

*A short Discourse concerning Concoction: Read at a Meeting of the Royal Society, May 1699, by Clopton Havers, M. D. Fellow of the Royal Society.*

THE Manner in which the Digestion of the Aliment is performed, is a thing not very easie to be understood and explain'd. However, it has not escap'd the Conjectures of some Philosophical Men, who having curiously observ'd the *Phænomena* of Nature, and enquired into their Causes, have, amongst other things, endeavour'd to account for this. But their Sentiments about it have been various, and the Hypothesis, by which they have studied to explain it, very different. Some have thought the Concoction of the Food to be a kind of Elixation; and that the grosser and more solid Parts being as it were boiled in the Liquid by the Heat of the Stomach, and the Parts adjacent to it, as the Liver, Spleen, and Omentum, are by a long and continued Elixation first render'd more tender, and then colliquated, and dissolved into minuter Particles, so as to mix more equally with the fluid, and with that to make one Pulpament, or chylous Mass. And *Hippocrates*, tho' he does not plainly call it an Elixation, yet seems to attribute the Concoction of the Food to the Heat of the Stomack, as the Cause of it: *Sect. 4. Libro de salubri victus ratione.* So where he takes Notice of the voiding of such Fœces as appear to be like the Food that has been eaten, he adds, *Constat enim, sanè ventriculum, ciborum copiam, ut concoquat, calefacere non posse.* And there are other Passages in the same Book, from which we may conclude, that he sup-

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pos'd the Heat of the Stomach to be the great Cause of the Digestion of the Food.

There are others that make the Stomach it self to be the great Instrument of Digestion, but in a different manner : And they suppose it to be perform'd by an Attrition, as if the Stomack, by those repeated Motions, which are the necessary Effects of Respiration, when it is distended by the Aliment, did both rub or grind off some minuter Particles from the grosser Parts, and by continually agitating the Mass of Food, make those Parts, which are not contiguous to the Stomack, strike one against another, and break one another in pieces, until they are all attenuated. It is evident enough, that the sides of the Stomack do in Expiration press upon the Contenta, so as to oblige, at least some Parts of them, every time the Muscles of the Abdomen are contracted, to move and shift their Places. So in Inspiration, when the Diaphragme and Liver press upon the upper Part of the Stomack, the Aliment must be moved again. So that by these reciprocal Motions, that part of the Food, which is contiguous to the Stomack, and moves in a Line parallel to it, must rub against it : And all the other Parts being moved by such a Compression, as gives them a different Tendency, it is certain they must be continually striking one against another. And for Bread, and such Things as are made of Flower, that will be soften'd and dissolv'd with any common Liquid, that Agitation of the Stomack, which moves them in Respiration, might seem sufficient to break and dissolve them, when they are sufficiently moisten'd with a Fluid. Yet this cannot be thought enough to break and digest Flesh-meat, Fruits, or any other thing that will not be softned and dissolv'd in Water, or some such Liquid. But altho' this Motion of the Aliment, caus'd by Respiration, does not actually digest it, yet it has a great  
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and necessary Use in Concoction, and makes all the grosser Parts, as they are attenuated, mix equally with the Fluid.

Some think that the Bilious Juice ; others, that the Spirits, are chiefly concern'd in this Affair. *Galen*, in his Book *de Naturalibus Facultatibus*, makes it to be the Effect, not of one, but of several Causes ; as, a Pituitous Juice in the Stomack, the Bile, &c. which appears from what he has said, and the Translator thus render'd : “ *Verum quanto ii (cibi) qui mansi sunt, iis, qui inhæserunt, magis sunt alterati ; tanto etiam his magis ii, qui devorati sunt. Siquidem incomparabilis erit horum alterationis excessus, si & quæ in ventre est Pituita, & Bilis, & Spiritus, & Calor, & tota Ventris substantia, æstimentur.* ”

Some there are that will have the Food to be dissolv'd by a Menstruum, which is supply'd from the Glands of the Stomack, or some other way : But those that do so far agree in the General, as to think Concoction is perform'd by a Dissolvent, do differ in their Notions of the Nature of the Menstruum : For there are some that suppose it to be an Acid, which does erode the grosser Parts of the Food, and dissolves them in the same manner as Vinegar, Spirit of Vitriol, or any such-like Acid, will dissolve even so solid a Body as Iron. And it cannot be deny'd, but that Oil of Vitriol will dissolve Fleish-meat, and reduce it to a Pulp : But it is not to be suppos'd that the Fibres of the Stomack can admit any such strong and corroding Acid, without something to correct it, but it must be injur'd in its Tone, and labour under great and extraordinary Pains. Neither does such a Menstruum, tho' it will digest some things, seem capable of dissolving so great a Variety of Things as we eat, especially when a great many of them are of a contrary Nature. Some will have the Menstruum to be a

*nitro-aëreous* Spirit, that is, quick, and ve<sup>r</sup>y penetrating, and included in its proper Vehicle ; which, being in its own Nature apt to penetrate the Mass of the Aliment, does diffuse it self through the Whole, and breaking the Vinculum of the more solid Parts, does dissolve their Compages. By others, it is thought to be some Saline Juice in the Stomack, by which the Parts of the Aliment are divided and dissolved, and those which are fit for Nourishment, are volatiliz'd.

Lastly, There are some others who reject the Opinions I have already mention'd, and suppose the Digestion of the Food to be perform'd by the Benefit of a Ferment, which, when it is mix'd with the Aliment, excites in the Mass an intestine Motion, and the different and contrary Motions or Tendency of the Parts making some kind of Collision, gradually break off Particles from the Grosser, and more solid Parts, till they are so attenuated as to be apt to mix more equally with the Fluid, and with them to make one soft or chylous Substance. But yet there is not amongst them an universal Consent, either about the Nature of this Ferment, or the manner how it is supply'd. For first, some think it to be the Remains of the Food that was last digested ; which, having lain some time in the Stomack, after the rest is carried down into the Intestines, contracts an Acid, or some other Quality, and is so alter'd as to partake of the Nature of a Leaven. And this Leaven being a Part of the Food, which has been already digested, is so soft and liquid as to be capable of mixing with the Aliment, which is next taken into the Stomack, and being agitated with it by the repeated Pressures of the Diaphragme, Liver, and Abdominal Muscles upon the Stomack in Respiration, does diffuse it self through the whole Mass, and being mixed with it, like Leaven, or Yest added to new Wort, &c. puts it into a State of  
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**Fermentation**, and by this Fermentation, or the Expansion of the Ferment, and the more tenuious Parts, which are first put into Motion by it, those which are more solid, and with which they are intermix'd, are rent, and divided, and so attenuated, as to become a soft and pulpous Matter. And altho' the greatest part of the Food, that is thus broken and concocted, is by the Contraction of the Fibres of the Stomack press'd into the Duodenum, yet they do not contract themselves so as to force out all the Aliment, but leave between the *Rugæ* or Folds, on the inside of the Stomack, a sufficient Quantity to be a Leaven to the next Meal; and so from time to time.

Some have a Notion, That this Ferment, or Principle of Fermentation, is in the Aliment it self; which being a Congeries of Matter, consisting of various Parts of a different Nature, is no sooner enclosed in the Stomack, and digested in the Heat of that, and the adjacent Parts, but the more spirituous and subtil Particles are put into motion both from that Warmth, and the Difference of their Natures, and enter upon a Fermentation. And so by their intestine Commotion, and the Violence they offer to those Parts which oppose the Tendency of any of them, they break and dissolve what is more solid.

Again : Some suppose, that this Ferment is supply'd from the Glands of the Stomack.

And Lastly, Others, and perhaps with much better Reason, contend for the Saliva, and make that to be the Ferment, which serves principally for the Digestion of the Food; which in Mastication being mix'd with our Aliment, is with that carried down into the Stomack, where the Parts of it being put into Motion by a kindly and agreeable Heat, they do ferment with, and exagitate first those Parts of the Food which are most  
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apt to ferment with it, and then both conspire to break and dissolve the grosser and more stubborn Parts. And *Galen*, in the Book I have before-mentioned, plainly allows that the Saliva is concern'd in the Business of Concoction, tho' he supposes the Alteration, which is produc'd by this Juice, to be made in the Mouth, as appears from these Words: *Quæ (alteratio) in ore agitur mutat quidem id (nutrimentum) in alteram speciem manifestè, non tamen ad perfectionem transmutat— Qui mansi sunt Cibi primum quidem hæc Pituitâ (oris) imbuuntur, & cum eâ miscentur— Itaque majorem mutationem consecuti sunt, quam ii, qui in vacuis dentium intervallis fuerè im-* *paçti.*

Now I have given this short Account of the various Opinions of some Ingenious Men, concerning the Manner how Concoction is perform'd; I come now to propose my own Hypothesis, by which I shall endeavour to explain it.

In order to the more easie and effectual Digestion of the Food, Nature has appointed some Parts for the breaking our Aliment, and reducing whatever is gross into smaller Parts, before it is put upon Digestion: Others to supply the Ferment, by which it is to be dissolv'd and concocted, and which, before it comes to be included in the Stomack, does moisten, and make it more soft, that it may more easily be penetrated and broken by those Parts which serve to divide every Morsel into smaller Pieces, and prevents the Inconvenience and Trouble which would arise from the Nourishment sticking about or between them, when it is dry or viscous.

For the breaking of that part of our Food, which is not liquid, Nature has furnish'd us with Teeth, and those of two sorts: For some are ordain'd to divide and  
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break off smaller Morsels from a larger Mass ; others are made for the grinding those Morsels into much smaller parts. The Teeth, which serve to break off Pieces of a convenient Magnitude from a larger Mass, are of two sorts accommodated to the Nature of the Substance which we eat. These are the *Incisores*, and the *Dentes Canini*. If the Substance, which we have to eat, be not hard, but more easily penetrated and<sup>s</sup> divided, then the *Incisores* are capable of making an Impression upon it, and fix'd firmly enough in the Jaws to break off that Part which they take hold of. But if it be more solid, and not easily penetrated, nor any Piece without Difficulty to be separated from that Body, whereof it is a Part, then we apply the *Dentes Canini*, or Eye-Teeth to it, which are not spread, nor have such an edge as the *Incisores*, but are sharp and pointed like an Awle, and so do more readily penetrate a Substance that is hard, and which the *Incisores* can scarcely make any Impression upon. And as the Parts of a more solid Body are commonly with more Difficulty separated, and there must be a greater Stress put upon those Teeth which pull it into pieces ; so these Teeth are much more firmly fixed in the Jaws than the *Incisores*, tho' they have but one single Root. Besides, the Position of all these Teeth is accommodated to their use, as being planted opposite to the Aperture of the Mouth, so that they may be conveniently apply'd to the Substance which we have to eat, before it is broken, and when it is too large to be admitted within the Mouth.

The Teeth which do by a Compression and Attrition reduce the little Morsels to smaller parts, are from the manner in which they break the Aliment, called *Dentes Molares*, because they do, like so many little Mill-stones, grind the Food between them. And that they might be render'd fit for this purpose, they are made broad at  
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that Extremity, which stands out of the Gums, by which means they retain some Quantity of the Food between them every time the lower Jaw is pulled up and forc'd against the *Maxilla superior*. And as they are broad, so they are formed with Inequalities and Protuberances, and by the motion of the lower Jaw, from one side towards the other, they grind what they have between them into pieces. The Position of these Teeth too is as convenient as that, of the *Incisores*, and the *Dentes Canini*: For being design'd to break those pieces of our solid Food, which are taken into the Mouth, and these pieces, when they are compress'd, and moved by the *Dentes Molares*, being apt to fly out of the Mouth, if there were no Contrivance to prevent it, they are placed beyond the Aperture of the Mouth, and opposite to the Checks, which keep the Food within that Cavity, and not only so, but press it in between the *Dentes Molares* on one side, as the Tongue does on the other, until they have sufficiently broken and divided it.

At the same time, whilst the *Dentes Molares* are breaking the Food, there flows into the Mouth a salival Juice which mixes with it, and not only serves to moisten it, and to render it more apt and easie to be divided, but seems to be the Ferment, by the Benefit of which the Food is dissolved and digested. And therefore it is intimately mixed with it by the Teeth agitating or stirring them together in mastication.

This Liquor, which we commonly call the Saliva, or Spittle, seems to be a Composition made of two several Juices, very different in their Nature. And therefore the several Parts of it are separated by their proper Glands, and Nature has planted no fewer than four pair about the Mouth, which supply the Juices that make the Saliva; to wit, the *Parotides*, and the *Glandulæ Nuckianæ*, the *Glandulæ Maxillares internæ*, and *Sublinguales*.



*guales.* Whereas if the *Saliva* were but one more simple Liquor, a less Number of Glands might have been sufficient. At least there appears no Reason why one of every Pair should disembogue it self into the Mouth so very near to the Orifice, by which a Gland of some other Pair throws in its Juice; and they are not rather all planted at more equal Distances from one another, so to flow in upon every part of the Aliment at the same time.

Not that I suppose, as there are four pair of salivatory Glands, so there are four sorts of Juices supply'd from them, to make the *Saliva*; but, as I hinted before, that there are only two different Juices, that constitute it. And these are not only sufficient, but more proper to excite and secure that Fermentation, which is necessary to Concoction. For we find that most of those Fermentations, which arise upon Mixtures made for Experiments, are produced from the Mixture of two things, and it is not so easie to find out three or four such Liquors of a different nature, as will, upon the Mixtion of them all, produce a Fermentation, and from the Omission of any one of them discover no Discord or Disposition to ferment. Besides, it is certain that two do better secure the End, which Nature designs. For, if there were three or four different Juices, of which the *Saliva* naturally consists, these must all have their proper Qualities preserv'd to them, or else the Fermentation, which should arise between them, will not necessarily follow upon their Mixture; and it is certain, that there would be more Danger, that one of three or four should be depriv'd of its natural Quality, than one of two.

What Nature these two Juices are of, I do not pretend positively to determine; but so far as I have been able to make my Conjectures about it from Experiments, I do think one of them to be an acid Juice; the other

an oleaginous Liquor, something like Oil of Turpentine. For amongst the many Experiments I have made, there was no one that gave me so much Satisfaction as that which I made with Oil of Turpentine and Oil of Vitriol, tho' I try'd several other things, that will produce a Fermentation upon their Mixture. And it was for this Reason that I made the Experiment with Oil of Turpentine, and the other Oil.

I took a piece of raw Flesh, and having cut it into pieces, but much larger than what our more solid Food is reduc'd to by due Mastication, I mix'd some Crums of Bread with it, then I poured in the Oil of Turpentine to them, and upon that the Oil of Vitriol, and having shak'd them together, I digested them about four Hours in *Balneo Mariæ*, and then shaking them again in the Glass, I found the Meat dissolv'd, and they all became a thickish Pulp. I could not but take notice, that Oil of Camphire (tho' it does not otherwise seem much different in its Nature from Oil of Turpentine) and Oil of Vitriol, which upon Mixture will produce an effervescence as well as the Oil of Turpentine and Oil of Vitriol, yet did not touch the Meat, upon which I poured them, so as in the least to dissolve them. I cannot deny but that an Acid, and a Solution of Salt of Tartar, did dissolve some part of the Flesh-meat, which I mix'd them with, but yet neither so soon nor so perfectly as the two forementioned Oils. And I do the rather think one of those Juices, which constitute the Saliva, to be of the Nature of Oil of Turpentine, than of a fix'd Salt, because it will correct and temper even Oil of Vitriol, so as to render it more tolerable to the Fibres of the Stomack. Not that I suppose the acid part of the *Saliva* to come near to the Acidity of Oil of Vitriol. For tho', when they are mix'd, they will make a Liquor that may not be injurious to the Stomack, yet the acid  
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Juice, if it were so corrosive as Oil of Vitriol, would certainly be injurious and painful to the salivatory Ducts, which convey it to the Mouth before it is mix'd with the oleaginous Liquor. But I only say it is an Acid, and in some degree approaches to the Nature of that Oil. And Nature, which can much better adapt several Causes for the Production of such an Effect than Art, may attain her End by a more temperate Acid. Tho' at the same time we may be able to make some probable and true Conjectures about the Nature of those Causes from Experiments.

It being most reasonable to suppose, that there are but two sorts of Juices, of a different Quality, that make the *Saliva*, I do conceive, that four of the eight salivatory Glands, or two pair of the four, do supply one of these Juices, and the other four Glands the other. And this seems to be a very good Reason, why they are so planted, and the Orifice of their Ducts so order'd, that the Juice, which is supply'd by one Gland, is discharg'd into the Mouth, very near to the Orifice, by which the Juice of a different Nature is transmitted from another, so that they must necessarily meet and mix together. Thus the *Glandulæ Nuckianæ*, and the *Parotides*, throw in two different Juices by Orifices, which open into the Mouth very near to one another; and the *Glandulæ Maxillares internæ*, and *Sublinguales*, do below supply the same kind of Juices by Orifices, that open so near to one another as to secure the Mixture of the two different Juices.

These Glands, I say, do between them afford two diverse sorts of Liquors, of such a Nature as are apt to ferment upon their first Mixture, but perhaps more considerably when they come to be digested by the Heat of the Stomack. So that the Colluctation, or Fermentation, which attenuates and concocts the Food in the

Stomack, does not ordinarily arise between the Aliment and the *Saliva*, but between the several Parts of the *Saliva* it self. And indeed, if the *Saliva* did not consist of two Juices, whose Nature is in such a manner different, as to render them apt to ferment upon their Mixture, it would be very hard to conceive how it should so readily and indifferently serve for the Digestion of all Eatables; how it should ferment with, and dissolve so great a Variety of things, not only of a different, but of a contrary Nature; how it should ferment with Acids as well as Alkalies, digest things that are cold as well as hot or temperate; some things that are salt, others that are insipid, bitter, and sweet, mucilaginous, oily, &c. But if we suppose, that the Fermentation, which serves for the Digestion of the Food, arises from a peculiar Difference in the nature of two Juices, which constitute the *Saliva*, it will be easie to give a rational Account of our Concoction of innumerable things of a different Nature. And this seems to be as effectual, and a more certain way to attenuate and dissolve the grosser Parts of our Food, than if the Fermentation were made only between the *Saliva* and the Aliment: Besides, the *Saliva* seems to discover a Fermentation upon the Mixture of its constituent Juices, even at those times when we do not actually eat; for it is always attended with Bubbles, and a Froth, when it has not been at all agitated in the Mouth, and many of those Bubbles will remain for some considerable time after we have spit it out.

Nature therefore having appointed the *Saliva* for the Digestion of the Food, has taken care that it shall be thrown in upon the Aliment on every side. Thus the *Glandulæ Nuckianæ*, and the *Parotides*, supply their Juices to that part of the Food, which lies on the outside of the Gums, between the Cheeks and the Teeth, and the

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*Glandulæ Maxillares internæ*, and *Sublinguales*, do bestow their Liquor upon the Meat, which is within the Teeth and Gums. Neither has she had a Regard only to that Supply, which is due to all the Parts of our Food, but likewise to the Mixture of the two different Juices of the *Saliva*, which is necessary to its Fermentation. And therefore, as I have already observ'd, the Orifices of the Ducts, which belong to one sort of Glands, are placed near the Aperture of a Duct, which conveys a Juice from one of the other Glands. So the Ducts of the *Glandulæ Nuckianæ*, and the *Ductus Stenoniani*, do on each side open into the Mouth, near one another; and the salivatory Ducts of the *Glandulæ Sublinguales*, and the *Maxillares internæ*, tho' they have distinct Orifices, empty themselves under the same *Papillæ*; and the Juices, which are supply'd by them, meet there, and flow into the Mouth together.

The several Parts of the *Saliva* being discharg'd into the Mouth in such a manner as to meet and begin a Fermentation, the *Saliva* does, partly as it is agitated with the Food by the Teeth, and some other Parts of the Mouth, partly by its own Fluidity insinuate it self into, and mixes with the Food, and not only moistens and softens it, but excites the Fermentation, which is to dissolve it. And when the Aliment is thus mix'd with the *Saliva*, which serves to ferment the whole Mass, it is then to be convey'd into the Stomack, that great digestive Vessel of the Body, where the Fermentation is not only continued but improved.

The Nourishment being convey'd into the Cavity of the Stomack, is there kept for some time in a digestive Heat, all which time it is under a Fermentation produc'd by the different Parts or Juices of the *Saliva*, which are mixed with it; which Fermentation does first agitate the more tenuious or subtil parts of the Food, and puts them

them into motion, and so with the Fermentation of its own, and those Alimentary Parts, which it first communicates a motion to, improv'd by the Heat of the Stomack, the *Saliva* must necessarily act upon the grosser Parts. For the intestine Motion, which is excited in the Mass, does not give the Particles, which are fermented, the same Tendency, but what is so various and confus'd, that they must inevitably strike not only one against another, but against those, which are more gross, so as to attenuate them, sometimes by a Collision, which strikes off smaller Particles from the larger Parts ; sometimes by a Compression, when the Particles, which are in motion happen to strike directly against any grosser Part, on every side of it ; sometimes by a kind of Explosion. For without doubt the *Saliva*, which is fluid, insinuates it self into the Interstices of the more crass Parts of the Aliment, and whatever is agitated and expanded in those Interstices, requiring a larger space for the Freedom of its Motion, and offering a Violence to every thing, that opposes its Tendency, will, like Gun-powder included in a Shell, force its way out, and tear to pieces that Matter, which does endeavour to confine it.

Thus the grosser Parts are broken and divided, until they are at last so far attenuated as to mix more equally with the Fluid, and with them to make one Pulp or chylous Mass. And altho' I do not apprehend how the Stomack should by its reciprocal Motions in Inspiration, and Expiration, be able to break and attenuate any Matter, that will not be soften'd and dissolved by agitation in a Liquid, yet it is certain that these Motions, caused by the Diaphragme and Abdominal Muscles in Respiration, do make those Parts, which are broken off, as they are dissolv'd, mix intimately with the more liquid, as the Meat which I digested with Oil of Turpentine, and  
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Oil of Vitriol, did by agitation mix more equally with the Oils, and became a Pulpament.

As the Juices, which constitute the *Saliva*, do ferment upon their Mixture, so it is probable that from their Mixture and Fermentation there results such a *Tertium quid* as is apt to ferment with the Bile. And therefore, when the Aliment has been under the Fermentation, excited by the *Saliva*, a sufficient time, it is then thrown into the *Duodenum*, where it meets with the bilious Juice, which flows into that Intestine from the Liver, from which a new Fermentation seems to begin; and the Commotion of the Parts of the Aliment being still continued, does carry on the Business of Digestion until the Food is perfectly concocted. Tho' it is probable, that this new Fermentation serves not only for the more perfect Digestion of the Food, but likewise for the Separation of the Chyle from the feculent Parts.

Neither do I by a random Guess, and an ungrounded Conjecture, suppose that from the Mixture and Fermentation of the two Juices, which constitute the *Saliva*, there results a Matter, which is apt to ferment with the Bile. But to me the Notion seem'd to be confirm'd by an Experiment that I made. For considering with myself that the Bile is generally allow'd to have much of a saponary nature, I made a Solution of Soap in fair Water, and mix'd it with the Oils of Turpentine and Vitriol first put together, and from their Mixture I observ'd a very easie and gentle Fermentation, which continued for a considerable time.