

Giovanni Alfonso Borelli Renaissance Astrophysicist and Bioengineer

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Borelli's influences

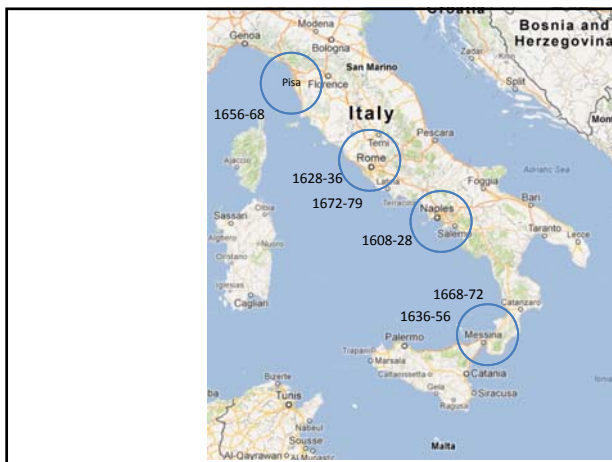


Giovanni Borelli
(1608-1679)

Galileo Galilei
(1564-1642)



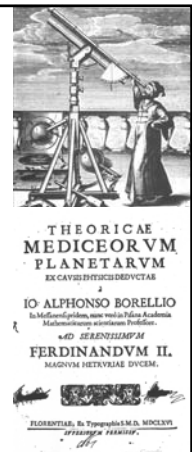
William Harvey
(1578-1657)



Borelli the astronomer

- Translated Apollonius' *Conics* from Arabic to Latin
- Demonstrated that the orbits of the moons of Jupiter were **elliptical**
- Tracked a comet from December 1664 to February 1665, showing its trajectory to be **parabolic**

Borelli concluded that there was, acting between celestial bodies, a *'virtue that attaches them and unites them so that they cannot recede from their centre of action'* ie a gravitational force



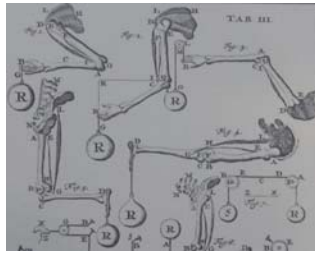
Marcello Malpighi
(1628-1694)

"I undertook this work ... to bring anatomy into physics and mathematics, as has been done for astronomy"

"Do not fear difficulty because the author involves mathematics, ... (which is) clear for a physicist and a perspicacious anatomist".

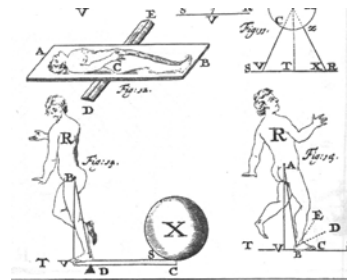
"If the spine of a stevedore is bent and supports a load of 120 pounds carried on the neck, the force exerted by Nature in the intervertebral disks and in the extensor muscles of the spine is equal to 25585 pounds. The force exerted by the muscles alone is not less than 6404 pounds".

"Cartilage..... by its softness would be used as a cushion preventing attrition of the bone, by its strength it would impede dislocation, by its elasticity it would permit small movement of the vertebrae in all directions."



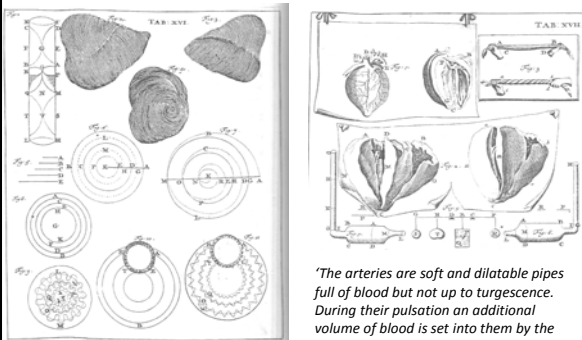
Borelli's concepts and vocabulary were entirely mechanical: forces and moments, gravity and weight, movement and percussion, inflow and outflow, contraction and expansion, volumes and velocities, swelling, binding and wrinkling, ebullition and effervescence, mixing, scraping and separation. His analogies are mechanical: pulleys and scales, goatskin bottles and bladders, wet ropes and balls of string.

Centre of gravity



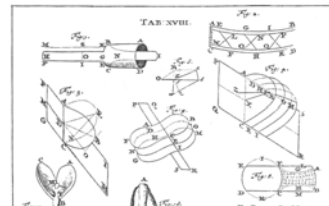
'why (is) walking up a slope is fatiguing and unpleasant?', whilst 'going down a slope is somewhat more fatiguing than walking over a horizontal plane?'

The heart as a piston



'The arteries are soft and dilatible pipes full of blood but not up to turgescence. During their pulsation an additional volume of blood is set into them by the contraction of the heart, as by a piston.'

Respiration



'During quiet and normal expiration air is *not ejected by force* of the some muscles but as a result of the quietness and *absence of action* of the intercostal muscles, of the *relaxation of the diaphragm* and of the opening of the epiglottis.'

'Respiration was not instituted to cool and ventilate the flame and heat of the heart.'

- *"To determine the temperature of the heart accurately, at Pisa, I took care of opening the chest of a live stag and immediately let a thermometer be introduced through the wound into the left ventricle of the heart.*
- *I saw that the highest temperature of the heart did not exceed 40° (gradus 40) which is the usual temperature in the sun in the summer in our country.*
- *Afterwards, using similar thermometers, I measured the temperature of the liver, lungs and intestines in the same stag alive.*
- *It appeared that the heart has the same temperature as the other viscera"*

How does muscle contract? Borelli's model

- **Basic hypothesis:** The muscle fibres swell, becoming harder and tighter, causing a contraction between the ends of the muscle whilst expanding its girth.
- A nervous juice, "a fluid, very delicate, extremely pure and mobile substance" is activated at the origin of a nerve by "a movement of concussion or by a stinging mordant".
- At the distal end, in the muscle, some of the juice is shaken out of the nerve, "as droplets of water can be shaken from a full sponge".
- The nervous juice, once released, sparks a chemical reaction which results in the release of tiny bubbles, causing the muscle fibre to swell.
- As soon as the nerve stops its action, the reaction ceases and the muscle returns to its resting, flaccid, state.

Borelli's diving suit and submarine



Publication of *De Moto Animalium*



- *De Moto Animalium* was published in Rome in 2 volumes, in 1680 and 1681, just after Borelli's death
- Queen Christina of Sweden gave financial support "*her generosity provided the poor Author with considerable funds to improve his destiny and for his work.*"
- Borelli's scientific philosophy: he quotes Plato's reply to the question "*What does God do?*" : "*God exerts geometry.*"

Not all physicians agreed with Borelli's mechanical interpretations of physiology

"The Greatest Numbers of Professors of Medicine are declared Enemies to it , and make nothing of breaking their Jestes upon Angles, Cylinders, Cones, Celerity, Percussion, Resistance and such like terms, which they say have no more to do with Physic, or the Human Body, than a Carpenter has to do in making Venice Treacle, or curing a fever"

John Quincy, *Medical Statica: Being the Aphorisms of Sanctorius Translated into English*, 5th edition. London. 1737.

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*'One of **the great pioneers** of physiological anatomy; his imprint is everywhere; his office has been **so universal** that his name is **never mentioned** in the texts upon which our medical education is founded!'*

William Wightman. *The Growth of Scientific Ideas*. 1953.