PORTRAITS OF SCIENCE

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Logic, Learning, and Experimental Medicine

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Based on logic, learning, and, above all, an experimental methodology, Galen's ideas dominated medicine for centuries.

Few medical men have exercised as much influence for as long as Galen of Pergamum (*1*, *2*). His ideas dominated medicine in the Byzantine world from A.D. 300 onward and, through the medium of translation, in the world of Islam and in Western Europe from the 12th to the 17th century. As Yunani (Greek) medicine, they still form one of the learned traditions of medicine in the modern Muslim world (*3*). Yet by presenting repeatedly his conclusions rather than the empirical evidence and procedures on which they were based, his followers unwittingly helped to create the common view of Galen as bookish, dogmatic, and authoritarian, and as a stumbling-block to medical progress until the Renaissance. Over the last 30 years, scholars, aided by the rediscovery of many of Galen's works in Arabic translation, have begun the process of rehabilitation.

Galen achieved his authority through abundant energy, massive self-confidence, enormous learning, near impeccable logic, and cogent rhetoric, allied to remarkable practical skills as an experimenter, observer, and clinician. His career was unusual for a doctor in the ancient world. Taking up medicine only at the age of 17, he then spent a decade in medical studies, including 4 or 5 years at Alexandria, the greatest medical center of antiquity. In A.D. 157, he returned to his native Pergamum (Bergama, western Turkey), where, among other duties, he cared for the health of a troop of gladiators. He soon moved on again, arriving in Rome for the first time in A.D. 162, where he quickly established a reputation by public dissections of animals.

In 166, he fled Rome for his native Pergamum, either because of the hostility of his less successful competitors or to avoid the onset of an epidemic, perhaps of smallpox. He was not forgotten, though. In 168, he was summoned to join the Roman Emperors on campaign. From then on, until his death around 216, he remained in imperial service. In addition to his intermittent royal duties, he treated enormous numbers of patients in Rome (and some by correspondence). But above all, he wrote.

Even though half of his total output has been lost over the centuries, Galen's surviving works in Greek, some 115 titles, constitute about 10% of all that remains of Greek literature from before A.D. 300. Another 50 treatises survive in translation, mainly in Arabic or medieval Latin. This prolific outpouring of ideas on topics as various as anatomy, physiology, pharmacology, logic, ethics, and lexicography was made possible by his staff of shorthand writers, who took down his words as he discoursed to friends, colleagues, and patients.

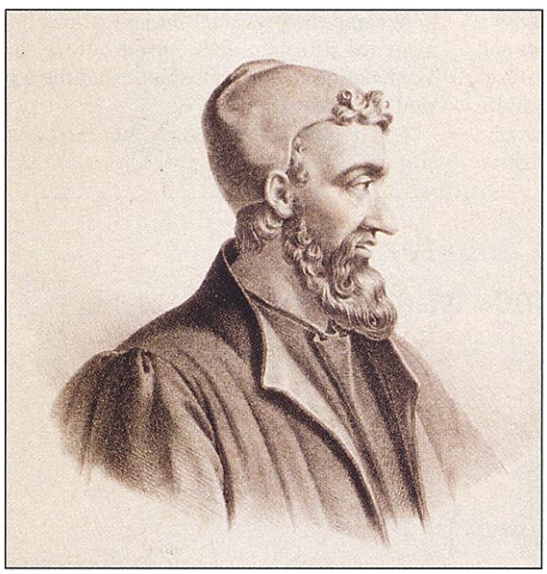
His message was simple and powerful. The true doctor required sound learning, sober thought, and practical experience. All these could be found in Galen's hero, the 5th-century-B.C. physician, Hippocrates of Cos, and in the writings that constitute the Hippocratic Corpus. According to Galen, Hippocrates had laid down the first principles of medicine, most notably that health and disease depended on maintaining an appropriate balance between the four main fluids, or humors, of the body, blood, bile, black bile, and phlegm.

Galen was not alone in following Hippocrates, but his was the interpretation that became the norm in all subsequent discussions of "humoralism." But Galen's Hippocrates was based far more on Galen's own idealized image of himself than on any ancient texts (*4*, *5*).

The second major strand in his writings was his insistence that the good doctor was also a philosopher, a thinking individual. Not only must he practice morality in his dealings with patients, but he required logical ability to derive the right conclusions from observations and diagnose correctly. Galen's most innovative philosophical treatise, *On scientific demonstration*, is now mostly lost, but his books on logic have earned the approval of both medieval and modern scholars for their precision. His conclusions are almost always correctly derived from his premises: it is the premises themselves that are disputable.

The long-winded repetitions in his writings and his reliance on logic to fill in gaps where observation was lacking damaged Galen's subsequent reputation, particularly because it obscured the extent to which he believed in the importance of accurate observation and practical skills. Although he might, if challenged, prefer a doctor who could think to one reliant solely on experience, Galen stressed over and over again the unity of reason and experience. He himself was a shrewd and keen-sighted observer. His exemplary tales of his own cures show how one can profit from observing the slightest of changes in the patient—and in the paraphernalia of the sickroom. He had a sharp eye, wherever he traveled, noting the variety of wheat growing in northern Greece, the fighting habits of weasels, and the annoying behavior of young children, some of whom, he commented ruefully, seem to have been born naughty.

Observation was linked in Galen to wide practical experience. Patients flocked to him with stomach complaints and dislocated limbs, with fevers and symptoms of stress. Establishing the connection between mental and physical problems was one of his proudest achievements, although a tactful withdrawal from public life was all he could recommend to senators who ap-



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Galen of Pergamum

(A.D. 129–ca. 216)

Like all other pictures of Galen, this 18th-century print by Vigneron is based on speculation. The earliest image of Galen dates from ca. 516.

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proached him, afraid of being murdered by the bloodthirsty emperor Commodus (*6*).

Nowhere is his emphasis on practical experience more obvious than in his work on anatomy. His teachers, themselves trained in Alexandria, had taught him the importance of anatomy for understanding the workings of the body, and he readily admitted its value for the surgeon. He gained his first post in part through his surgical skills: Galen demonstrated delicate wound-management and, on one occasion, successfully removed a suppurating breastbone. His advice on safe suturing, preferably with catgut, shows a sound understanding of the differences between the various tissues of the body.

But he went far beyond his teachers in insisting on the fundamental need for the doctor to dissect, dissect, dissect. He claimed to have performed a dissection every day for most of his working life—partly to hone his surgical skills but mainly to investigate the body. But although in the course of performing operations, Galen had seen inside the human body and was relatively familiar with human bones, he regretted that he had never had the opportunity to dissect one systematically. Religious, social, and even medical objections had prevented the dissection of human corpses for 500 years. All his dissections were performed on animals, mainly rhesus monkeys, pigs, sheep, goats, and, on one famous occasion, the emperor's pet elephant.

These animals were chosen both for their similarity to humans (for Galen admitted the problem of generalizing from one species to another) and for their effect on the audience. The loud squeal of a piglet suddenly ended by a spinal ligature demonstrated dramatically a link between the two events; by contrast, the pained face of a monkey as the knife entered should be avoided by turning it away from the audience (*7*, *8*).

Galen was an exceptional anatomist. He repeated experiments on blood flow first performed 500 years earlier by the Alexandrian anatomist Erasistratus, and, as far as is known, never repeated since then. But his greatest achievement was a systematic study of the nervous system. By tying or cutting the spinal cord at each vertebra to see its effect, he discovered the recurrent laryngeal nerves and established the workings of the thoracic nerves in breathing.

Comparative anatomy has its perils, however. Galen's anatomy of the womb is that of a dog, his positioning of the kidneys that of a pig, and his anatomy of the brain—the result of some delicate work with the knife—that of a cow or goat. One such error had important consequences. The presence of a network of nerves at the base of the ox brain (the rete mirabile) provided Galen with what he considered to be anatomical proof that the Athenian philosopher Plato (427–347 B.C.) had been right to divide the human soul into three parts, each with its own seat and system of conduits.

Galen developed this notion through dissection. Food digested in the stomach was passed to the liver, where it was turned into blood. This blood, moving in the veins, provided nutriment for the body. Most of what was not needed for nutriment was excreted, but a small amount seeped through the septum of the heart from one side to the other. In the left ventricle, mixed with air drawn in from the lungs, it was transformed into arterial blood, which as it flowed in the arteries gave life and energy to the body. A tiny fraction of this blood underwent a third transformation in the rete mirabile to become "psychic pneuma" in the brain. This pneuma, or spirit, operating in the channels of the nerves, was the agent of sensation that transmitted perceptions to the brain. It was also the means whereby the reasoning part of the soul in the brain could control the rest of the body and instigate voluntary action.

"...the overthrow of Galenism in the Renaissance was due precisely to the rediscovery of Galen's methods..."

Galen's tripartite anatomical system, based on the liver, heart, and brain, reinforced and was in turn supported by Plato's notion of a tripartite soul. It was based on accurate animal dissection and intelligent reasoning. We now know many of Galen's conclusions to be false, but for a long time they were extremely hard to refute without the talents of a Galen. Later interpreters forgot or, since Galen's major anatomical writings were hard to find, never read his warnings about relying solely on animals or on descriptions in books, and omitted his hesitations and qualifications in their systematic exposition of what they believed were assured facts.

Certainly, his tripartition made more sense of the body than Aristotle's notion of the heart as the unique seat of the soul. But Galen did not reject Aristotelianism entirely. His explanation of natural processes such as the transformation of matter depended on Aristotelian concepts, and he was convinced, like Aristotle, that the body had been carefully designed by a provident and purposeful creator (a view that commended Galenism to Christians and Muslims alike).

Throughout Galen's writings, we find this insistence on practical experiment. His studies of the pulse in health and disease show many valid correlations between illnesses and pulsation, even though Galen did not envisage the heart as a pump. His thousands of pages on pharmacology not only repeat many prescriptions from authors now lost to us, but also reveal him as an inveterate hunter for new or neglected drugs, be it in the backwoods of Mysia (modern Turkey), the copper mines of Cyprus, or the imperial storehouses in Rome (*9*).

The very size of his achievement both daunted his successors and damaged Galen's reputation. To pick a way through his writings without indexes or finding aids was almost impossible. Besides, copying out a big treatise, such as his *Method of Healing*, equivalent to 500 pages in a modern book, was extraordinarily expensive and time-consuming until printing presses were developed (*10*). Hence, Galen was transformed into Galenism, reduced to summaries, selections, and guides that left out his queries, doubts, and practical experiences and emphasized the doctrinaire. His anatomical conclusions were repeated, but not his methods.

Paradoxically, the overthrow of Galenism in the Renaissance was due precisely to the rediscovery of Galen's methods by Vesalius (A.D. 1514–1564) and Harvey (A.D. 1578–1657). The medical scholars of the first half of the 16th century had returned to reading Galen in the original Greek. They emphasized his superiority over his later interpreters, stressing his learning and the centrality of anatomy in his view of medicine. Vesalius, while openly contemptuous of Galen, followed his advice and methodology to produce a new anatomy of the human body. Harvey, more conservative, repeated Galen's experiments to overthrow his tripartite system of physiology. The spirit of Galen can thus be said to have triumphed over his conclusions.

References and Notes

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