One of the most fortuitous experiments in medicine began on June 6, 1822, at Fort Mackinac on the upper Michigan peninsula. Beaumont tended the accidental shotgun wound that perforated the abdominal wall and stomach of Alexis St. Martin, a 19-year-old voyager for the American Fur Company. Part of the wound formed a small natural “valve” that led directly into the stomach. Beaumont turned St. Martin on his left side, depressing the valve, and then inserted a tube the size of a large quill 5 or 6 inches into the stomach. Beaumont performed two kinds of experiments on the digestive processes from 1825 to 1833. First, he observed the fluids discharged by the stomach when different foods were eaten (in vivo). Second, he extracted samples of the stomach’s content and put them into glass tubes to determine the time required for “external” digestion (in vitro). For centuries, the stomach was thought to produce heat that somehow cooked foods. Alternatively, the stomach was imaged as a mill, a fermenting vat, or a stew pan. Through his experiments, Beaumont revolutionized concepts about digestion.

*Jean Baptise van Helmont (1577–1644), a Flemish doctor, is credited with being first to prescribe an alkaline cure for indigestion. He reasoned that acid in the digestive tract could not alone decompose meats, and that other substances (“ferments”) must break down food. Today we refer to the ferments as digestive enzymes.
Beaumont published the first results of his experiments on St. Martin in the 
*Philadelphia Medical Recorder* for January, 1825, and full details in his *Experiments and 
Observations on the Gastric Juice and the Physiology of Digestion* (1833). Beaumont 
ends his treatise with a list of 51 inferences based on his 238 separate experiments. 
Although working away from the centers of medicine, Beaumont used findings from 
prominent European researchers and scientists—for example, the Italian biologist and 
physiologist Lazzaro Spallanzini (1729–1799), who, in his two-volume book, 
*Dissertationi di fisica animale e vegetale* (1780), first described the process of digestion 
involving the stomach’s chemical decomposition of food by the action of gastric juice.† 
Even with their information he cites from other researchers (e.g., Carminiti, Viridet, 
Vauquelin, Tiedemann and Gmelin, Leuret and Lassaigne, Montegre) and particularly 
English physician and chemist William Prout (1785–1850), who discovered that stomach 
juices contain hydrochloric acid and that substances in food could be classified into 
sugars and starches, oily bodies, and albumen, (later to be known as carbohydrates, fats, 
and proteins). Beaumont, despite all the new knowledge he culled from the known 
literature about aspects of digestion, still obeyed the scientific method, basing all his 
inferences on direct experimentation. Beaumont wrote:

“With respect to the agent of chymification, that principle of life

† Beaumont enlisted the aid of two prominent American scientists, Robley Dunglison, Professor of 
Physiology, Medical Department, University of Virginia (physician to Thomas Jefferson), and Benjamin 
Silliman, professor of Chemistry, Yale University, to analyze samples of gastric juice.‡ Dunglison 
suggested further experiments on St. Martin, which Beaumont carried out, but Silliman’s analysis provided 
little new information to Beaumont. With an introduction by Silliman, Beaumont corresponded with 
Swedish chemist Jacob Berzelius and sent him a pint of pure gastric juice (sealed and capped with strong 
leather and twine and cased in tin, with the lid soldered on, that no one could open it) for analysis. The 
Myer text§ contains the correspondence among Beaumont, Dunglison, Silliman, Berzelius, and others, 
including extensive correspondence with Alexis St. Martin, his family, and officials of the United States 
Government. Myer also includes photos of the original documents, including several of St. Martin and 
Beaumont, as well as illustrations of Beaumont, his family, his residences, and St. Martin’s wound.
which converts the crude aliment into chyme, and renders it fit for
the action of the hepatic and pancreatic fluids, and final
assimilation and conversion into the fluids, and the various tissues
of the animal organism—no part of physiology has, perhaps, so
much engaged the attention of mankind, and exercised the
ingenuity of physiologists. It has been a fruitful source of
theoretical speculation, from the father of medicine down to the
present age. It would be a waste of time to attempt to refute the
doctrines of the older writers on this subject. Suffice it to say, that
the theories of Concoction, Putrefaction, Trituration, Fermentation
and Maceration, have been prostrated in the dust before the lights
of science, and the deductions of experiment.”

I had opportunities for the examination of the interior of the
stomach, and its secretions, which has never before been so fully
offered to any one. This most important organ, its secretions and
its operations, have been submitted to my observation in a very
extraordinary manner, in a state of perfect health, and for years in
succession. I have availed myself of the opportunity afforded by
concurrence of circumstance which probably can never again
occur, with a zeal and perseverance proceeding from motives
which my conscience approves; and I now submit the result of my
experiments to an enlightened public, who I doubt not will duly
appreciate the truths discovered, and the confirmation of opinions
which before rested on conjecture.”

I submit a body of facts which cannot be invalidated. My opinions may be doubted, denied, or approved, according as they conflict of agree with the opinions of each individual who may read them; but their worth will be best determined by the foundation on which they rest—the incontrovertible facts.”

Beaumont concluded:

“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, (100F/38C).”

The fact that alimentary matter is transformed, in the stomach, into chyme, is now pretty well conceded. ... 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.”

The decay of the dead body is a chemical operation, separating it into its elementary 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 papillae, 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.”

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 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, fetid sores, and foul, ulcerating surfaces.”

Beaumont’s important experiments quickly reached an international audience. In the United States, Dunglison’s 1844 second edition of *Human Health* included a three-page appendix of Beaumont’s “...time required for the stomachal digestion of different alimentary substances,” and Cutter’s popular *Anatomy and Physiology Designed for Academies and Families* (1848) included Beaumont’s results for the mean times for digesting foods. In France, Claude Bernard cited Beaumont’s work in his 1865 *Introduction to the Study of Experimental Medicine*. Bernard may have learned about it from a German translation published in 1834 or from Beaumont’s own 1825 article in the *Philadelphia Medical Recorder* that was abstracted both in a German magazine (1826) and a French medical journal (*Archives generales de Medecine*, 1828, Paris).

Interestingly, Bernard created fistulas in animals to observe how the pancreas and small intestines functioned during digestion.

A letter from Dr. W. G. Edwards, an Illinois physician who studied in Paris, provides further evidence of Bernard’s keen interest in Beaumont’s experiments. Edwards wrote Beaumont that Bernard wished to know more details about St. Martin’s health, occupation, and other personal information. Beaumont replied, in part,
“To comply with your request affords me pleasure, and I shall be happy in gratifying M. Bernard if such be the effect of this communication. Mingled emotions of gratification and regret, of pleasure and chagrin fill my breast at the suggestion of the kindly credited approbation and importance that my imperfect experiments have been or may be to the truly scientific investigators of the most essential of all hygienic subjects, the physiology of digestion; pleasure and gratification that my feebly imperfect results shall have added even in a small degree to the benefits of science, chagrin and regret that the opportunity has been so unworthy the credit and commendation awarded.”

Beaumont’s accomplishment is even more remarkable because the United States, unlike England, France, and Germany, provided no research facilities for experimental medicine. Little was known about the physiology of digestion. Beaumont, a “backwoods physiologist,” inspired future studies of gastric emptying, intestinal absorption, electrolyte balance, rehydration, and nutritional supplementation with “sports drinks.”

References


**Additional Resources**


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