

MEDICAL MILESTONE

Three and a half centuries ago a German printer issued a slim 72-page book that was to revolutionize anatomy and physiology and place its author in the pantheon of immortal physician-scientists. William Harvey's epoch-making description of the circulation of the blood in *Exercitatio anatomica de motu cordis et sanguinis in animalibus*, published in Frankfurt-am-Main in 1628, threw the medical world into turmoil and earned for him scorn from some and high praise from others. ■ **THE AUTHOR.** William Harvey was born 400 years ago, on April 1, 1578, in the small fishing town of Folkestone, on the Channel coast, the son of a yeoman



Harvey demonstrates the blood's circulation to King Charles I to whom his book is addressed.

University of Padua herb garden, 55 years old when Harvey studied there and important in his medical education, introduced new plants to Europe. (Tall modern greenhouse protects a palm that fascinated Goethe in 1786).



who rose through commerce to the gentry. He attended King's School in Canterbury, studied in Caius College of Cambridge University.

After obtaining his bachelor of arts degree in 1597, he went on an expedition to the Azores with the Earl of Essex and Sir Walter Raleigh to capture a Spanish treasure fleet. The expedition was a failure, but it sent Harvey into medicine as a career. He chose Padua, then one of the most renowned medical schools in Europe and spent four years at the university. He represented his nation as a councillor and was thus entitled to a stemma, or coat of arms. His stemma has a hand grasping a lighted candle around which two serpents are entwined.

Receiving the degree of Doctor of Physic on April 25, 1602, with high honors, he returned to England. That same year he also received a medical doctorate from Cambridge, but it was Padua that left a lifelong imprint on Harvey, who studied anatomy and physiology under Fabricius ab Aquapendente and presumably also learned clinical medicine in St. Francis Hospital, where bedside teaching of medical students had been introduced by Padua professors more than half a century earlier.

In London he practiced medicine and in 1604 married Elizabeth Browne, daughter of the royal physician to Queen Elizabeth and James I. He was elected a fellow of the Royal College of Physicians in 1607, and two years later was appointed physi-

cian to St. Bartholomew's Hospital and later professor of anatomy and surgery.

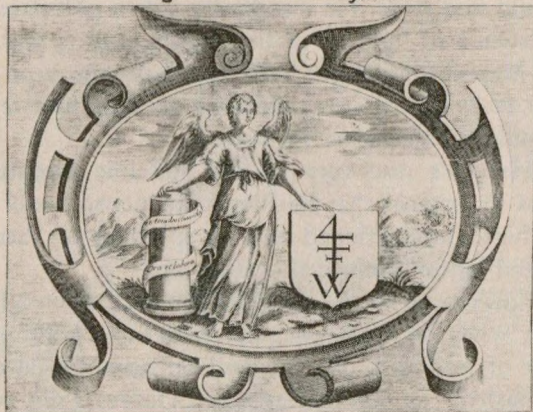
He became personal physician to James I in 1618 and retained this appointment with Charles I, with whom he became friendly and whose second son (later Charles II) he tutored. He also numbered the Lord Chancellor Francis Bacon and the Earl of Arundel among his patients.

Harvey accompanied Charles I on his campaigns in Scotland and attended him almost constantly after the outbreak of the civil war in 1642, during which his lodgings at Whitehall were plundered by Puritan forces and all his notes and the manuscript of a book on insects were destroyed, which he later said was the most devastating loss he ever experienced. Many of the notes for *De motu cordis*, written in a quaint mixture of English and Latin, escaped destruction by Roundhead troopers and are now in the British Museum.

In 1644 the House of Commons ordered Harvey's dismissal from St. Bartholomew's Hospital as a royalist. He remained with the King until he surrendered to the Scots in May, 1646, and six months later Parliament granted Harvey's petition to attend the King at Newcastle. After the King was handed over to Parliament in 1647, Harvey returned to London. Following the King's execution, he came under the order of 1650 forbidding "delinquents" to come within 20 miles of London. A temporary

EXERCITATIO
ANATOMICA DE
MOTU CORDIS ET SAN-
GVINIS IN ANIMALI-

BVS,
GVILIELMI HARVEI ANGLI,
Medici Regii, & Professoris Anatomia in Col-
legio Medicorum Londinensi.



FRANCOFVRTI,
Sumpitibus GVILIELMI FITZERI.
ANNO M. DC. XXVIII.

pass allowed him to visit London for 14 days to attend his former patient, the dowager Lady Thynne, in her illness, providing "that he shall do nothing prejudicial to the commonwealth."

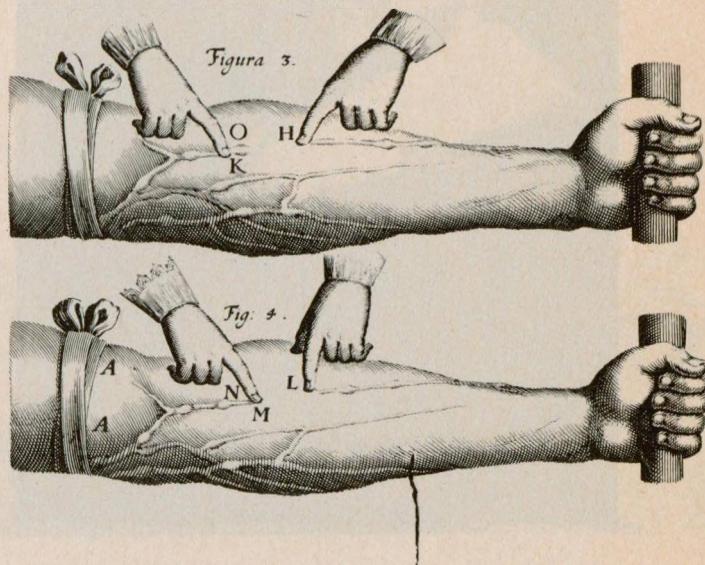
Despite his political problems, Harvey maintained his medical contacts and gave money for a library for the Royal College of Physicians; when finished, his bust was placed in it in 1651. Three years later he was offered the presidency of the Royal College, but he refused because of age and infirmity.

Harvey appears to have spent most of his declining years, complicated by gout and kidney stones, in the country home of his brothers Eliab and Daniel. He continued his observations and writing and in 1651 the book *Exercitationes de generatione animalium* was published through the efforts of Dr. George Ent. He died of what was probably a stroke on June 3, 1657, at the age of 79 and was buried in the village church at Hempstead, Essex, some 50 miles northeast of London.

DE MOTU CORDIS. In 1615, when Harvey was appointed Lumleian lecturer at the Royal College of Physicians, the general notion of the blood's function in the body was derived from Galen's second-century view of an ebb and flow system involving vital, natural, and animal spirits. Andrea Cesalpino at first taught that the heart circulated "innate heat," then repudiated the idea of circulation.

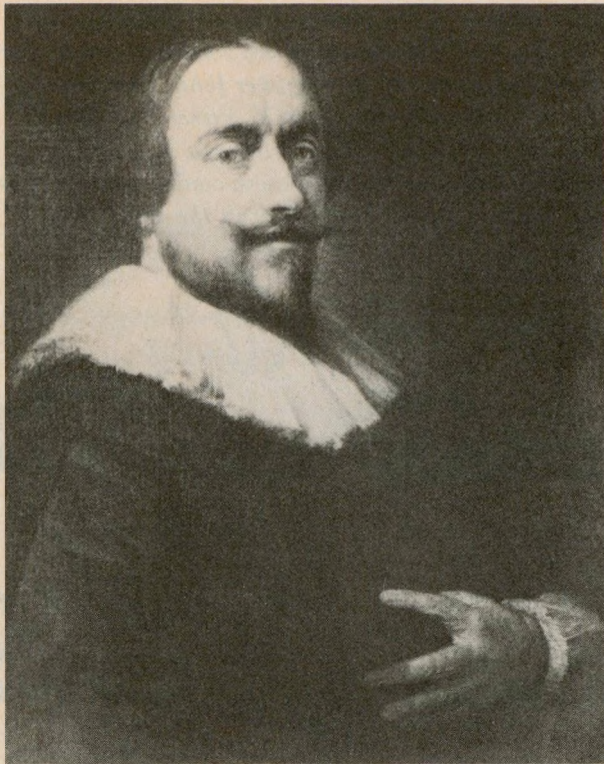
Earlier, Michael Servetus, a Spanish theologian-

First edition of *De motu cordis* was published in Frankfurt by William Fitzer who married a daughter of the great printer and engraver John Théodore de Bry and succeeded Bry in 1626. Fitzer had been the publisher of Robert Fludd, Harvey's Rosicrucian friend. Illustration from *De motu cordis*, below, shows the direction of the blood flow in the veins.



physician, had described the pulmonary circulation of the blood in an obscure religious work for which he was burned at the stake. Realdo Colombo, a pupil of Vesalius at Padua, also described the pulmonary circulation. Fabricius of Aquapendente had also discovered the existence of valves in the veins, which he called "little doors," but whose function he did not understand.

Harvey knew most of these works, and he spent several years experimenting, mostly with dogs, on the anatomy and physiology of the heart and blood. It was the valves in the veins that suggested to him the idea of circulation, a fact that he reported to the Irish chemist Robert Boyle in an interview that was not published until 31 years after Harvey's death. Then by measuring the flow of blood in the heart and blood vessels, he demonstrated mathematically that a certain fixed volume of blood must circulate through the veins and arteries under pressure of the heart as a force-pump. In his final Lumleian lecture for 1616 he declared: "It is proved by the structure of the heart that the blood is continuously transferred through the lungs to the aorta, as by two clacks of a waterbellows to raise water. It is by the ligature that the passage of blood is from the arteries into the veins. It is therefore demonstrated that the continuous movement of the blood in a circle is brought about by the beat of the heart."



Little-known portrait of William Harvey was painted by William Dobson, a court painter to King Charles I.

Galen had asserted that the venous-arterial circuit was completed by the passage of blood through pores in the ventricular septum. Harvey wrote in the introduction to his famous work: "But damn it, no such pores exist, nor can they be demonstrated."

His 1616 lecture on the circulation of blood apparently aroused little interest, since *De motu cordis* was not published for 12 years. His probable choice of Frankfurt-am-Main for publication was because that town was the center of the continental book trade, and every semester a book market was held, attended by leading London booksellers, to display all the new books.

PUBLICATION. Between the lecture and publication, Harvey conducted numerous experiments on animals. On the difficulty of observing a quickly beating mammalian heart he wrote: "I kept finding the matter so truly hard and beset with difficulties that I all but thought with Fracastoro, that the heart's movement was only to be comprehended by God." One solution was to use cold-blooded animals, such as frogs or snakes, where the heart beats slowly and its movements can easily be followed.

In vivisection Harvey was able to observe the systolic and diastolic movements of the heart in relation to the action of its valves. From these studies he deduced that the heart was a pump that took

blood from the veins and pumped it out through arteries into the rest of the body, after passing through the lungs.

The missing link in Harvey's circulatory schema was how blood traveled from the ends of the arteries into the ends of the veins. He repeatedly examined tissues for evidence of some kind of connecting vessels, but with his weak microscope he could find none. He was finally led to postulate the existence of "pores" in this region, and it was left to Marcello Malpighi, who was born the year that *De motu cordis* was published, to demonstrate the capillary circulation in 1661.

Harvey's discovery of the systemic circulation was so original that he found "points so novel and hitherto unmentioned that in speaking of them. I dread lest all men turn against me."

CONTENTION. All men did not turn against Harvey when his book was published, but a good number of leading physicians and scientists raised cries of horror and roundly attacked Harvey's discovery and him personally.

James Primrose, the son of a Scottish emigrant to France, dashed off a book attacking Harvey's "inconsistencies" in 14 days. As a devout Galenist, he vilified Harvey for daring to question the great Roman physician. The most erudite and violent opponent was Jean Riolan, whom the French called the "prince of anatomists." He declared that if dissections produced anatomical facts that did not agree with the great Galen, it meant that nature's organisms had changed in the intervening 14 centuries and not that Galen was wrong. Riolan was the only one of many adversaries whom Harvey dignified with a reply, published in 1649.

The eminent *doyen* of the Faculty of Paris, Guy Patin, was another formidable opponent. He was an arch-enemy of any medical innovation and a master of violently vindictive prose. He declared pontifically that Harvey's theory was "paradoxical, useless, false, impossible, absurd, and harmful, in fact it was an "ingenious piece of fiction." And in Italy, Giovanni della Torre waxed indignant against "the scandal of this man who seeks to destroy so many perfect dogmas and admirable theories."

On Harvey's side a foremost defender was the Cornishman Richard Lower, an eminent physiologist who was the first to make a blood transfusion from one animal to another. Regardless of attacks by the Paris medical faculty, Raymond de Vieussens, professor at Montpellier, who studied the anatomy and pathology of the heart, also came to Harvey's support. And in Denmark, the eminent physician-priest Niels Stensen joined the Harvey camp. René Descartes announced his complete ac-

ceptance of Harvey's hypothesis in *Descours de la méthode*, published in 1637, as did Francis Glissen. As early as 1639 Franciscus Sylvius was demonstrating to his classes at Leyden the circulation in dogs. Of scientific significance was the work of Hermann Corning of Helmstadt, who repeated Harvey's experiments, publishing his findings in *De sanguinis circulatione* in 1643.

ume "that even my lifetime would be too short to make an end of it."

Living modestly, Harvey amassed a considerable fortune, with which he had planned to endow a professorship of experimental philosophy and a laboratory at Cambridge, but he abandoned the idea after the rise of the Commonwealth, declaring to his friend Sir Charles Scarborough: "I see plainly



Earl of Arundel's party at Straubingen on the Danube, a drawing by Wenceslaus Hollar. Harvey was a member of the embassy to the Emperor of Germany. En route Arundel and Harvey bought paintings for King Charles I.

In 1647 France's anatomist and physiologist Jean Pecquet discovered the canal that joins the thoracic duct of the dog with the superior vena cava, thereby confirming Harvey's theory. Four years later Olof Rudbeck of Sweden, while a student at the University of Padua, discovered the lymphatic vessels of the intestine.

His hesitancy in publishing the book was well confirmed by the personal attacks that Harvey, a retiring and uncombative man, endured by a temporary decline in his private medical practice, and by having the book banned by the Holy Inquisition.

EPILOGUE. *De motu cordis* was more than a revolutionary theory on the physiology of circulation. It also marked the beginning of a new era in scientific medicine based on *anatomia animata*, to be called physiology.

Harvey's experiments and the conclusions he drew from them were in the new spirit of the 17th century, seeking not only to describe objects but also to understand how they functioned. After centuries of dogmatism and rigid scholasticism, a few inquiring minds, such as Harvey's, dared to defy established doctrines with new theories.

At the end of his memorable book, Harvey admitted that any attempt to pursue the medical implications of his discovery would fill so huge a vol-

ume, that, were I to dedicate my fortune, as I had intended, to the promoting of the knowledge of truth and to the public weal, I should do nothing other than make Anabaptists, Fanatics and all manner of thieves and parricides my heirs."

His will left a liberal legacy to the poor of his native Folkestone. He also donated a large sum of money to the Royal College of Physicians, which used part of it to build a museum to house the anatomical collection given by Harvey.

To honor the dual anniversary of the publication of *De motu cordis* and the birth of its author, the Royal College of Physicians has prepared a five-day celebration from July 9 to 13, including a scientific program of lectures and symposia, in which papers on medical history and modern developments in cardiovascular medicine will be presented by leading historians and medical scientists from various countries. Two other conferences celebrating the Harvey quatercentenary will be held in the early fall at the Imperial College of Science, London, and Worcester College, Oxford.

SUMMING UP. By Sir William Osler: "For the first time a great physiological problem was approached from the experimental side by a man with a modern scientific mind who could weigh evidence and not go beyond it."

