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Giovanni Borelli's *De motu animalium*, 1685

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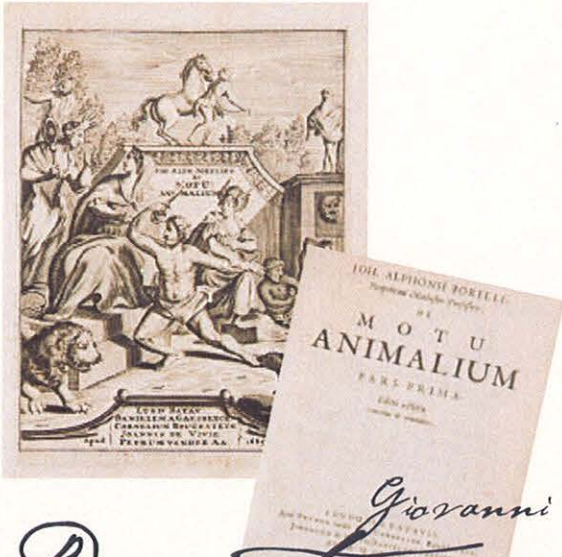
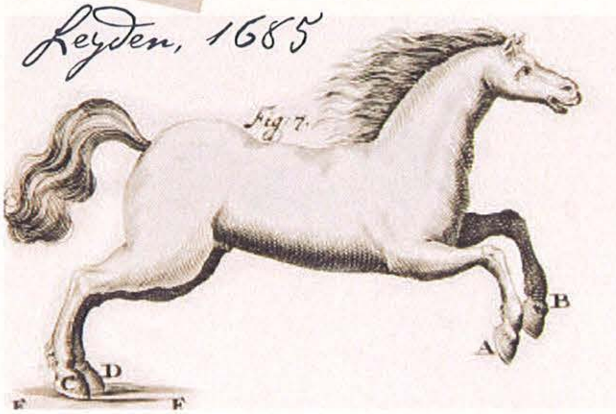


Giovanni Borelli's *De motu animalium* Leyden, 1685



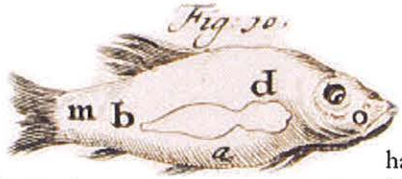
Giovanni Alfonso Borelli (1608-1679) was an Italian polymath who is remembered today mainly for his posthumously published work *On the Motion of Animals.* Here he interpreted the movement of animals (vertebrates mainly) from a mechanical perspective, i.e., as a collection of rods and levers. More familiar to us was his contemporary, the French philosopher and scientist René Descartes (1596-1650), who also viewed the animal world mechanistically. He held that animals were mere automata—man being the exception since he has a rational, immortal soul.

Both Borelli and Descartes lived in a period of Western medical history characterized by two rival schools of thought—iatrophysical and iatrochemical. (The prefix *iatro* is Latin for "physician.") The iatrophysical school believed that all functions of the human body have a mechanical cause, e.g., the circulation of blood (pumps), respiration (bellows), digestion (grinders, contractors), etc. The iatrochemical school also maintained that fermentation (or other chemical reactions) was the dominant physiological mechanism in the human body. The truth, as we now know, involves both.

Borelli was born in Naples, studied under a student of Galileo, and later taught mathematics and astronomy at Messina, Pisa, Florence, and Rome. His quarrelsome nature led to his losing the professorship at Florence and returning to Messina, from which he was soon expelled when he joined the movement against the Spanish dominance of Sicily. He went to Rome, fell into straitened circumstances, at one time may have begged on the streets, and finally entered a monastery, where he was allowed to teach and pursue his various interests.

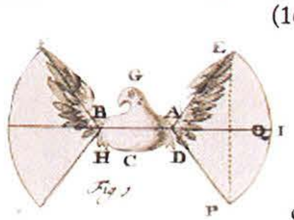
In physiology, Borelli endeavored to apply the laws of mechanics and statics to bodily movements as Galileo had done to the universe, and to give a mathematical expression to them as Galileo had done to mechanical events. In his book, Borelli focused attention on the swimming of fish and the flight of birds. One illustration from *De motu animalium* shows figures of a man, horse, birds, and various mechanical devices indicating the movement of animal limbs. This book is regarded by some as the starting point for experimental biology.

Anticipating Borelli by a century and a half was Leonardo da Vinci (1452-1519), who was the first to visualize the movement of parts of the body in a mechanical way. Da Vinci's drawings of individual limbs or their bare bones depicted the principles of the lever. In one sketch, he compared the leg of a man and a horse when they were standing and moving, as Borelli would later show a man and a bird bending their legs at the knee or its equivalent. The movement



of birds also had attracted Leonardo's attention because of his interest in potential human flight. One of Borelli's illustrations compares a bird flapping its wing and a man throwing a round object. After his death in 1519, da Vinci's notebooks of drawings fell into private hands, were lost to the scientific community, and thus were unknown to Borelli.

In a different area of physiology, Borelli proposed a neurogenic theory to explain the heartbeat, suggesting that impulses for contraction arise from nerve fibers within or outside the heart. This was later challenged by the myogenic theory, which posited that impulses are initiated within cardiac muscle fibers. Borelli's theory now seems more accurate with the discovery of ganglion nerve cells located within the heart at strategic points to control its beat. His interest in the heart likely was prompted by the publication in 1628 of William Harvey's discovery of circulation—*De motu cordis (On the Motion of the Heart).*



Borelli may have made original contributions in mathematics, but they were lost in his cryptic writings, which characterized the secretive nature of the field then. He made significant observations about Jupiter's satellites, whose orbits he described, taking care not to infer too openly of their similarity to that of the moon and earth and thus not to invite possible scrutiny from the geocentrically minded Catholic authorities. Galileo's trial for heresy before the Congregation of the Holy Office of the Inquisition in 1633 was not forgotten. Isaac Newton (1642-1727) cited Borelli as one of his predecessors in the area of cosmology.

Earlier, while living in Florence, Borelli had been an early member of the *Academia del Cimento*, a short-lived group (1647-1667) which sought to promote the experimental method in Europe. His research in physiology represented the beginning of iatrophysics, or biomechanics. For this reason he could be regarded as the founder of the later field of biophysics. Modern rational medicine may be said to have begun with the studies of Borelli, Harvey, and the rival iatrophysicists and iatrochemists of the seventeenth century. From this perspective, Transylvania's Special Collections has a notable treasure in *De motu animalium.* TT

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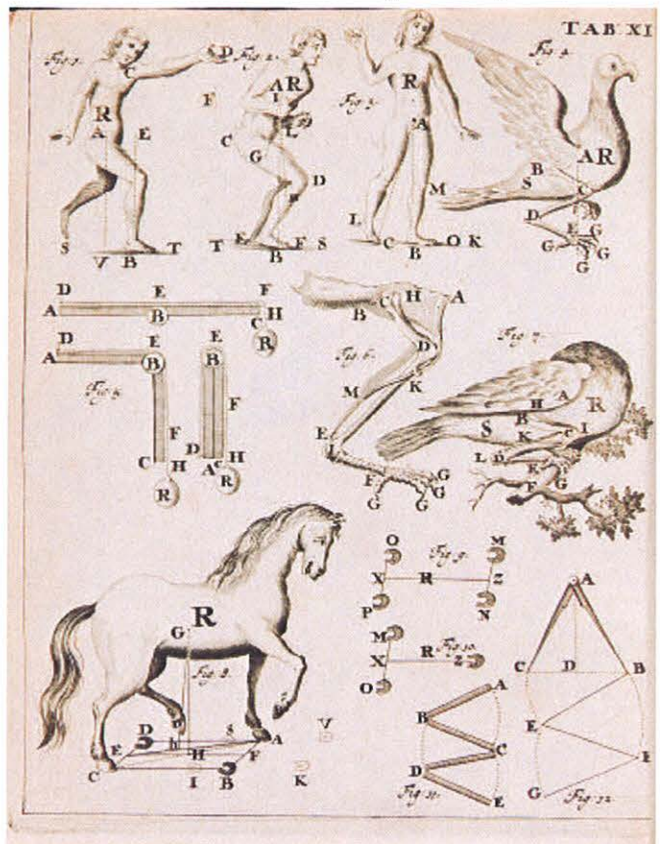

Figures of a man, horse, bird, and various mechanical devices indicate the movement of animal limbs. Borelli was the first to apply the principles of mechanics and statics to bodily movements, and his book is regarded as the starting point for experimental biology.