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THE MAN WHO COUNTED HEARTBEATS

A THIN BOOK OUT OF FRANKFURT

In 1628 a thin, poorly printed book came out of Frankfurt: an anatomical exercise on the motion of the heart and the blood, by William Harvey, physician to Charles the First and a fixture of London's College of Physicians. He had taught its argument in his anatomy lectures for more than a decade before committing it to print, and with reason. It contradicted GALEN, the second-century Greek physician whose account of the body had been taught essentially unbroken for fourteen centuries. Harvey had learned to dissect at PADUA under FABRICIUS, the anatomist who first described the small MEMBRANOUS flaps inside the veins. Afterward his practice suffered; some took him for crack-brained.

SPELL Spell: **FABRICIUS**

FABRICIUS

SPELL Spell: **MEMBRANOUS**

MEMBRANOUS

KNOWN Which second-century Greek physician's account of the body had been taught essentially unbroken for fourteen centuries before Harvey's book contradicted it?

GALEN

KNOWN In which Italian university city did Harvey learn to dissect under Fabricius?

PADUA

OPEN Harvey taught his argument in lectures for more than a decade before he printed it. What would make you wait that long before putting something you had worked out in front of others?

Open response - use practitioner judgment

MATH Harvey argued from arithmetic that the heart moves far more blood than anyone had supposed. Suppose a resting heart beats 70 times each minute. How many beats is that in one hour?

4200

THE ARITHMETIC NOBODY DID

Galen's body made blood continuously in the liver from digested food, pushed it outward through the veins, and consumed it at the tissues like fuel. A share crossed from the right VENTRICLE to the left through invisible pores in the SEPTUM, the muscular wall dividing the heart's lower chambers. Harvey did the arithmetic nobody had bothered to do. Grant the left ventricle an ounce or two expelled at each SYSTOLE - the contraction that is the heart's active stroke, driving blood into the AORTA - and a thousand beats in half an hour, and the hourly total runs past the body's entire mass of blood many times over. No diet supplies that.

SPELL Spell: VENTRICLE

VENTRICLE

SPELL Spell: AORTA

AORTA

KNOWN What is the term for the heart's active contraction, the stroke that expels blood from the left ventricle?

SYSTOLE

KNOWN What is the name of the muscular wall dividing the heart's lower chambers, the one Galen thought was pierced by invisible pores?

SEPTUM

OPEN Harvey trusted his own count over fourteen centuries of teaching. What is something you believe because you checked it yourself?

Open response - use practitioner judgment

MATH Suppose the left ventricle expels 2 ounces of blood at each stroke, and the heart beats 1000 times in half an hour. There are 16 ounces in a pound. How many pounds of blood leave the heart in that half hour?

125

THE LIGATURE TEST

Arithmetic alone convinces no one, so Harvey demonstrated. A LIGATURE drawn tight around the upper arm shut off the arteries and left the limb pale; slackened, it admitted arterial blood while still pinching the veins, which swelled into knots at the VALVES. Pressing the blood out of a stretch of vein with a fingertip, he showed the emptied length refilled only from the hand, never from the shoulder - Fabricius's flaps were one-way gates fixing a direction, not brakes. VIVISECTION, the dissection of living animals, let him follow the slow hearts of frogs and fish chamber by chamber. Centuries earlier in Cairo, Ibn al-Nafis had already denied the septal pores.

SPELL Spell: VIVISECTION**VIVISECTION****SPELL Spell: VALVES****VALVES****KNOWN What is the term for a band drawn tight around a limb to squeeze its blood vessels shut?****LIGATURE****OPEN Pressing the blood out of a vein and watching which end refills is a test anyone could repeat. What is something you would only believe after seeing it done?**

Open response - use practitioner judgment

MATH Ibn al-Nafis described the lung's circulation in Cairo around the year 1242, and Harvey published his own account of the circulating blood in 1628. How many years apart were those two accounts?**386**

PIECES BEFORE THE LOOP

Harvey was not first to every piece of it. Servetus, in a THEOLOGICAL work suppressed in 1553, and Colombo, in an anatomy of 1559, had each described the PULMONARY transit - blood passing from the right ventricle through the lungs to the left rather than seeping across the wall between them. Fabricius had drawn the venous valves accurately but read them as brakes slowing the blood, not as gates governing it. What was new in 1628 was the closed CIRCUIT, one continuous loop in which the same blood returns, and behind it the method: a measured quantity no rival account could absorb.

SPELL Spell: CIRCUIT**CIRCUIT****SPELL Spell: THEOLOGICAL****THEOLOGICAL****KNOWN Blood leaves the right ventricle and travels through the lungs to reach the left side of the heart, instead of seeping across the wall between the chambers. That route is called what kind of transit?****PULMONARY**

OPEN Servetus and Colombo each had a piece of the picture years earlier. Why do you think it took a measurement, and not one more observation, to close the loop?

Open response - use practitioner judgment

MATH A resting adult heart pumps about 5 liters of blood each minute. At that rate, how many liters pass through it in 20 minutes?

100

THE GAP IN THE CIRCUIT

The circuit still had a visible gap. Harvey could trace blood out through the ARTERIES and back through the VEINS, but the junction between them lay beyond his eyes; he postulated ANASTOMOSES, direct connections too fine to see, or a seepage through the POROSITIES of the flesh. The CAPILLARIES that actually close the loop were first observed in 1661, when MALPIGHI turned a microscope on a frog's lung - four years after Harvey's death. Nor did Harvey know what the blood was carrying: oxygen was not identified until the 1770s. In his dedication he still compared the heart to the sun of the microcosm.

SPELL Spell: ANASTOMOSES

ANASTOMOSES

SPELL Spell: POROSITIES

POROSITIES

SPELL Spell: MALPIGHI

MALPIGHI

SEMI_OPEN Name two of the vessels that together complete the circuit of the blood.

NEEDS 2 OF ARTERIES / VEINS / CAPILLARIES

OPEN Harvey compared the heart to the sun of the microcosm. What would you compare the heart to?

Open response - use practitioner judgment

THE ARITHMETIC YOU CARRY

Your own circuit is still measured with Harvey's ARITHMETIC, renamed. Cardiac output is stroke volume times heart rate - the same MULTIPLICATION, done now with ultrasound instead of a deliberately modest guess. The cuff on your arm at a checkup is his ligature, inflated rather than tied. TRANSFUSION, the moving of blood from one body into another, and DIALYSIS, which pumps your blood out through a filter and returns it, are coherent only because the blood comes back. The habit underneath is portable: when an authority and a number disagree, count carefully, then follow the figure wherever it lands.

SPELL Spell: MULTIPLICATION

MULTIPLICATION

SPELL Spell: ARITHMETIC

ARITHMETIC

KNOWN What is the term for moving blood out of one body and into another?

TRANSFUSION

KNOWN What is the term for pumping a person's blood out through a filter and returning it to them?

DIALYSIS

OPEN The cuff at a checkup is Harvey's ligature, inflated instead of tied. What is something ordinary you use that has an old idea inside it?

Open response - use practitioner judgment