EXPERIMENTS AND OBSERVATIONS

ON

DIGESTION:

AN INAUGURAL ESSAY,

FOR THE DEGREE OF

DOCTOR OF MEDICINE.

SUBMITTED TO THE EXAMINATION OF THE REV. JOHN ANDREWS, D. D. PROVOST (PRO TEMPORE) THE TRUSTEES AND MEDICAL PROFESSORS OF THE UNIVERSITY OF PENNSYLVANIA, ON THE EIGHTH DAY OF JUNE, 1803.

BY OLIVER H. SPENCER,
OF NEW-ORLEANS, HONORARY MEMBER OF THE PHILADELPHIA MEDICAL AND CHYMICAL SOCIETIES.

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1803.

TO DR. RICHARD ALLISON,

OF THE STATE OF OHIO,

THIS ESSAY,

AS A

TESTIMONY OF THE MOST LIVELY FRIENDSHIP,

IS INSCRIBED,

BY

AN AFFECTIONATE AND GRATEFUL PUPIL,

THE AUTHOR.

TO BENJAMIN SMITH BARTON, M.D.

PROFESSOR OF MATERIA MEDICA, NATURAL

HISTORY AND BOTANY,

IN THE UNIVERSITY OF PENNSYLVANIA,

THIS ESSAY

IS ALSO RESPECTFULLY INSCRIBED,

AS

A TRIBUTE OF RESPECT,

AND

THE MOST LIVELY ESTEEM,

BY HIS FRIEND AND HUMBLE SERVANT,

THE AUTHOR.

EXPERIMENTS AND OBSERVATIONS

ON

DIGESTION.

PREVIOUS to commencing the ſubject of our eſſay, it will be proper to take a ſhort anatomical view of the ſtomach. The other viſcera concerned in chylification, by means of the different fluids which they ſecrete, we think it unneceſſary to notice; becauſe in no part of the work ſhall we examine the changes which the chyle undergoes, after leaving the ſtomach and mixing with the fluids ſecreted by theſe viſcera.

The human ſtomach is oblong, large, and membranous; of different dimenſions in different perſons, and capable of conſiderable contraction as well as diſtention, without much inconvenience: the former ſtate is obſerved in the ſavage of our country, who is obliged, frequently, to ſubſiſt for months on a ſpare diet, during which time the ſtomach is contracted by its muſcular fibres, and he returns from his excurſions with a conſiderable depreſſion in the epigaſtrium, as

well as the whole abdomen: civil ſociety preſents us with daily proofs of the latter ſtate, from indulging in the pleaſures of the table.

It is ſituated partly in the epigaſtrium, and partly in the left hypochondrium, immediately under the diaphragm, and contiguous to the heart, liver, ſpleen, and pancreas; and when diſtended with food, lies in an oblique direction, inclining anteriorly downwards and forwards.

The ſtomach is formed of four tunicæ, or coats, connected ſtrongly to each other, by condenſed cellular membrane. The firſt, or outer coat, is ſimply membranous, and is common to the inteſtines as well as to the ſtomach; being a continuation of the peritoneum, which, after lining the whole cavity of the abdomen, is reflected and forms a covering to all its viſcera; in ſome inſtances, indeed, but partial, as is the caſe with the kidneys, which lie without the peritoneum. Immediately under the firſt lies the ſecond, or muſcular coat, compoſed of fibres in a circular and longitudinal direction, upon the contraction and relaxation of which depends the periſtaltic motion of the ſtomach.

The third may properly be called cellular, being made up, almoſt entirely, of condenſed cellular membrane, and capillary veſſels, ſupported by fine ligamentary filaments. Laſtly, the inner coat, termed by the ancients fungoſa, is exceedingly delicate, and forms with the cellular coat, to which it adheres, a number

of rugæ upon the inner ſurface of the ſtomach, particularly about the pylorus, which ſerve to counteract its periſtaltic motion, by preventing the food from being thrown too haſtily into the duodenum.

The nerves of the ſtomach ariſe, chiefly, from the par vagum, or eighth pair; and from the intercoſtalis, or great ſympathetic nerve, by means of the ſtomachic nerve, the ganglions of the plexus hepaticus, and plexus ſplenicus.

Its arteries are derived, principally, from the cœliac; and as no glands are to be met with in the ſubſtance of the ſtomach, agreeable to Morgagni, Haller, and Sabbatier, it is probable that the gaſtric juice is poured out by the minute branches of theſe arteries, which are interſperſed throughout the coats of this organ.

The ſtomach is a viſcus of primary importance in the animal economy. To a proper ſtate of its ſecretion (depending, we ſuppoſe, upon a certain tone, and healthy action of its veſſels) are we indebted for health, mental enjoyment, and long life. Few men, obſerves profeſſor Ruſh in his manuſcript lectures, attain to old age, who have been ſubject, in their youth, to dyſpeptic complaints. We cannot, therefore, be ſurpriſed, when we find it ſo abundantly ſupplied with blood-veſſels and nerves.

Preparatory to the food being received into the ſtomach, it is neceſſary, in moſt perſons, that it ſhould

be minutely divided by maſtication, and formed, by mixture with the ſaliva, into a ſoft maſs; not only to render it eaſy of deglutition, but to favour, likewiſe, its more ſpeedy ſolution in the ſtomach. To the labouring part of mankind, particularly thoſe who exerciſe much in the open air, we find that the minute diviſion of the food is by no means ſo neceſſary as for ſedentary people. The former, we obſerve, often ſwallow food of the moſt difficult ſolution, almoſt entire, without experiencing, afterwards, any inconvenience. Exerciſe gives tone to the ſyſtem, and by increaſing the circulation, a large quantity of gaſtric fluid is ſecreted; and food, being well maſticated, would, in ſuch a ſtomach, be diſſolved and formed into chyle in greater abundance than is required for the nutrition of the ſyſtem, if the appetite of hunger was ſatisfied as often as the ſtomach became empty.

Happily and wiſely for mankind, the gratification of the appetite of hunger and thirſt is attended with pleaſure, ſufficient, in moſt inſtances, independent of the love of life, to compenſate for the trouble of obtaining the means. The ſtimulus of the gaſtric juice upon the ſenſible coats of the ſtomach, and the weight of the liver, unſuſtained and pulling downwards the diaphragm, to which it is attached by means of the middle ligament, cauſes that uneaſy ſenſation we call hunger, the principal ſeat of which is generally ſuppoſed to be at the cardia. But for this, mankind would not have, perhaps, a ſufficient incitement to rouſe them from their natural indolence.

By the term Digeſtion we mean the proceſs which the aliment undergoes in the ſtomach. It ſhould extend farther, and embrace in its ſignification, not only this change, but the alteration which farther takes place before the chyle is finally emptied into the ſubclavian veſſels. Want of time, however, will prevent us from going thus far.

Much controverſy has prevailed in every age, reſpecting the manner in which digeſtion is begun and carried on in the ſtomach; and, until the talents and attention of Reaumur, M'Bride, Stephens, Spallanzani, and Hunter had been exerted, the ſubject was involved in obſcurity; and for want of a juſt phyſiology, the diſeaſes of this organ were frequently very improperly treated. The limits of my eſſay will not permit me to examine the variety and contradictory opinions which prevailed among the ancients upon this ſubject. Some of them, for their ſingularity, are worthy the attention of the curious, but, as relating either to medicine or natural hiſtory, are of but little importance in their application.

Trituration, one of the cauſes, according to ancient opinion, and perhaps the moſt probable of them, was revived as late as the beginning of the laſt century; and from the general reception which it met with at that time, it has been common for the phyſiologiſts of the preſent day, when writing upon the ſubject, to notice the doctrine.

In accounting for this proceſs, fermentation and putrefaction have likewiſe had their advocates; but the latter having leſs plauſibility, and being diſagreeable in its contemplation, has been leſs generally embraced than the former, particularly ſince the writings of the celebrated Dr. Cullen have been publiſhed. We ſhall proceed to examine theſe ſeveral doctrines in rotation; and after introducing ſome experiments performed, not with a view to eſtabliſh any favourite theory (for I had none when I began them) and quoting a variety of others, ingeniouſly made by celebrated men in the literary world, endeavour to draw fair concluſions from eſtabliſhed facts, unbiaſſed by prejudice.

The ſupporters of the doctrine of mechanical force, or trituration, inſiſt on it, as a proof of their theory, that birds digeſt their food by this means. We cannot conceive how this can be alleged in favour of the opinion; for there is certainly but little analogy between the ſtomach of man, and the muſcular ſtrong ſtomach of theſe animals. No doubt the minute diviſion of their food, which is performed in the ſtomach, aſſiſts its ſolution, in the ſame way that any ſubſtance is rendered more readily ſoluble in a menſtruum by diviſion, inaſmuch as a greater ſurface is expoſed to be acted upon by the fluid.

Reaumur took a buzzard, becauſe that bird has a membranous ſtomach, incapable of any great degree of triturative power. To preclude, however, the poſſibility of any, he employed perforated tin tubes, that

would admit the gaſtric fluid to come in contact with the beef which he employed in the experiment. This was forcibly thruſt into the bird's ſtomach, and remained there twenty-four hours. Upon examination, the beef was found reduced to three-fourths of its original quantity: what remained had the appearance of threads, extremely fine, but was neither putrid, acid, nor volatile, but quite inſipid. Spallanzani, the illuſtrious profeſſor of natural history, in the univerſity at Pavia, made a number of experiments upon this point, which are deciſive in eſtabliſhing the power of the gaſtric juice, while they ſhow the falſity of the other theories. He encloſed, after the example of Reaumur, entire barley, in perforated metal tubes. Theſe were given to common fowls, turkeys, &c. and after remaining, in ſome inſtances, forty-eight hours, were taken out of their ſtomachs undigeſted, and without being ſenſibly altered; but upon bruiſing the ſame food, and again introducing it by means of the tubes, when voided they were frequently found, in the courſe of the experiments, to be empty. The ſame able experimenter filled tubes with raw veal, finely divided, which were forcibly given to a hen. They remained in the ſtomach twenty-four hours, and when taken out the fleſh was found to be conſiderably diminiſhed; the parts which continued firm were red, and retained the true flavour of fleſh.

If we deemed it neceſſary, a variety of other facts might be advanced, which prove that trituration aſſiſts, but is not poſitively requiſite for digeſtion. In

fowls, poſſeſſed of muſcular ſtomachs, it anſwers the purpoſe of maſtication. In fact, it is to them what maſtication is to man and to the phytivorous animals: they ſwallow their food whole, and the ſtrong coats of the ſtomach break it down, and prepare it for ſolution in the gaſtric fluid. To eſtimate this force, we have only to conſult the repeated experiments of Reaumur and Spallanzani. Tin tubes of conſiderable ſtrength were found, after remaining ſome time in the ſtomach of turkeys, to be bent and diſtorted in a ſingular manner. 'Having found,' ſays Spallanzani, 'that 'the tin tubes, which I uſed for common fowls, were 'incapable of reſiſting the ſtomach of turkeys, and 'not happening, at that time, to be provided with any 'tin plates of greater thickneſs, I tried to ſtrengthen 'them, by ſoldering to the ends two circular plates of 'the ſame metal, perforated only with a few holes for 'the admiſſion of the gaſtric fluid. But this contri-'vance was ineffectual; for, after the tubes had been 'twenty-four hours in the ſtomach of a turkey, the 'circular plates were driven in, and ſome of the tubes 'were broken, ſome compreſſed, and ſome diſtorted 'in the moſt irregular manner.'*

The ſame author employed, afterwards, a variety of ſharp bodies, as angular pieces of glaſs, ſtrong tin needles, and even lancets, fixed in balls of lead; and found them all to be equally incapable of withſtanding the comminuting force of their ſtomach. 'The ball,

* Spallanzani's Diſſertations, vol. i. p. 12.

'armed with the lancets, was given to a turkey cock, 'and left eight hours in the ſtomach; at the expira-'tion of which time, that organ was opened; but 'nothing appeared except the naked ball, the lancets 'having been broken to pieces.'* We obſerve, that children frequently ſwallow currants, cherries, &c. in an entire ſtate, and void them as unbroken as when they were firſt taken into the ſtomach. Theſe fruits, when ripe, are ſoft, eaſily broken, and incapable, we muſt ſuppoſe, of reſiſting the ſlighteſt degree of preſſure.

Next in order, we proceed to examine the different kinds of fermentation, as promoting or impeding ſolution in the human ſtomach. The experiments already quoted from Reaumur and Spallanzani, although poſitive in proving that trituration is not neceſſary for digeſtion, do not ſhew but that fermentation is a part of the proceſs. After Boerhaave, chymiſts have divided fermentation into three kinds: the ſpirituous, which furniſhes ardent ſpirits; the acetous, which yields the acid of vinegar; and the putrefactive, which produces volatile alkaline gas, &c. For the firſt, or ſpirituous fermentation, ſaccharine bodies are abſolutely, and when aſſiſted by heat to a certain degree, with air and humidity, only neceſſary. The ſecond, or acetous fermentation, depends on mucilage. The putrefactive, upon the preſence of a gluten.

* Spallanzani's Diſſertations, vol. i, p. 13.

Dr. Cullen, in his Lectures on the Materia Medica, delivered in the univerſity of Edinburgh, in the year 1769, ſuppoſes, that the acetous fermentation always takes place during digeſtion, in the ſtomach of healthy perſons; 'And I am certain, from experiment,' ſays he, 'that the vegetable aliment firſt turns acid in the 'ſtomach; for every ſtomach, human or brute, is 'always, on examination, found to have an acid pre-'ſent in it. Hence that aceſcency is not a diſeaſe, but a 'ſtep towards aſſimilation. Whenever the aliment 'enters into a high vinous fermentation, with copious 'generation of fixed air, commonly called gas ſilveſtre, 'as of the ſame nature with that produced in the ordi-'nary vinous proceſs, it becomes a diſeaſe, and has the 'power of deſtroying the mobility and contractility 'of the moving fibres, and even the tone of the ſto-'mach itſelf.'

In order to produce fermentation, a conſiderable maſs of matter favourable to it muſt be preſent; but this is by no means the caſe in the ſtomach of inſects, birds, and other ſmall animals, ſome of which we know have, in a ſurpriſing degree, the power of diſſolving hard and even ſolid bodies. Secondly, if the ſtomach was a viſcus intended merely as a veſſel to contain the aliment for fermentation, as this doctrine, if eſtabliſhed, would go to prove, why, I would ask, are tonics given, with ſuch evident advantage, in debility of that organ? If this was the principal proceſs, it would only be neceſſary to regulate it by mixing with our food a proportion of vegetables diſpoſed for fermentation,

and every purpoſe would be anſwered, when indigeſtion occurred. The power of bitters, ſays the ſame writer, in correcting acidity and flatulence in the ſtomach, may be aſcribed to their power of checking aceſcent fermentation. He ſuppoſes, that digeſtion commences with a fermentation of the aceſcent kind. If bitters check this, it muſt, agreeable to his own doctrine, impede, inſtead of aſſiſting the proceſs; for we cannot conceive that a ſubſtance, acting thus chymically, can produce two ſuch oppoſite effects. A variety of tonics, among which are the different preparations of iron, have as ſalutary an effect in preventing acidity, by giving tone, we preſume, to the ſtomach, as do the claſs of bitters.

Doctor Fordyce attentively examined the chyle, in the beginning of the duodenum of the ſheep and the cow, with a view to aſcertain whether, fermentation generally took place in the healthy, living ſubject. We might ſuppoſe that it would appear, if any where, in theſe animals, which live on aceſcent, ſaccharine food; ſince every thing really neceſſary is preſent, and a maſs conſiderably large and finely broken down. He did not however, diſcover, by the uſual teſts employed for detecting the preſence of an acid, that any did really exiſt.

The ſupporters of the theory of fermentation, as being a neceſſary part of digeſtion, allege, againſt the experiments of Dr. Fordyce, and others who have experimented upon the chyle in the duodenum, that the bile is a real animal ſoap, compoſed of an alkali in ſuf-

ficient abundance to neutralize the acid produced by digeſtion, and prevent its being detected, after mixing with that fluid. A variety of correct and judicious experiments by Dr. Roebuck, of the Iſland of St. Croix, made with a view to analyze the bile, contradict and fully explode the theory of its ſaponaceous nature and Dr. Boerhaave's ſpeculations, ſo ably ſupported by Cadet. Theſe experiments ſhow, that different neutral ſalts are generally preſent in the bile; as the muriate and phoſphate of lime and ſoda; and that the bile of different animals, although ſomewhat various, does not contain a particle of an alkali in an uncombined ſtate: therefore to neutralize the acid by an alkali or earth, it muſt decompoſe the muriate or phoſphate of lime or ſoda (which is impoſſible from the natural order of affinity) contained in the bile and unite with their radicals producing an acetite of lime, or ſoda. But even if this chymical decompoſition could take place, what would become of the acids originally combined in forming the neutral ſalts?

In order to determine whether an acid is always, or even frequently, preſent in the ſtomach, upon the eſtabliſhing or contradiction of which the whole doctrine which we are examining depends, I had recourſe to the following experiments.

EXPERIMENT I.

I gave to a middle aged man, of a delicate form, but enjoying a perfect ſtate of health, a ſmall quantity of emetic tartar in a glaſs of wine. He had breakfaſted five hours before on tea, bread and butter and

ſauſage. In half an hour he was ſeized with nauſea and vomiting. The firſt retchings threw up part of the food which had been eaten in the morning; and after drinking plentifully of warm water, which I prevailed upon him to do, he vomited repeatedly, which emptied his ſtomach, perhaps entirely. Neither the firſt nor the laſt diſcharges altered the colour of litmus paper, nor the blue colour of the ſyrup of violets.

EXPERIMENT II.

For a conſiderable compenſation I prevailed upon a healthy negro man, aged twenty-five years, to take a ſolution of emetic tartar at ten o'clock, A. M. He had breakfaſted two hours before on coffee, and bread and butter. In a few minutes it produced a very conſiderable, long, and obſtinate vomiting; during which he threw up the whole of his breakfaſt, which was but little altered from its natural ſtate, retaining its original ſmell and appearance. I could not, by the teſts employed, diſcover the preſence of acidity. This man was of a temperament oppoſite to that of the former; being of a full habit, with a broad cheſt, and muſcular form.

The extreme difficulty I found in procuring human ſubjects for experiments, prevented me from making ſo many of them as I could have wiſhed, and at firſt intended; and obliged me to have recourſe to experiment made upon our domeſtic animals, whoſe ſimilarity of ſtructure and food will permit a fair analogy to be drawn.

EXPERIMENT III.

I fed a dog, for ſeveral days, on freſh boiled and baked meat, bread, cabbage and parſnips. During the time, he drank water when he choſe, and occaſionally had milk. In four hours after eating moderately, I had him killed, and after ſecuring, by ligature, the upper and lower part of the duodenum, I opened the ſtomach and examined its contents. The beef, which had been eaten four hours before was diſſolved in a conſiderable degree, the bread and cabbage a little, but not much altered. The whole maſs was mild, of its natural odour, and without an appearance of putrefaction. After repeated immerſions of the litmus paper in this, and in the chyle which I found in conſiderable quantity in the duodenum (owing probably to the animal's having been plentifully fed, while preparing for the experiment) I could not diſcover any change produced in its colour.

EXPERIMENT IV.

A cat having been fed moderately, for three days, on bread, fiſh, and roaſted veal, during which time ſhe drank nothing but milk, or a mixture of milk and water, was killed on the evening of the third day, after having faſted five hours. I found the contents of the ſtomach were perfectly digeſted, with the exception of a ſmall piece of bread, which had been laſt eaten. I could not diſcover any acidity, or fœtor indicative of putrefaction.

EXPERIMENT V.

I fed a healthy male cat plentifully, for ſeveral days, on a diet of boiled beef, fiſh, bread, and potatoes; allowing him as much water as he pleaſed to drink. He was killed four hours after eating. On opening the ſtomach, I found the beef and fiſh ſoft, and conſiderably diſſolved, retaining much of their natural flavour, ſweet, and without rancidity or pungency. In this inſtance, the bread and potatoes had advanced much ſlower towards a ſtate of chylification, than the other kinds of food which had been given a ſhort time after, viz. the fleſh and fiſh. Syrup of violets, and litmus paper, both of which teſts I made uſe of, did not ſhow the preſence of any acidity.

EXPERIMENT VI.

While making the laſt experiment I procured a large dog of the maſtiff breed, apparently healthy, but weak and much emaciated. He ate ravenouſly, every thing that was offered him, from whence I concluded that his leanneſs was owing to want of food alone. He was fed ſix days plentifully, on bread, beef, ſoup, and potatoes, at the end of which period eight hours after having eaten, he was killed; and, after having ſecured the lower part of the ſtomach, I opened its coats, and brought the digeſting maſs into view. I was ſurprized to obſerve a large number of the lumbrici, or round worms, ſome of which meaſured a foot, and many of them ten inches, in length. In other reſpects the digeſting aliment looked natural, but had rather an un-

pleaſant flavour, though not putrid. The general texture of the food, which had been eaten during the day, was deſtroyed, and much of it, in the lower part of the ſtomach, formed into chyle, and ready to paſs into the duodenum. After repeated trials, my teſts could not diſcover an appearance of acidity, either in the ſtomach or in the duodenum, which I alſo examined with attention.

From the reſult of theſe experiments, conducted with much care and attention, we infer, that when the ſtomach is in a ſtate of health, the appetite good, and proper food only employed, digeſtion goes on rapidly, without the aliment undergoing any fermentation by which an acid is produced, either in the courſe of the ſtomach or duodenum: and farther, that when acidity does take place, it is a proof of the unhealthy condition of the ſtomach. The ſtomach may, no doubt, have its functions impeded, like every other part of the ſyſtem, by too much or too little excitement. In the diſeaſed ſtate of the ſtomach, called dyſpepſia, we ſuppoſe, that the action of the veſſels pouring out the gaſtric liquor for the purpoſe of digeſtion, is ſometimes exceſſive. From this view of the ſubject, and from the ſmall, frequently chorded pulſe, ſo often obſerved in dyſpeptic habits, might we not reaſonably expect greater ſucceſs from depletion than from ſtimulants and tonics,—the remedies heretofore moſt generally employed, owing to the idea, that dyſpepſia depends on imbecility, and want of tone in the muſcular fibres of the ſtomach?

In preparing my animals, I was attentive to give them ſuch food only, as they would eat with avidity; principally fleſh, but with a ſufficient proportion of vegetables to undergo the vinous, or acetous fermentations if either was neceſſary for the complete chylification of our food.

On a review of the above experiments, we find, that animal food was more readily ſoluble in the ſtomach of dogs and cats, than bread, potatoes, or parſnips. I was more particular in obſerving this fact, becauſe the experiments of Walœus, made upon dogs, had led me to believe, that even ſome carnivorus animals digeſted herbs, and bread ſooner than butcher's meat.* The conſtant ſtate of reſt in which the animals were kept for ſeveral days, previous to being killed, was favourable to the formation of an acid, by aſſiſting fermentation.

The arguments in favour of the theory of animal putrefaction, which we are next to conſider, as occuring during, and conſtituting a part of the proceſs of digeſtion, requires I conceive, but little labour to refute. During animal putrefaction, the ſubject matter, after loſing its natural ſmell, gives out a putrid, nauſeous odour, with one of a more penetrating kind, ariſing from the diſengagement of ammoniacal gas, the ſmalleſt quantity of which from its extreme volatility, would be made, in the moſt diſagreeable manner, ſenſible to our feelings during digeſtion.

* Vid. Epist. de mot. chyl. et sang. ad Thom. Bartholin.

Dr. Stevens, in an inaugural theſis publiſhed at Edinburgh, in the year 1777, tells us that he collected, from a dog, a quantity of freſh gaſtric juice, half an ounce of which he added to twelve grains of beef, which had been previouſly put into a vial. He put the ſame quantity of beef into another vial, and poured upon it half an ounce of water. Having placed both in a furnace heated to 102 or 103 degrees of Farenheit's thermometer, and ſuffering it to remain in that temperature for eight hours, he examined the vials, and found that the beef which was immerſed in the gaſtric fluid was entirely diſſolved, while the other had undergone no ſenſible alteration. Twenty-four hours afterwards the two vials were removed from the furnace, and attentively examined. The one which contained the gaſtric juice and beef, emitted a rancid, and pungent ſmell; while the other, with the water and beef, had become putrid, and emitted an intolerable ſtench. During the ſolution of the beef in the gaſtric juice, there were no ſigns of fermentation in the vial, ſuch as an appearance of air, &c.* A repetition of the experiment produced a ſimilar reſult. Spallanzani's experiments, made on the gaſtric fluid of various animals, had the ſame effect with thoſe made by Dr. Stevens. Some of them, indeed, go farther and ſhew that animal food may even be recovered from a ſlight degree of putreſcency, by being placed for a ſhort time in gaſtric juice.†

* Stevens's Diſſertation, Exp. 23.

† Spallanzani's Diſſertations, vol. i. p. 349, 353, 355.

Dr. Cullen, whoſe ingenuity and abilities we muſt ever venerate, although we cannot always admit his ſpeculations, poſitively ſays, that no man can ſubſiſt, even for a few days, on animal food alone, without its becoming highly putreſcent in the ſtomach and producing naufea and thirſt; and, when carried into the bowels, violent purging, cholera, and dyſentery, from putrid exhalations. This diſpoſition of the animal food to undergo putridity, he ſuppoſes, is corrected by the quantity of vegetable matter, which we are in the habit of mixing with it at our meals.

We are informed by the moſt reſpectable authorities, that whole nations ſubſiſt on animal food alone, without experiencing the diſeaſes which the profeſſor tells us would be produced in a few days by ſuch a diet. Dr. Fordyce, in his treatise upon digeſtion, obſerves, that the Laplander, inhabiting a country extremely cold and incapable of affording vegetables for the ſubſiſtence of its inhabitants, lives for the greater part of the year upon the fleſh of the rein deer, without mixing with it any vegetable food; and no appearance is indicated of a putreſcent matter being formed in the ſtomach, or organs of digeſtion. The inhabitants of the banks of the Orange river, in Africa, ſays the ſame author, live on limpets, dead and putrid ſeals, and whales, without taſting a particle of vegetable food of any kind whatever, except aromatics.

If a high degree, or indeed, any putrefaction took place during digeſtion, the whole of the circulating fluids muſt, in a ſhort ſpace of time, become affected through the medium of the abſorbent ſyſtem; the breath, and the ſecretions neceſſary to life, would become acrimonious, and the evil, conſtantly increaſing by the taking in of freſh food, would end only with the extermination of the people uſing it, unleſs a different diet was reſorted to.

It is a fact well known to thoſe who are acquainted with the aborigines of our country, that the tribes, particularly thoſe which inhabit the northern parts of the United States, frequently ſubſiſt, for whole weeks, on animal food alone, when hunting at a diſtance from their towns, or at war. In the latter caſe, they eat what the people of the back country call *jirk*, which is the muſcular part of the game which they kill, preſerved by drying and ſmoaking over a very gentle fire, ſo as to deprive it entirely of its juices. When thus prepared, it will keep for a long time during the heat of ſummer, and is very nutritious for its weight and bulk; a circumſtance of great importance to Indians on long excurſions. The ſavage will live, expoſed to the greateſt fatigue, on a few ounces of this ſubſtance, which nothing but the power of habit could enable him to do.

Not only man, who by nature is reſtricted to no particular kinds of aliment, can ſubſiſt on one entirely of fleſh, but even phytivorous animals, intended cer-

tainly to live upon herbage, grain, &c. In proof of which Dr. Barton informed me of the following intereſting fact: During a voyage of two and thirty days acroſs the Atlantic, ſaid the profeſſor, a pair of (sciurus volucella, or) flying ſquirrels, were fed on dry ſalted beef, which they continued to eat until the veſſel arrived in Europe: in this time they became fond of their animal diet, and refuſed, afterwards, their accuſtomed vegetable one. A ſimilar one, I think, is mentioned by Reaumur, but not having, at this time, an opportunity of conſulting his works, I will not inſiſt that the fact is recorded by him. A ſheep was fed, for a conſiderable length of time, on fleſh, varying in kind, and differently prepared. He became, at length, fond of it, and when the two were offered, ate it in preference to the vegetable.

In the courſe of the experiments on ruminating animals, as the ſheep and the ox, inſtituted by Dr. Stevens, he diſcovered that the gaſtric juice readily diſſolved vegetables, and made but little impreſſion upon beef, mutton, and veal. My experiments upon dogs and cats, carnivorous animals, ſhow that they digeſt animal food much ſooner than vegetable, but ſtill, that they are capable of completely digeſting the latter. Though they are altogether carnivorous, neceſſity, by obliging them to eat frequently of vegetables, makes it, at length, a cuſtomary part of their food. Had the animals employed by Dr. Stevens been gradually deprived of the uſe of vegetables, and fed upon fleſh, they would in a ſhort time, no doubt, have digeſted the latter with perfect facility.

From theſe ſeveral experiments, we conclude that nature has given to the different claſſes of animals ſolvents of different qualities and powers, calculated for the ſolution of the peculiar food, which ſhe intended them to uſe; but at the ſame time, capable of being changed, if requiſite for the life of the individual, and accommodated for the ſolution of food of a different nature.

Independent of the arguments which we have advanced the variety of facts mentioned, particularly applicable to the point in queſtion, can admit of no refutation: they are, we conceive, ſufficient to eſtabliſh the poſition, that putrefaction is a proceſs never, perhaps, preſent during the ſolution of our food in the ſtomach, as fermentation frequently is, owing to an unhealthy ſecretion of the gaſtric liquor, when that fluid from inſufficiency in point of quantity, or quality, is incapable of reſiſting the diſpoſition of the vegetable part of our food to run into fermentation. To admit either of the doctrines which we have been endeavouring to refute, would be conſidering nature as deviating from that general order of ſimplicity which marks her productions, throughout the whole of the animated world; for neither of the three kinds of fermentation alone can account for the various phenomena produced in digeſtion. If the acetous fermentation takes place as a neceſſary part of it, we muſt believe that the putrid does likewiſe; or how ſhall we account for the ſolution of animal ſubſtances? For in no circumſtances do they undergo the acetous fermentation. The experiments

of Stevens, with the vials, enclosing beef in the gastric juice, and my own with the dogs and cats, disprove the theory of putridity. Lastly, the acetous fermentation cannot in any degree take place without evolving an acid, which our experiments could not, in a single instance, discover.

Dr. Stevens performed a number of experiments upon a poor German who for many years had gained a miserable subsistance by swallowing stones for the amusement of spectators; he gave him to swallow silver spheres, perforated, so as to admit the gastric fluid freely to pass: at different times were enclosed fish, raw and boiled beef, pork, and cheese; the sphere was, for the most part, retained from thirty to forty hours, and when voided, generally found to have lost the most, and frequently the whole of its contents. Having observed that animal substances were readily dissolved by the gastric juice, the Doctor tried whether the same effect would be produced on vegetables.—He enclosed in his sphere raw parsnip and potatoe, which were swallowed as before by the German, and retained for forty-eight hours; and when voided, not a vestige of either remained. Apples and turnips, both raw and boiled, were digested in thirty-six hours.

The same experimenter enclosed live leeches and earth worms in different spheres, which the German, as usual, swallowed. He retained them for some time, and when discharged in the natural way, the animals were deprived of life, and completely dissolved. It is a

pleaſing reflection, that no reptile, if taken into the ſtomach accidentally, or otherwiſe, can reſiſt the operation of this powerful ſecreted menſtruum, the gaſtric liquor. Worms, hatched in the inteſtines, are alone an exception.

In accounting for the proceſs of digeſtion by ſolution alone, a very natural queſtion has frequently been aſked by its oppoſers: 'If the gaſtric liquor acts as a 'ſolvent, why is not the ſtomach acted upon, ſeeing it 'is compoſed of the ſame materials we make uſe of in diet?' The ſtomach, as long as it retains the principle of life, is not affected by the gaſtric liquor; but the moment that this principle is deſtroyed, and death takes place, it is equally liable to be corroded as other ſubſtances. The ſame thing happens to live animals generated in the alimentary canal. As long as they have the vital principle, it reſiſts the power of digeſtion. 'Hence it is,' Mr. Hunter remarks, 'that we find 'animals of various kinds living in the ſtomach, or even 'hatched and bred there; but the moment that any 'of theſe loſe the living principle, they become ſubject 'to the digeſtive powers of the ſtomach. If it were 'poſſible, for example, for a man's hand to be introduced into the ſtomach of a living animal, and kept 'there for ſome conſiderable time, it would be found 'that the diſſolvent powers of the ſtomach could have 'no effect upon it. But, if the ſame hand were ſeparated from the body, and introduced into the ſame ſtomach, we ſhould then ſee, that the ſtomach would 'immediately act upon it. Indeed, if this were not the

'caſe, we ſhould find that the ſtomach itſelf ought to 'have been made of indigeſtible materials; for, if the 'living principle was not capable of preſerving animal 'ſubſtances from undergoing that proceſs, the ſtomach 'itſelf would be digeſted. But we find, on the con-'trary, that the ſtomach, which at one inſtant, that is, 'while poſſeſſed of the living principle, was capable of 'reſiſting the digeſtive powers which it contained; the 'next moment, viz. when deprived of the living prin-'ciple, is itſelf capable of being digeſted; either by the 'digeſtive power of other ſtomachs, or by the remains 'of that power which it had of digeſting other things.'

Mr. Hunter mentions three caſes of perſons who had died of violent deaths, without previous indiſpo-ſition, where he obſerved the ſtomach had been cor-roded by the gaſtric fluid. 'In theſe caſes,' ſays he, 'the contents of the ſtomach are generally found looſe 'in the cavity of the abdomen, about the ſpleen and 'diaphragm. In many ſubjects this digeſtive power 'extends much farther than through the ſtomach.— 'I have often found, that, after it had diſſolved the 'ſtomach at the uſual place, the contents of the ſto-'mach had come into contact with the ſpleen and 'diaphragm, had partly diſſolved the adjacent ſide of 'the ſpleen, and had diſſolved the ſtomach quite 'through; ſo that the contents of the stomach were 'found in the cavity of the thorax, and had even affect-'ed the lungs in a ſmall degree.'

It is only by the aid of facts and experiments that we can arrive at truth, particularly in researches connected with natural philosophy and medicine. The physiologist who would instruct himself, or teach others, by conjecture alone, had better do nothing, but leave the subject for others, possessed of more industry or more leisure than himself.

FINIS.