroke of a downy feather, not excepted; however difficult it is to imagine, that the gentle stroke of a down should raise vibrations through one vessel, to such a length, either in the solid parts, or in the liquid it contains; and that whether stroked backward or forward.

BUT a small examination into the circumstances of the ear, raises greater objections. The auditory nerve, though of great bulk at its entrance into the *os petrosum*, where the organ for hearing is seated, yet so obscure a part of it reaches that organ, that *Du Verney* doubted if any of it entered the labyrinth at all; and the four or five different passages, by which a few filaments enter, are rather pores than holes, and some of them land at the canals, and others at the *cochlea*; so that, thus divided, they do not at all look as if contrived to carry the formed sound back to one point of the brain, but rather to support with nourishment the membranes perpetually agitated with the motions of the air in this hidden labyrinth; for which we cannot reckon
them

them too liberally bestowed: for their faithful attendants, the arteries and veins, pass with them by the same pores; and consequently, by themselves, they must be exceeding small filaments. These nerves seem no way fitted then for conveying the formed sound, but would rather make it split and diverge when formed: and certainly it must be greatly disturbed, when its canals are wrapt up in common with a much greater multitude of others in the auditory packet, scattered to bones and muscles through a great space; while no more enters the labyrinth, than is proportionally shared to other membranes: and these who reckon a great sympathy amongst the branches of nerves of the same pair, how much, in this case, should they expect to find the hearing disturbed under the exercise of the muscles, supplied by the *portio dura* of the auditory nerve, than which none are more exercised? Which observations, with these, where it was noticed, that the hearing continued after the whole brain was abolished, must satisfy us how far the soul is present with the organ, and is immediately touched by it.

C H A P. III.

Of the Organ of Sight.

WHAT we have observed just now concerning the obscure filaments of nerves entering the labyrinth, may be likewise observed at the eye: for though the optic nerve is of great bulk where it enters the bone; yet immediately, upon its reaching the globe of the eye, it seems to terminate in a kind of small knob, without spreading into the *retina*, as has been imagined. To see this, and the whole course of the optic nerve, with its integuments, Mr. *Winslow* advises to make a division through the middle of that part of it, within the bony socket of the scull, parallel to its sides, and to carry the division in the same course some length into the body of the eye itself; by which, he assures us, we shall find, that the portion of the *dura mater* which covered the nerve differs from the *sclerotis*, both in thickness and texture; and that the *pia mater* lying under it, enters the body of the

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the nerve, and divides it into cellular portions; and that what of it is continued to the eye, does not answer to the *choroides*; and that, as the optic nerve seems to terminate without entering into the eye, so the *retina* is too bulky to be admitted as the medullary part of that nerve dilated and spread. By which observations we must suspect greatly, that the received opinion concerning the *retina* and other coats of the eye, is not so agreeable to anatomy as was believed; and that the *retina* seems in no sense to be nervous, either as the product of a distinguished nerve, or as wrought into a tense firm membrane, which form of texture has made several parts acquire that name; for in fact it is as slippery and loose a membrane as is in the whole body, looking, as *Winslow* observes, like paste spread on a delicate fibrous net-work; and thus seems as unfit to be irritated by the touch, or any other way moved, as its origin from the optic nerve is doubtful. But as it is plainly transparent to the view, especially when viewed in water in a live animal; as Mr. *Le Cat* informs us had been done by Mr. *Mery* to a cat, and thereby shewed, that it consisted greatly of lymphatics,

lymphatics, as has been observed by the Anatomists (*Vid. Boer. Inst. art. 525.*), we would therefore suspect, that the *focus* did not exert its force here, but passed to the next coat, the *choroides*, which is quite tense, polished and opaque, besmeared on the back with a black pigment, as mirrors with quick silver, that the rays may not pass. Than which nothing can give us a greater suspicion that this very coat is the seat of the sense, while the *retina* guards it from the friction of the vitreous humour, as the mucous coat of the intestines does the nervous from what passes their cavity; and therefore we cannot easily allow that the optic nerve receives the shock. But suppose we could, in spite of this, persuade ourselves that it does; yet since Anatomists have found, that the optic nerve is a collection of very different parts of the brain, (*Vid. Morgagn. epist. 16. art. 12. ad scripta Valsalvæ*), we cannot easily conceive where the mind receives the impression, since the different filaments would resolve the formed figure, as much as the eye had united it: so that the *focus* seems the only proper place for the mind's attention. And thus what we have observed of the eyes, conspires

conspires with that of the other senses, and what we said of muscular motion, to confirm to us, that the nerves have no proper business either at the muscles or senses: and the *pia mater* being wrought in with them in their whole course, we see how they can be supplied at a distance from the brain.

BUT, before I quit with the eyes, I must explain a little that which I only mentioned, the connexion of the fibres of their different parts, that I may here give a notable example of the connexion of the parts of the body, which I found so necessary to give us a right notion how the parts communicate their motion and feeling one to another.

MR. *Le Cat*, with most Anatomists, reckons the *sclerotis* a production of a ply of the *dura mater*; but *Valsalva* would have it the production of the tendons of the muscles of the eyes: Mr. *Morgagni*, examining more narrowly, found, that as the *dura mater* was continued with it on one hand, so likewise were the tendons of the straight muscles quite to the anterior parts of that coat, while from the other hand the tendons, with the tendi-

nous

nous sheath of the oblique, spread to the posterior parts of it, (*epist.* 16. *art.* 37.); and he found, that the *adnata* spread its fibres over the *cornea*, as well as the *sclerotis* did; so that in most places, every part is involved with another.

AND thus I have at some length given an account of the brain, and the nerves arising from it, to discover their importance, and how they are employed in the body, which, I persuade myself, should help us to judge more mechanically of the actions of the body, *i. e.* more intelligibly than what we have hitherto done; and put us on a method to improve our theory more to the advantage of medicine, to which all our speculations should be designed.

BUT I must further make an observation on the experiments which seem to prove the flow of spirits by pressure through the nerves. It is alledged, that immediately upon snipping off the head of a frog with a pair of scissars, upon pressing the spinal marrow gently down with a probe, the frog draws up its legs, and upon pressing the *medulla oblongata* at the
foramen

foramen magnum occipitis, it opens its jaws, and rolls its eyes. But what is the connexion of the *medulla oblongata* at this part and the optic nerves? Is it to be imagined, that any part of these arises here, where the medullary part of the brain is running into that of the spine? Or is it not much more natural to allow, that the irritation of the probe provoked the dying animal to exert the parts most under its power to move? as we gape and grasp with our hands when prick'd in the soles of our feet.

THE experiments many have made, of setting the diaphragm a moving, by stripping down the phrenic nerves, are no less uncertain proofs; for others have found, that, by stripping the nerves upwards, that muscle is as certainly set a moving, as in stripping up the vertebral nerves of a frog, its legs will move; for in that case the member has a great irritation from the small fibres of the nerve spread through it; as the fibres by which the tooth was hanging, in the case we mentioned, when agitated, caused such a remarkable disturbance.

AND thus, I reckon, I have adduced a sufficient variety of arguments, why the received doctrine concerning the brain should undergo a further examination, and other uses for it be considered, than what have yet been admitted.

*An Account of the ossified Brain of a
Cow, killed at Fettercairn, a Vil-
lage near to Montrose, in the
County of Angus, Scotland.*

IT being my good fortune to be some nights at a Gentleman's house, in our neighbourhood, *August* 1744, attending a patient, with a worthy old Gentleman of our faculty Dr. *Wedderburn* in *Dundee*. Among other subjects we had occasion to discourse of, we argued some time about the use of the nerves, and the diseases arising from their disorders, which our patient's case naturally led us to: and as it was a subject I had treated of at length in my lectures, I was prepared to lay before him my scheme, as I have explained it in the foregoing essay; which, however new, seemed to be pretty well relished by my friend. To confirm it, he acquainted me, that the Physicians and Surgeons at *Dundee*, had, in their collection of rarities, an ossified cow's head, which was killed at *Fettercairn*,

tercairn, when she had no seeming defect either in her senses or motion.

I took the first opportunity to get a sight of it; and finding it one of the compleatest brains I had heard of, though roughly vitiated, I drew up the fullest account of it I could get. And when it was my turn to bring in a paper before the Philosophical society at *Edinburgh*, laid it, with the brain itself, before them, as I likewise did before severals of my correspondents; amongst whom there were some who could not at all allow it to be the brain, but rather some excrescence from the scull; which certainly was a very forced supposition: for, upon surveying it, it is found quite smooth all over its surface, except some seemingly carious spots at the place I reckon the base; and, among these, the small granulated pieces which shoot out the most being quite smooth, and as it were glazed over, shew there was no cohesion there: so that the only place to be suspected for being joined to the scull is the small end; which indeed is quite rough, and looks as if it had been broke off from the parts next to it, from the mammillary processes, running upon the *os cribriforme*, which
are

are very large in cows. Now as this is the only part at which we can suspect a cohesion to the scull or the parts contiguous to it; what freedom in suppositions is it, to reckon that such an *exostosis* had arisen from so small a root, and had spread to such an extent both in breadth and length? Where was there ever found such a smooth and regular piece of bone not natural, except upon some regular part being ossified?

It was further argued, that, upon comparing it with another brain of a cow, it was found much larger, and not at all of the shape. But who could expect, in such a vicious disposition of a part, that either the bulk or shape could be preserved? Is it not a sufficient testimony of the fact, that the butcher found it in the scull, and depended upon its being the brain: that Mr. *Gentleman*, to whom the cow belonged, received it as such, and delivered it to his brother, an inhabitant in *Dundee*, to be delivered to our faculty there; who always look'd upon it as such, and no doubt, would then be as particular in inquiring about its circumstances as possible; as would that curious and learned Gentle-

Gentleman, *Duncan Forbes Esq;* late President of the Court of Session, who was at the place two days after the slaughter of the cow, and desired the brain to be delivered to the college of Physicians at *Edinburgh*; but was refused; because of the prior engagement to deliver it to those at *Dundee*. I have compared it with two different brains of cows, whence the upper and lateral parts of the scull were separated, and found a much greater resemblance between them, than I could expect between a part in its most natural state, and when so strangely changed in its consistence; which we cannot suppose should happen, without great disorder about the part so changed.

WHAT I take to be the *cerebellum*, is indeed six times, at least, bigger than the natural, and is bounded from the other by a chink, running cross what I reckon its upper part, and pretty deep, inclining forward, and glazed on both sides, as far as we can see down, as is the upper surface and sides of the whole bone; and the hinder part, which is tuberous, and the lateral parts of the base, more prominent than the middle, which is some-

something hollow, and appears as it were carious; but all the other parts, except these we reckon broken from the mammillary processes, are not only of a glazed smoothness, but in colour of a tarnished yellow, as if the *pia mater* was ossified with the brain.

AND, besides the bigness of that part I reckon the *cerebellum*, it is raised much above its ordinary height, to a level with the other part; and in its middle there is a particular protuberance, as big as a walnut: so that this part is out of all form; only its undermost posterior part consists of two gibbous portions, as we find the lobes of the *cerebellum*, though these are much less.

BUT the bigness and figure of the *cerebrum* are preserved greatly in the ossification; for I found the greatest resemblance in it to one of these with which I measured it, and otherways compared it: both of them bulged along the sides of the upper surface; so that the middle between the two was somewhat hollow along which the *falx* runs: and both of them from behind tapered forward much in the form of a wedge, for two inches of the smaller extremity, where they
were

were much of the same breadth. From the chink to this in the ossified brain the length was $4\frac{4}{10}$ inches, and in the fresh $4\frac{3}{10}$. At the chink where the greatest breadth was in the ossified brain, the breadth was $3\frac{7}{10}$; in the other, the posterior part was in breadth $3\frac{8}{10}$; in both the breadth continued much the same, except for two inches where both turned so small: and the weight of the whole is one pound seven ounces and an half merchant weight: of which I have caused draw two views; one of the upper part, with a portion of the side; and the other of the base, and marked what is most considerable in them. The piece wanting was struck off by the butcher; who, finding great resistance to several blows he had given with his ax, to divide the head, at length, increasing the stroke, said, *If the devil was in it he should be into it*; and with that blow struck into the ossified part; which so far shews that all was solid; for if it had not been so, but supported with the soft brain, the scull would have yielded as easily as in ordinary cases. Considering then the resemblance it has to the brain, and its smoothness all over, except at some seemingly

ly carious parts, and at the fore-parts where it seems to have been broke off, it appears a very ill founded scepticism, to call in question if it is the original brain ossified: and I should have expected worse symptoms from such a weight lying upon the brain, than from its ossification, since the soft brains could not but have been bruised and torn, and its membranes greatly fretted by its neighbourhood.

IF some people, of whose judgment I have the greatest opinion, had not started the supposition, I could not have thought it worth while to have answered such objections; and as I look on it as a fact of the greatest importance, in our Medical inquiries, we cannot insist too long in clearing it up. For this purpose, after I had got the head in my possession, I immediately wrote to Dr. *Haddow*, who was then Physician at *Montrose*, to make inquiry, at the places where the cow was killed, about all its circumstances: and he, in company with Sir *Alexander Ramsay*, to whom the houses belonged, possessed by Mr. *Gentleman's* widow, owner of the cow, called for her and her sister, and several of the neigh-

bours who remembered the cow well, and got her history from them at length. That after she had been in their possession about a year and an half, she took a difficulty of breathing, which made her snort in her sleep, and and sleep ill, and, on this account, they reckoned, fall away in her flesh, and therefore they made one *Silver*, a Butcher, now dead, kill her. They likewise observed that she fell down with the stroke, as other beasts do, when killed with the ax; and that, when in life, she eat and drank, saw and heard, as well as any cow; and had a calf in the time she was in their possession.

THE Reverend Mr. *Anthony Dow*, Minister of the place, at whom we likewise inquired concerning the cow, gave us much the same account; and says positively, from what he learn't, that there were no brains found in the scull, but this ossified lump only.

BUT some time after I had sent the ossified brain to *Edinburgh*, understanding that it had given occasion to *Duncan Forbes Esq*; President of the Court of Session, to acquaint Mr. *Monro* Professor of Anatomy with its history;

history ; as I expected something accurate from the President's observations, who was one of the most learned and curious Gentlemen of the age, I immediately applied to my learned friend the Professor, to know what he had said concerning it, and had the following answer to my letter.

DEAR SIR,

“ The President told me, that, in travelling
 “ North, his landlord at *Fettercairn*, (if I mi-
 “ stake not) told him, that he had then caused
 “ a cow of his to be killed, because she seem-
 “ ed dull, and was losing flesh ; that the man
 “ who was endeavouring to cleave the head,
 “ finding a resistance he did not use to meet
 “ with, after cutting the bone through with
 “ an ax, examining what made the resistance,
 “ found the brain of a bony hardness ; that
 “ the people brought the fresh head to him,
 “ who found it ossified as they had described it.
 “ I cannot tell whether the President saw the
 “ ossified brain when it was here ; but it was
 “ on that occasion that I asked him to repeat
 “ the story, which I formerly heard him tell,
 “ and he promised to give it in writing to me,
 “ but

“but was either too much hurried, or too sick for doing it, when he was in the place afterwards”. Thus far the Professor.

I wrote to Dr. *Wedderburn* some years after our conversation on the subject, that I might be as distinct in it as possible; who returned me answer, That the cow being dull, and not healthful, was fed to be slaughtered, but did not get flesh; that the butcher, in attempting to open the scull after the ordinary manner, found an uncommon resistance, which made him give repeated cross blows, saying, *If the devil was there, he would be in*: thus the scull being very much broke, the ossified mass came out easily; and no body can view it, but must be satisfied, that it is the whole brain compleatly ossified. Thus this cautious Gentleman, who was present at the delivery of it, and who acquaints me, that Mr. *Gentleman*, from whom they had it, was a person of probity and sense.

AND this account agrees with what was got from the widow and others concerned in the cow, and that of the President; tho' none of them

them had opportunity to hear one another on the subject.

THERE was never any suspicion of any thing of brain but what was ossified.

THE beast was falling away in its flesh, and was more dull than ordinary, though going about with all its senses; and the only visible disease else, was a breathlessness which disturbed her in her sleep, and was look'd on as the cause of her losing her flesh.

WHETHER or not might the ossification be continued down the nose, as the extremity of the brain next to it seems to have been broke off from the olfactory nerves?

It was certainly a great misfortune that no Anatomist was acquainted with it on the opening the scull, to consider the state of the membranes, the rise of the nerves, &c. But as it is, in my opinion, we have a most certain example how far the muscles and senses can continue in office without the brain, though not without supplies; since where the brain was wanting the nerves have been found compleat, which we find accompanied with the *pia mater* at their exit, and to have a like supply of blood vessels in the whole of their progress; but

but though thus they are supplied with fluids, yet, from such histories, we must give up the correspondence of the mind with the different parts of the body, if we confine it to the brain; since, in such cases, their nerves have no communication with its seat, that is, with the cortical or medullary substance of the brain, to some distinguished part of which they suppose the mind confined.

F I N I S.



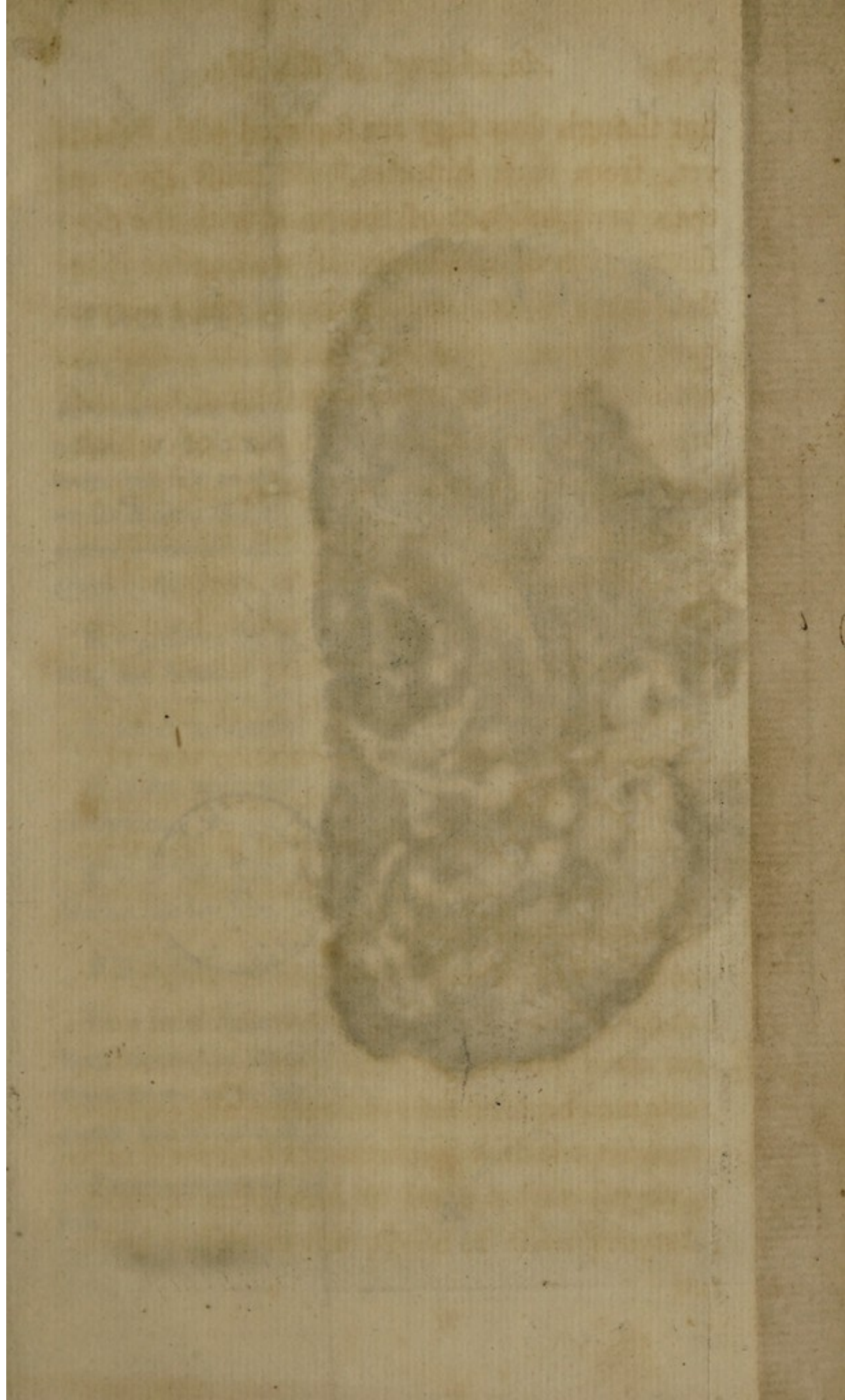
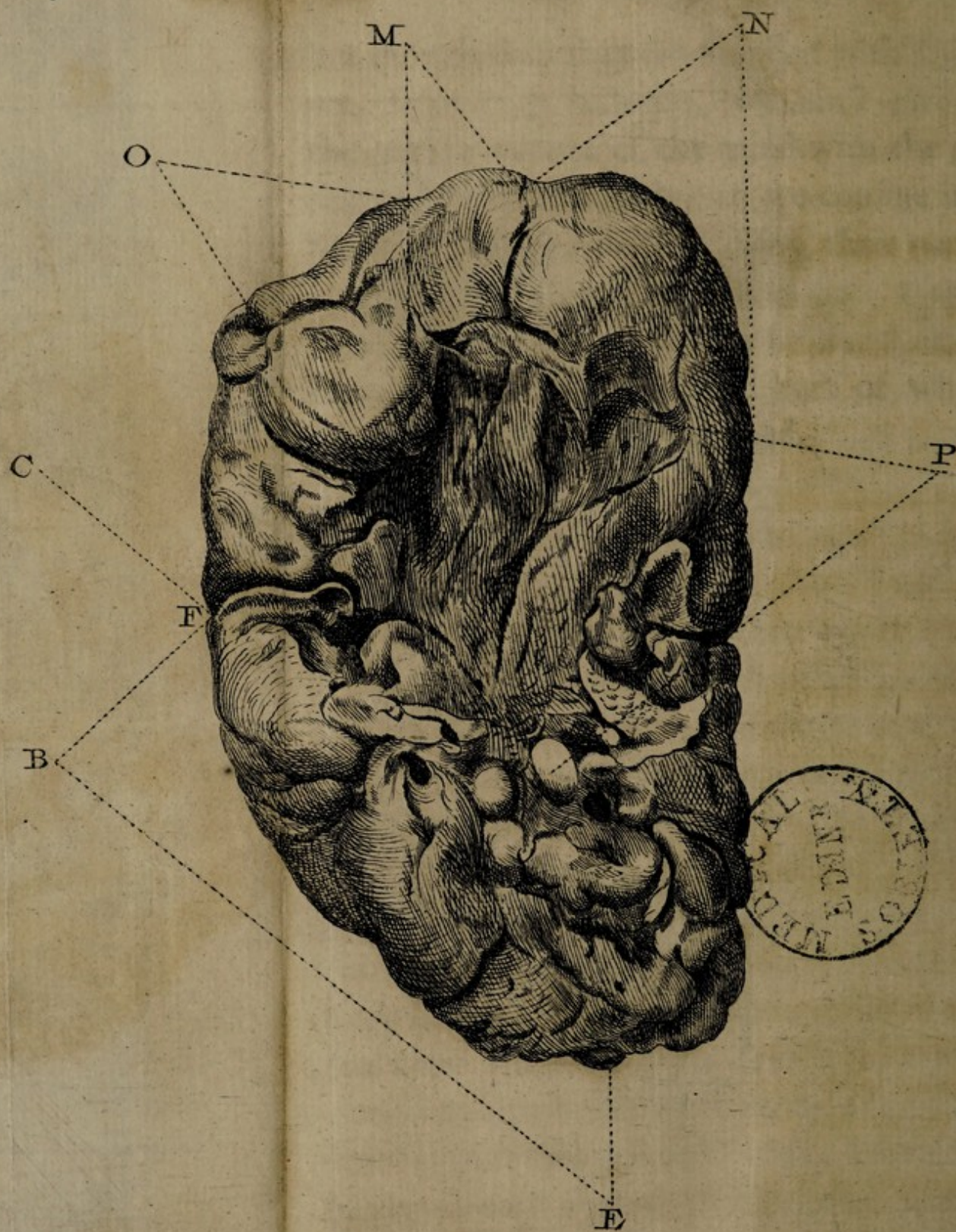


Fig. II.



A Bell Sculp.

F I G. I.

E A D is the length of the upper surface.

The angle C F B is at the chink, where I suppose the *dura mater* was separating between the *cerebrum* and *cerebellum*: it is so wide as to receive a shilling, and runs round the side to the base on the left side; but how it was on the other, is not to be known; it being at that place where a considerable part of the brain was driven off in opening the skull.

K represents the gap made by the ax, and is a full inch deep and broad.

L where a superficial splinter flew off.

H is the eminence in the middle of the surface of the *cerebellum*.

F C D the half of the upper surface of the *cerebellum* on the left side.

F B E the length of the *cerebrum*.

G a small sinuosity along its middle, which, we reckon, opened to the *corpus callosum*; and on each side of it there seems to be left some vestiges of the interstices, between the wreaths of the cortical substance.

I comprehends so much of the lateral parts on the right side.

F I G.

FIG. II.

Figure 2. is the base, with a view of a small part of the left side.

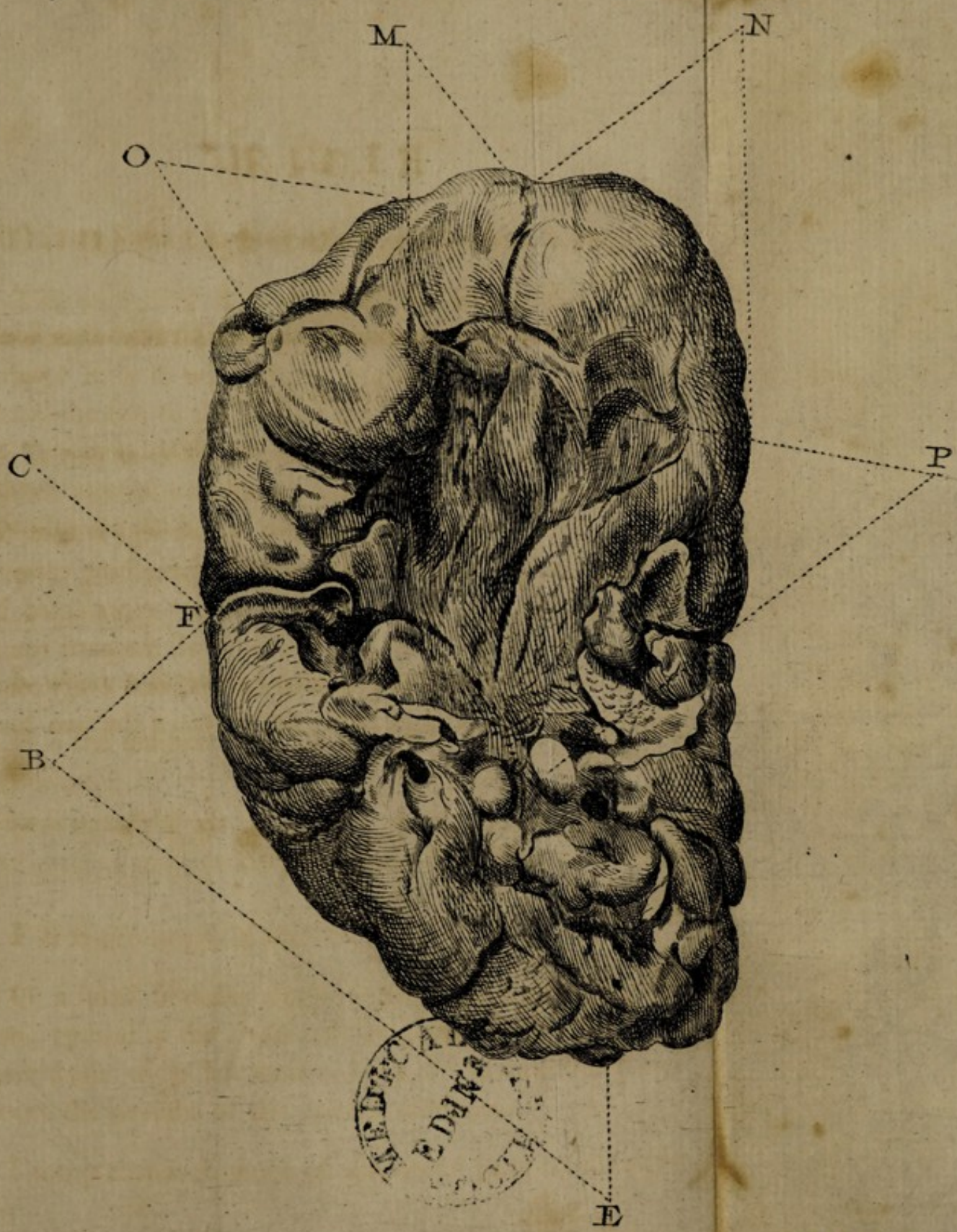
C F B the continuation of the chink round that side.

F B E the length of the *cerebrum*.

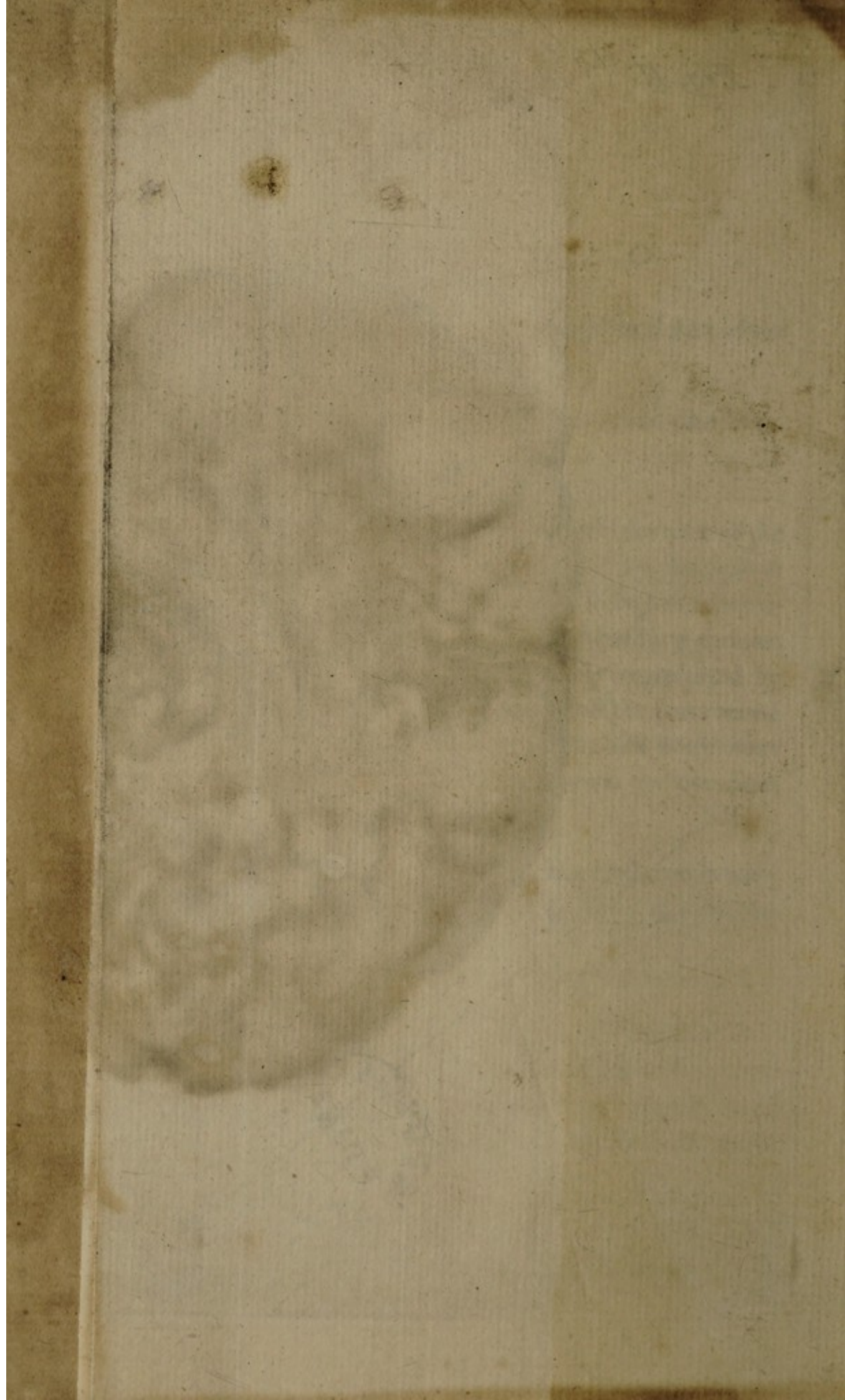
O and N are the gibbous parts on the posterior part of the *cerebellum*, which leave M between them a smooth hollow furrow, which runs to P, between whose legs is comprehended a part of the base, which looks something carious. This furrow, half an inch broad, is not represented by the Painter: it is glazed and yellow as all the parts round it: as are all the smaller granulated parts, and every other part of the base, except what lies between the two lines from P.

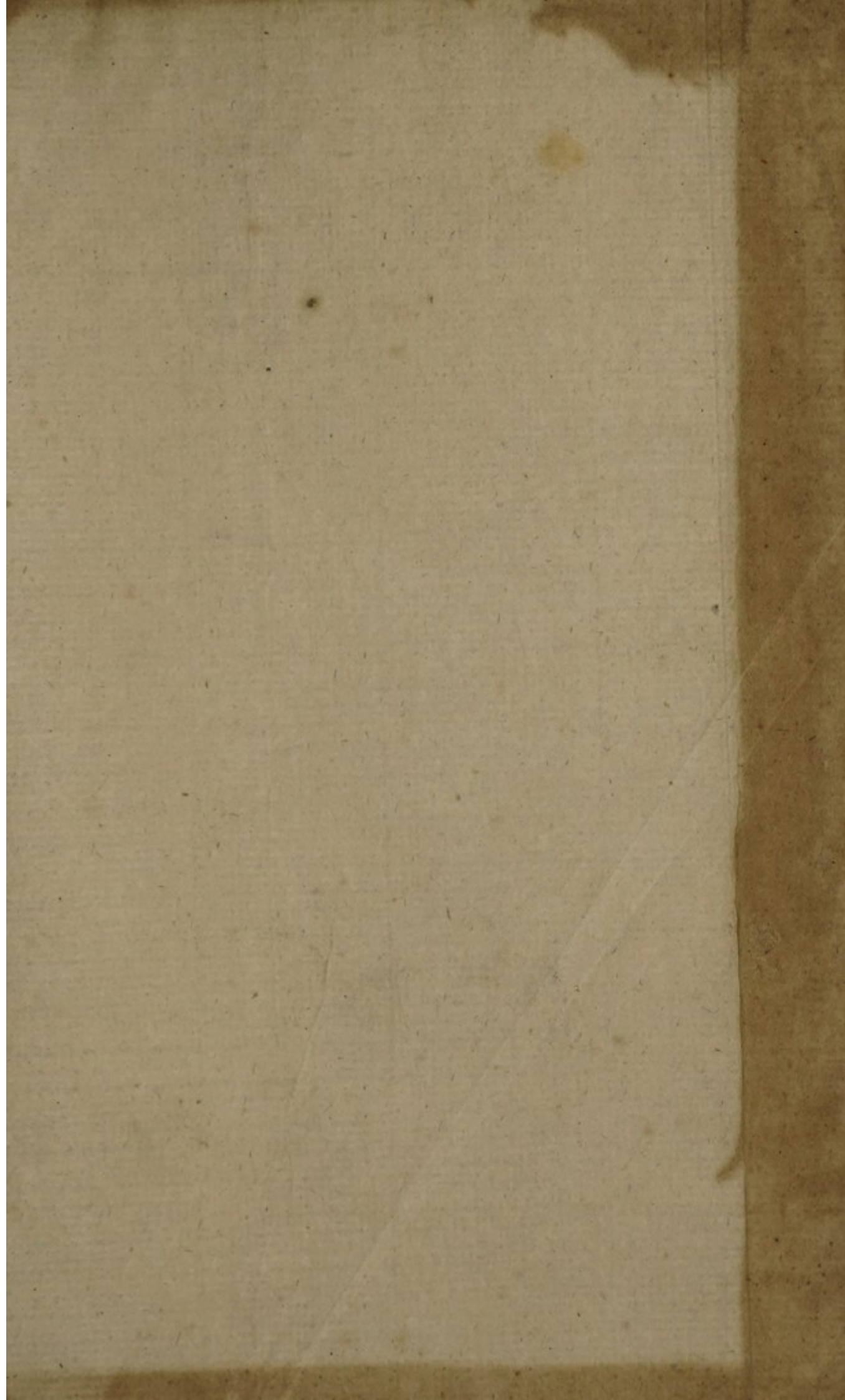
When we cut into any part of it, the substance is whiter than that of most bones, and scarce more porous than ivory.

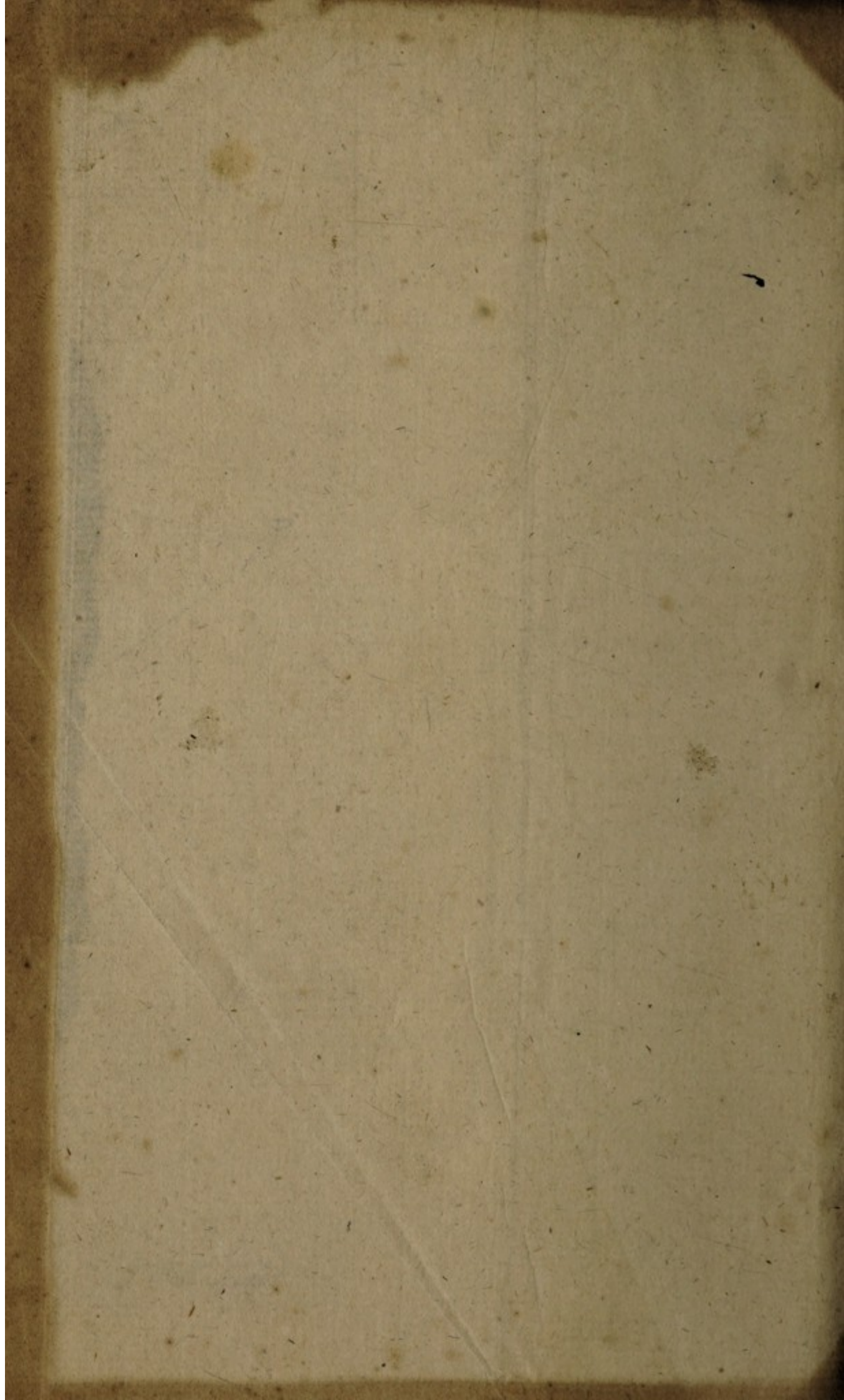
Fig. II.



A. Bell Sculp.







1771

