PHYSIOLOGY

The Gastric Juice

"A Classic of Science"

A Trapper, Recovered From a Shotgun Wound Which Pierced His Stomach, Acted as Laboratory for These Tests

EXPERIMENTS AND OBSERVATIONS ON THE GASTRIC JUICE AND THE PHYSIOLOGY OF DIGESTION. By William Beaumont. Plattsburgh, Printed by F. P. Allen, 1833. (Facsimile Reprint: Cambridge, Harvard University Press, 1929).

THE gastric juice has been submitted to chemical examination and analysis, with various results. Perhaps in the present state of the science of chemistry it will not be practicable to ascertain its exact chemical character. The parcels heretofore submitted to analysis, have been very impure; but the result of even these partial examinations, has been to show that this fluid contains a portion of free muriatic acid, combined with the acetic, and some salts. In the winter of 1832-3, I submitted a quantity of gastric juice, with no other admixture, except a small proportion of the mucus of the stomach, to Professor Dunglison, for examination, who, with the assistance of the professor of chemistry of the Virginia University, effected the following analysis, and was kind enough to communicate the result to me by letter.

"University of Virginia,
Feb. 6th, 1833.

"My Dear Sir:

"Since I last wrote you, my friend and colleague, Professor Emmett, and myself, have examined the bottle of gastric fluid which I brought with me from Washington, and we have found it to contain free *Muriatic* and *Acetic* acid, *Phosphates* and *Muriates,* with bases of *Potassa, Soda, Magnesia* and *Lime,* and an *animal matter, soluble in cold water, but insoluble in hot.* We were satisfied, you recollect, in Washington, that free muriatic acid was present, but I had no conception it existed to the amount met with in our experiments here. We distilled the gastric fluid, when the free acid passed over; the salts and animal matter remaining in the retort. The quantity of Chloride of Silver thrown down on the addition of the Nitrate of Silver, was astonishing."

I had been long convinced of the existence of free muriatic acid in the gastric fluids. Indeed, it is quite obvious to the sense of taste; and most chemists agree in this, however they may be at variance with respect to the other constituents. The analysis of Professors Dunglison and Emmett is certainly as satisfactory as any that has as yet been made. It is a question, too, whether gastric juice, in so great a state of purity, has ever before been submitted to chemical analysis.

It is to be hoped that no one will be so disingenuous as to attribute to Professor Dunglison the design of finding the existence of certain chemical agents in the gastric juice, with the view of propping the theory of the chemical action of this fluid, which he has maintained in his work on "Human Physiology";—or, in other words, to say, that he had determined to find certain results; and that he had accordingly found them. Those who are acquainted with him, know that his candour and fairness are above the reach of suspicion; and that he would be equally willing to retract a false opinion as to maintain a correct one. Another quantity was sent to him for further analysis; but I regret that no report has yet been received from him . . .

Action of Gastric Juice

The discrepance of results in the reports of those who have had opportunities of examining the process of, and have made experiments on, *artificial digestion,* by the gastric juice, as well as in the chemical examination of this fluid, has been owing more to the difficulty of obtaining it pure, in sufficient quantity, and under proper circumstances, than to any real difference in its effects. Under the circumstances in which the following experiments were made, I flatter myself that these difficulties have been obviated; and if the inferences are incorrect, the blame must be attached to the experimenter. He can only say, that the experiments were made in good faith, and with a view to elicit facts.

I think I am warranted, from the result of all the experiments, in saying, that the gastric juice, so far from being "inert as water," as some authors assert, is the most general solvent in nature, of alimentary matter—even the hardest bone cannot withstand its action. It is capable, *even out of the stomach,* of effecting perfect digestion, with the aid of due and uniform degrees of heat (100° Fahrenheit) and gentle agitation, as will be seen in the following experiments.

The fact that alimentary matter is *transformed,* in the stomach, into chyme, is now pretty generally conceded. The peculiar process by which the change is effected, has been, by many, considered a problem in physiology. Without pretending to explain the exact *modus operandi* of the gastric fluid, yet I am impelled by the weight of evidence, afforded by the experiments, deductions and opinions of the ablest physiologists, but more by direct experiment, to conclude that the change effected by it on aliment is *purely chemical.* We must, I think, regard this fluid as a chemical agent, and its operation as a chemical action. It is certainly every way analogous to it, and I can see no more objection to accounting for the change effected on the food, on the supposition of a chemical process, than I do in accounting for the various and diversified modifications of matter, which are operated on in the same way. The decay of the dead body is a chemical operation, separating it into its ele-

More Earths From Yttrium

Chemists kept taking new elements out of the rare mineral from Ytterby, as though it were a nest of Chinese boxes. The first accounts of the appearance of several of these elements will compose

THE NEXT CLASSIC OF SCIENCE

mentary principles—and why not the solution of aliment in the stomach, and its ultimate assimilation into fibrine, gelatine and albumen? Matter, in a natural sense, is indestructible. It may be differently combined; and these combinations are chemical changes. It is well known that all organic bodies are composed of very few simple principles, or substances, modified by excess or diminution of some of their constituents.

The gastric juice appears to be secreted from numberless vessels, distinct and separate from the mucous follicles. These vessels, when examined with a microscope, appear in the shape of small lucid points, or very fine papillæ, situated in the interstices of the follicles. They discharge their fluid only when solicited to do so, by the presence of aliment, or by mechanical irritation.

A Clear, Transparent Fluid

Pure gastric juice, when taken directly out of the stomach of a healthy adult, unmixed with any other fluid, save a portion of the mucus of the stomach, with which it is most commonly, and perhaps always combined, is a clear, transparent fluid; inodorous; a little saltish; and very perceptibly acid. Its taste, when applied to the tongue, is similar to thin mucilaginous water, slightly acidulated with muriatic acid. It is readily diffusible in water, wine or spirits; slightly effervesces with alkalis; and is an effectual solvent of the *materia alimentaria.* It possesses the property of coagulating albumen, in an eminent degree; is powerfully antiseptic, checking the putrefaction of meat; and effectually restorative of healthy action, when applied to old, fœtid sores, and foul, ulcerating surfaces.

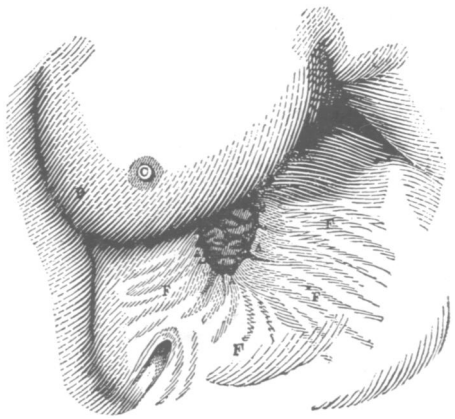
Saliva and mucus are sometimes abundantly mixed with the gastric juice. The mucus may be separated, by filtering the mixture through fine linen or muslin cambric. The gastric juice, and part of the saliva will pass through, while the mucus, and spumous or frothy part of the saliva, remains on the filter. When not separated by the filter, the mucus gives a ropiness to the fluid, that does not belong to the gastric juice, and soon falls to the bottom, in loose, white flocculi. Saliva imparts to the gastric juice, an azure tinge, and frothy appearance; and, when in large proportion, renders it fœtid in a few days; whereas the *pure* gastric juice will keep for many months, without becoming fœtid.

The gastric juice does not accumulate in the cavity of the stomach, until alimentary matter be received, and excite its vessels to discharge their contents, for the immediate purpose of digestion. It then begins to exude from its proper vessels, and increases in proportion to the quantity of aliment *naturally* required, and received. A definite proportion of aliment, only, can be perfectly digested in a given quantity of the fluid. From experiments on artificial digestion, it appears that the proportion of juice to the ingestæ, is greater than is generally supposed. Its action on food is indicative of its chemical character. Like other chemical agents, it *decomposes,* or *dissolves,* and combines with, a fixed and definite quantity of matter, when its action ceases. When the juice becomes *saturated,* it refuses to dissolve more; and, if an excess of food have been taken, the residue remains in the stomach, or passes into the bowels, in a crude state, and frequently becomes a source of nervous irritation, pain and disease, for a long time; or until the *vis medicatrix naturae* restores the vessels of this viscus to their natural and healthy actions—either with or without the aid of medicine.

Such are the appearance and properties of the gastric juice; though it is not always to be obtained pure. It varies with the changing condition of the stomach. These variations, however, depend upon the admixture of other fluids, such as saliva, water, mucus, and sometimes bile, and, perhaps, pancreatic juice. The special solvent itself—the *gastric juice*—is, probably, invariably the same substance. Derangement of the digestive organs, slight febrile excitement, fright, or any sudden affection of the passions, cause material alterations in its appearance. Overburthening the stomach produces acidity and rancidity in this organ, and retards the solvent action of the gastric juice. General febrile irritation seems entirely to suspend its secretion into the gastric cavity; and renders the villous coat dry, red and irritable. Under such circumstances, it will not respond to the call of alimentary stimulus. Fear and anger check its secretion, also: the latter causes an influx of bile into the stomach, which impairs its solvent properties.

When food is received into the stomach, the gastric vessels are excited by its stimulus to discharge their contents, when chymification commences. It has been a favourite opinion of authors, that food, after it has been received into the stomach, should "remain there a short period before it undergoes any change"; the common estimate is one hour. But this is an erroneous conclusion, arising from inaccuracy of observation. Why should it remain there, unchanged? It has been received into the organ which is to effect an important change upon it—the gastric juice is ready to commence its work of solution soon after the first mouthful is swallowed; and, certainly, if we admit that the gastric juice performs the office of a chemical agent, which most physiologists allow, it is contrary to all our notions of chemical action, to allow it one moment to rest. It must commence its operation immediately. That it does so, is distinctly manifested by close observation of its action on food, in the healthy stomach.

Science News Letter, July 4, 1931



"A LID ON HIS STOMACH"

This is the hole that remained in the subject after the shotgun wound healed. The opening was directly into his stomach so that bits of food could be inserted and samples of gastric juice taken out. He served Dr. Beaumont as servant and subject of experiment for about four years, then returned to Canada. He lived to be ninety.

REFRIGERATION

Ice Hung in Baskets Melts More Slowly

KEEPING ice away from refrigerator walls by suspending it in baskets prevents it from melting too fast and gives a more stable and evenly distributed cooling effect, according to experiments conducted by Charles F. Belshaw and reported to the American Society of Refrigerating Engineers, New York City.

Not only may insulating walls be made thinner because the ice is not in contact with them, Mr. Belshaw states, but air circulation is bettered, so that the cooling effect is more evenly distributed and better regulated.

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