

17. The Mechanical Philosophy



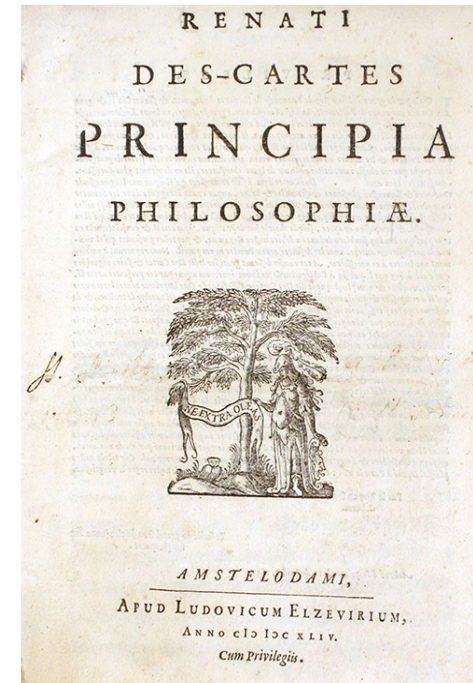
1. Descartes
2. Biology & the Mechanical Philosophy

1. René Descartes (1596-1650)

- (1644) *Principia Philosophiae* (*The Principles of Philosophy*)

Cartesian Metaphysics

- Three things exist:
 - *minds* = thinking substance
 - *bodies* = extended substance
 - *God* = infinite substance
- *Complete* separation of mind from body.
- Natural philosophy is concerned *only* with body: No active principles, substantial forms, final causes, occult properties, spirits, *etc.* in Nature.
- Only extended bodies in motion *via* contact forces (*i.e.*, efficient causes).



Key Points

(a) The essence of body is extension:



"...the nature of matter or body, considered in general, does not consist in its being hard, or ponderous, or coloured, or that which affects our senses in any other way, but simply in its being a substance extended in length, breadth, and depth... nothing remains in the idea of body, except that it is something extended in length, breadth, and depth; and this something is comprised in our idea of space, not only of that which is full of body, but even of what is called void space."

- Extension is *essential* to the concept of matter:
 - You *cannot* understand other properties of matter without presupposing extension.
 - You *can* understand extension without presupposing other properties.

Ex: World in which bodies move away from approaching hands.

- No concept of hardness of a body in such a world.
- Yet concept of body would still be understandable.
- Thus concept of body is independent of concept of hardness.

(b) Bodies are individuated through motion:

"All the properties we distinctly perceive to belong to [matter] are reducible to its capacity of being divided and moved according to its parts; and accordingly it is capable of all those affections which we perceive can arise from the motion of its parts. For the partition of matter in thought makes no change in it; but all variation of it, or diversity of form, depends on motion."



corpuscularianism

vs

atomism

- extended, infinitely divisible corpuscles.
- motion in a plenum.

- pointlike, indivisible atoms.
- motion in a void.

(c) Motion is caused by God:

- Instigated at creation.
- Constantly maintained *via* imposition of a principle of conservation of quantity of motion, and by three "Laws of Nature".

"Now as far as the general cause [of motion] is concerned, it seems clear to me that this is no other than God himself. In the beginning <in his omnipotence>, he created matter, along with its motion and rest; and now, merely by his regular concurrence, he preserves the same amount of motion and rest in the material universe as he put there in the beginning. Admittedly motion is simply a mode of the matter which is moved. But nevertheless it has a certain determinate quantity; and this, we easily understand, may be constant in the universe as a whole while varying in any given part... For we understand that God's perfection involves not only his being immutable in himself, but also his operating in a manner that is always utterly constant and immutable... From God's immutability we can also know certain rules or laws of nature, which are the secondary and particular causes of the various motions we see in particular bodies."



- God constantly imposes conservation principle and laws on bodies at every instant.
 - *Not an Absentee Landlord who sets up universe and then retires to Florida...*
 - *Cartesian physics = complete removal of all active principles from physical world; replaced with one big, external, principle (God).*

(d) Conservation Principle:

The total quantity of motion of bodies in the universe is conserved.

- Due to "immutability and constancy" of God.
- Quantity of motion = *size* × *speed*
- Qualifications: For Descartes,
 - *Size and mass are not distinct.*
 - *Speed and velocity are not distinct.*
 - *Thus quantity of motion is not identical to momentum (mass × velocity).*

(e) Three Laws of Nature ("secondary" causes of motion):

First Law of Nature:

"Each and every thing, in so far as it can, always continues in the same state; and thus what is once in motion always continues in motion."



Second Law of Nature:

"All motion is in itself rectilinear; and hence any body moving in a circle always tends to move away from the centre of the circle which it describes."



Third Law of Nature:

"If a body collides with another body that is stronger than itself, it loses none of its motion; but if it collides with a weaker body, it loses a quantity of motion equal to that which it imparts to the other body."



- Law 1 says motion and rest are *states* of a body.
- Law 2 says natural motion of a body is in a straight line.
- Law 3 describes how the motion of bodies, as described by Laws 1 and 2, can be reconciled when they come into contact.

Motion need not have an immediate cause in contact with moving body!

Circular motion is not natural!

(f) Consequences of motion in a plenum:

- All motion is *relative*: a body moves only with respect to another.
- All motion is "circular" in the sense of movement along a closed curve in the plenum in which one body displaces another immediately adjacent to it.

"It has been shown.. that all places are full of bodies... From this it follows that no body can move except in a complete circle of matter or ring of bodies which all move at the same time."



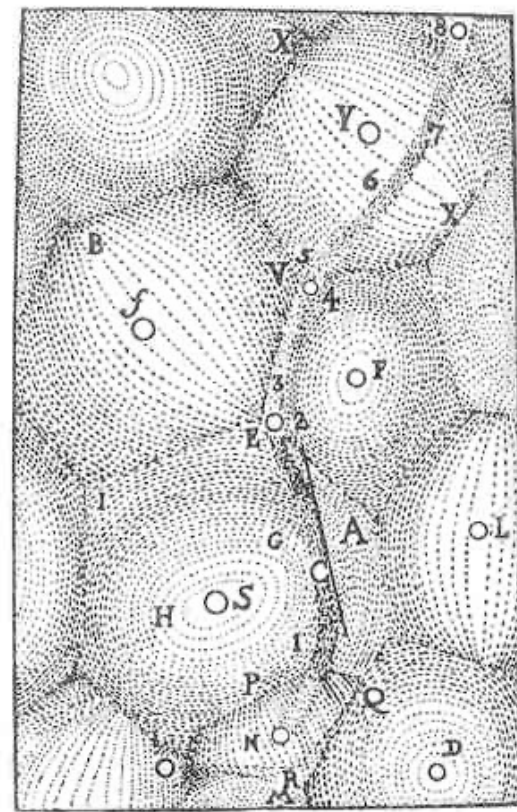
- Result: Unnatural circular movements generate centrifugal pressures.
- In particular: Motion in the solar system is due to vortices of matter.

"Let us suppose... that the whole of the celestial matter in which the planets are located turns continuously like a vortex with the sun at its centre. Further, let us suppose that the parts of the vortex which are nearer the sun move more swiftly than the more distant parts, and that all the planets (including the earth) always stay surrounded by the same parts of celestial matter. This single supposition enables us to understand all the observed movements of the planets with great ease, without invoking any machinery."



- The universe as a system of interlocking vortices of matter.

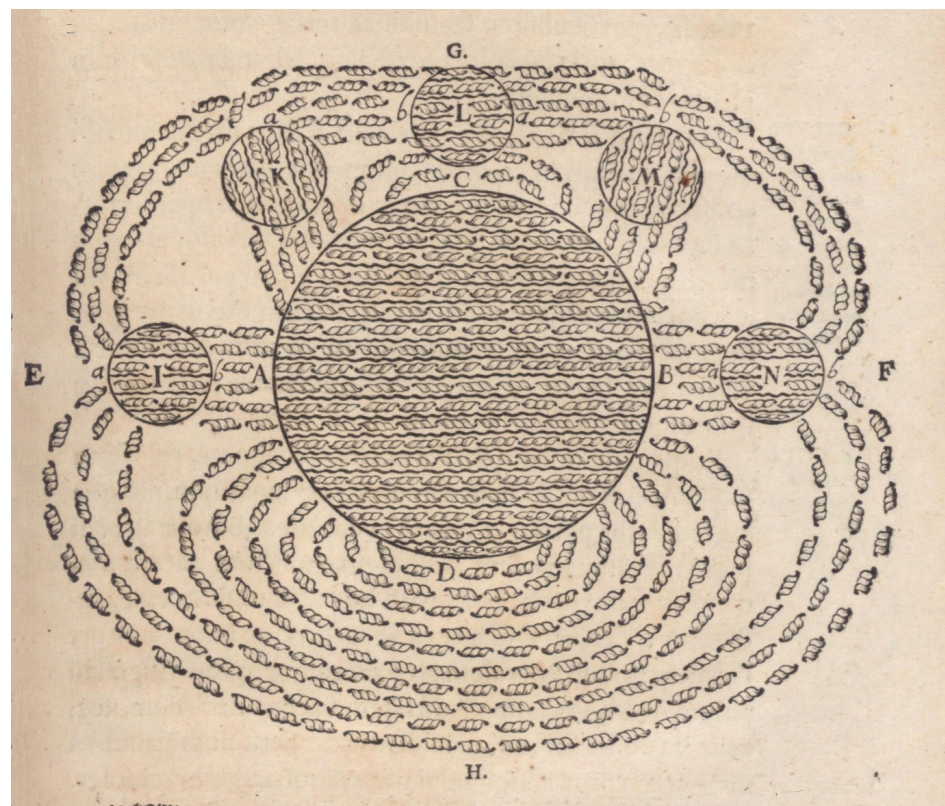
- *Smaller particles move away from vortex centers.*
- *Resulting pressure causes larger particles to move towards vortex centers.*
- *And: The earth is at rest with respect to the plenum particles in its immediate vicinity; yet it can still be said to orbit the sun!*



"...motion [in the strict sense] is simply the transfer of one body from the vicinity of the other bodies which are in immediate contact with it, and which are regarded as being at rest, to the vicinity of other bodies. But it often happens that, in accordance with ordinary usage, any action whereby a body travels from one place to another is called 'motion'; and in this sense it can be said that the same thing moves and does not move at the same time, depending on how we determine its location. *It follows from this that in the strict sense there is no motion occurring in the case of the earth or even the other planets, since they are not transferred from the vicinity of those parts of the heaven with which they are in immediate contact, in so far as these parts are considered as being at rest.*"



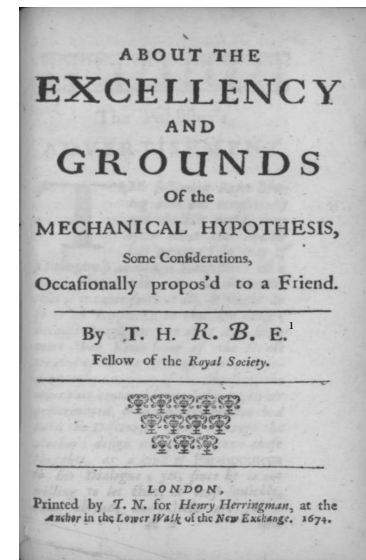
- Mechanical basis for light.
 - *Constant outward pressure of smaller particles from Sun due to centrifugal effects.*
- Mechanical basis for magnetism.
 - *Screw-shaped particles passing through pores in a magnet and iron.*
 - *Air between magnet and iron is driven out, causing them to move together.*



- Boyle's (1674) *About the Excellency and Grounds of the Mechanical Hypothesis.*
 - *Two "catholic principles" of the "mechanical philosophy": matter and motion.*
 - *Denial of action-at-a-distance.*
 - *Rejection of final causes.*



Robert Boyle
(1627-1691)



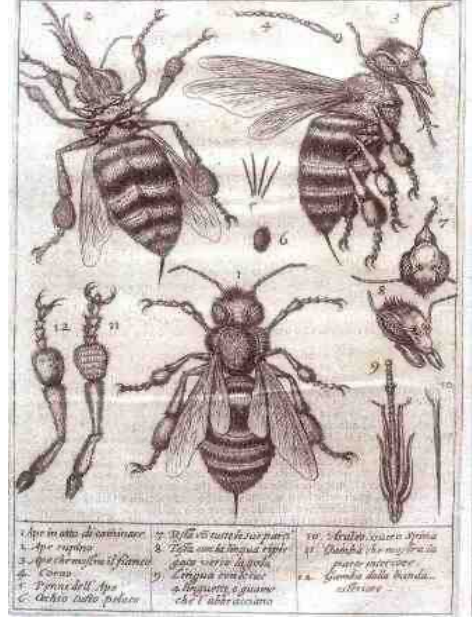
2. Biology and the Mechanical Philosophy

- 1624. Stilluti's *Melissographia*.
 - *First published microscopic observations.*



Francesco Stilluti
(1577-1652)

"I have used the Microscope to examine bees and all their parts..."



1625 Apiarium

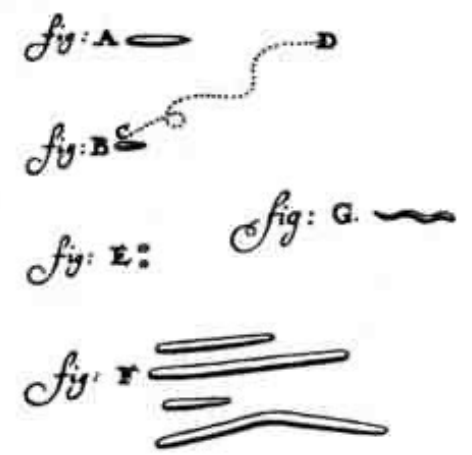
- 1683. Leeuwenhoek's observations.



Anthony van Leeuwenhoek
(1632-1723)

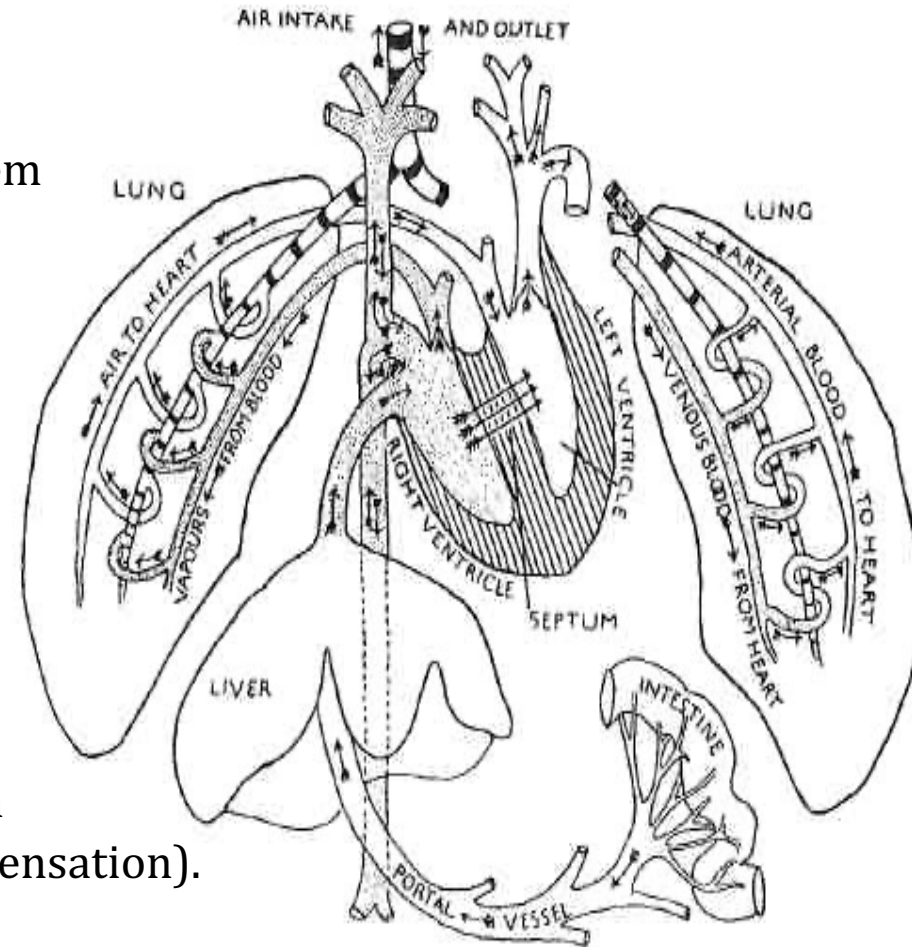
"I took a little white matter, which is as thick as if it were batter. I then most always saw, with great wonder, that in the said matter there were many very little living animalcules, very prettily a-moving. The biggest sort had a very strong and swift motion, and shot through the water (or spittle) like a pike does through the water. The second sort oft-times spun round like a top and these were far more in number."

PLATE XXIV



The Function of the Heart

- Galenic physiology: arterial system (*blood*) is different from venous system (*pneuma*).
 - Liver converts food into blood.
 - Blood flows from liver through venous system and absorbed by body.
 - Some blood enters heart through right ventricle and seeps through pores to left ventricle.
 - In left ventricle, blood combines with air from lungs to form *vital spirits (pneuma)*.
 - *Vital spirits* flow out into arterial system.
 - *Vital spirits* in brain are converted into *animal spirits* which are distributed through nervous system (causes of movement and sensation).

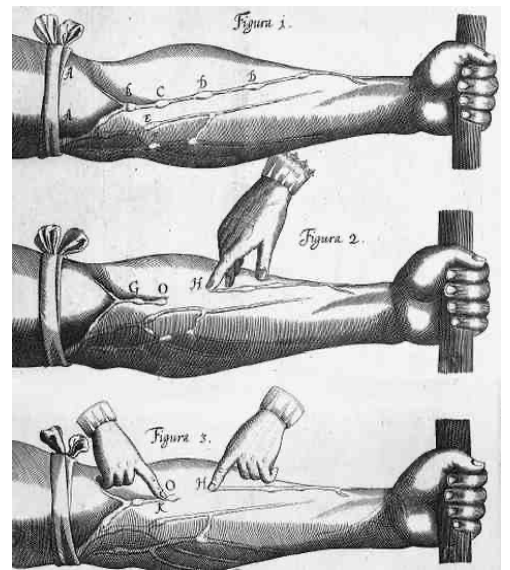
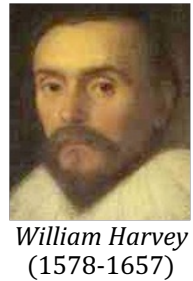


- Harvey's (1628) *De Motu Cordis et Sanguinis* (*On the Motion of the Heart and Blood*)

- Mechanical/quantitative reasoning:
 - Claim 1: The heart discharges more blood into the arteries in half an hour than the entire body contains.
 - Implication: The blood must circulate in the body.
 - Claim 2: The blood can pass from arteries to veins.

Demonstration:

- Applies ligature to arm.
- Loosens ligature to allow flow through artery but not veins.
- Veins below ligature fill with blood.



- Conclusion: The heart is a pump.



"From the structure of the heart it is clear that the blood is constantly carried through the lungs into the aorta as by two clacks [valves] of a water belows to rayse water."

- But: Aristotelian influences.



"I began to think whether there might not be a motion as it were in a circle. Now this I afterwards found to be true... which motion we may be allowed to call circular, in the same way as Aristotle says that the air and therein emulate the circular motion of the superior bodies..."

"And so in all likelihood does it come to pass in the body through the motion of the blood; the various parts are nourished, cherished, quickened by the warmer more perfect vaporous spiritous and as I may say alimentive blood; which, on the contrary, in contact with these parts, becomes cooled, coagulated and so to speak effete; whence it returns to its sovereign, the heart, as if to its source, or to the inmost home of the body, wthere to recover its state of excellence or perfection. Here it resumes its due fluidity and receives an infusion of natural heat -- powerful, fervid, a kind of treasury of life, and is impregnated with spirits, and it might be said, with the balsam, and thence it is again dispersed; and all this depends on the motion and action fo the heart."



Iatromechanics

- Mechanical biology



"I want you to consider that all these functions in this machine follow naturally from the dispositions of its organs alone, just as the movements of a clock or another automat follow from the disposition of its counterweights and wheels; so that to explain its functions it is not necessary to imagine a vegetative or sensitive soul in the machine, or any other principle of movement and life other than its blood and spirits agitated by the fire which burns continually in its heart and which differs in nothing from all the fires in inanimate bodies." (*Treatise on Man*, 1664)

"The body of man is a hydraulic machine contrived with the most exquisite art, in which there are numberless tubes properly adjusted and disposed for the conveyance of fluids of different kinds. Upon the whole, health consists of regular motions of the fluids, together with a proper state of the solids, and diseases are their aberrations."



Richard Mead
(1673-1754)

- Complete separation of *minds* ("spirits", hidden principles, occult forms, etc.) and physical *bodies*.
- Physical bodies are to be given *mechanical explanations* in terms of cause/effect relationships mediated through contact forces.

Extreme Example #1:
Vivisection of living
(mindless) animals is
permissible...

"I advise those who are not versed in Anatomy, before they commence the perusal of these observations, to take the trouble of getting dissected in their presence the heart of some large animal possessed of lungs, (for this is throughout sufficiently like the human)." (*On the Motion of the Heart and Blood*, 1628.)



Extreme Example #2

- 1950's. Behaviorism paradigm in psychology.

Claim: Learning proceeds by *reinforcement*

- positive reinforcement establishes behavior
- negative reinforcement eliminates behavior

- Extreme form: All human behavior can be explained in terms of *purely observable* responses to reinforcement.

- In particular: *There are no such things as unobservable mental/cognitive states.*

- Thus: "x feels pain" means "x exhibits certain behaviors"

Question: How should we perform operations on newborns?

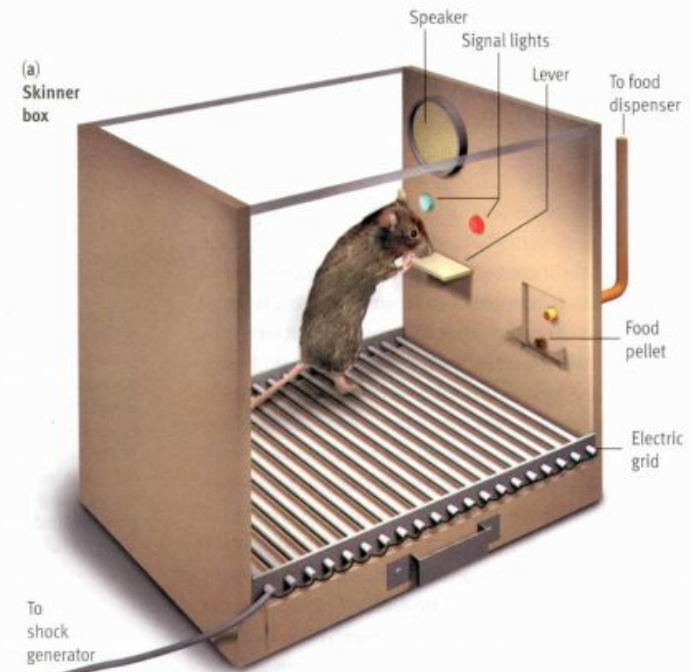
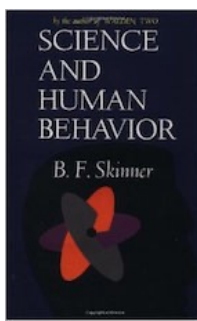
- Extreme behaviorist:

- *Newborns cannot verbally communicate.*

- *To say "Newborn is in pain" means "Newborn exhibits certain behaviors".*

- Thus: *Just use muscle relaxant as anesthetic.*

Skinner, B. F. (1953)
*Science and Human
Behavior*



Embryology

- Harvey's (1651) *De Generatione Animalium* (*On the Generation of Animals*).

- *Vitalistic epigenesis*.

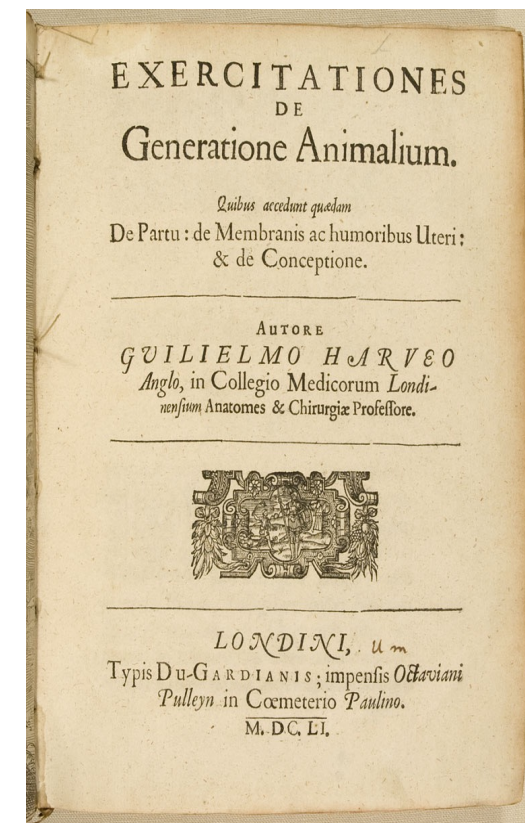
"An egg is the common origin of all animals."



- An egg = a *primordium* = a homogeneous first matter.
- *Epigenesis* = Creative generation under the guidance of a formative virtue embodying the divine idea of the species. (Heterogeneity from homogeneity *via* final causation.)
- Embryo differs fundamentally from adult; develops by stages into adult *via* budding and subdivision.



"Because it is certain that the chick is built by *epigenesis*, or the addition of parts budding out from one another... the first [part] to exist is the genital part by virtue of which all the remaining parts do later arise as from their first original... at the same time that part divides up and forms all the other parts in their due order..."





Pierri Gassendi
(1592-1655)

- Gassendi's atomistic *preformation*.

- Mechanism based on atoms (not corpuscles).
- *Preformation* = Generation as a process of the unfolding of heterogeneity, already present. No stage-by-stage development.

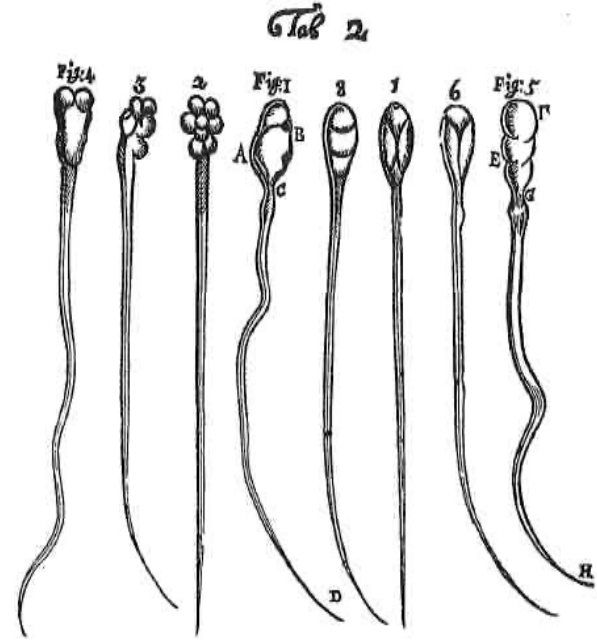


"the seed contains the thing
itself, but contains it as
rudiments not yet unfolded."

- *Seed* = tiny body containing particles from all parts of the individual.
- Atoms in seminal fluids of parents combine to form seed.
- And: The seed has a material soul (made out of atoms) that guides how it unfolds to reproduce the parents in the offspring.

- *Ovism*: universality of generation from egg.
- 1677. Leeuwenhoek observes spermatozoa.

"These *animalicula* were smaller than the corpuscles that make the blood red, so that I estimate a million of them are not equal in size to a large grain of sand. They had roundish bodies, blunt in front, but ending in a point at the rear; they were endowed with a thin transparent tail five or six times as long as the body and about one twenty-fifth as thick, so that I can best compare their shape to a small radish with a long root. They moved forward with a serpentine motion of the tail, like eels swimming in water."



- Animacular preformation.
 - *Animaculism* = generation from sperm.



Nicholas Hartsoeker (1656-1725)

"It can be said that each animal, actually and in miniature, contains and shields in a delicate and tender membrane a male or female animal of the same species, as that in the semen of which it is found." (*Essay on Dioptrics* 1694)



"...more comfortable to the dignity of man..."



Emily Martin

Martin, E. (1991) 'The Egg and the Sperm: How Science has Constructed a Romance Based on Stereotypical Male-Female Roles'

Claim: Cultural assumptions are embedded in the language of science.

Particular Claim: "The picture of egg and sperm drawn in popular as well as scientific accounts of reproductive biology relies on stereotypes central to our cultural definitions of male and female."

Egg characteristics

- large and passive.
- "is transported", "is swept", "drifts".
- Religious overtones: has "vestments" and a "corona, is accompanied by "attendant cells".
- The queen to the sperm's king.
- "a dormant bride awaiting her mate's magic kiss, which instills the spirit that brings her to life".

Sperm characteristics

- small, "streamlined", active.
- "deliver" genes to the egg.
- "activate the developmental program of the egg".
- have a "velocity", "energy", "fuel".
- tails are "strong" and efficiently powered.
- carry out a "perilous journey" into the "warm darkness" where some fall away "exhausted".

- But: Research suggests egg's role is more active.
- Baltz, Katz, Cone (1988) 'The Mechanics of the Sperm-Egg Interaction at the Zona Pellucida', *Biophysical Journal* 54, 643-54.
 - *Forward thrust of sperm is too weak to penetrate inner layer of egg (zona).*
 - *Sperm motion (side-to-side) suggests escape from egg rather than penetration.*
 - *Adhesive molecules on egg trap sperm.*

"The innermost vestment, the *zona pellucida*, is a glyco-protein shell, which captures and tethers the sperm before they penetrate it... The sperm is captured at the initial contact between the sperm tip and the *zona*... Since the thrust [of the sperm] is much smaller than the force needed to break a single affinity bond, the first bond made upon the tip-first meeting of the sperm and *zona* can result in the capture of the sperm."

- But: This revisionist account still involves another cultural stereotype: Woman as a dangerous and aggressive threat.
 - *Active egg "captures and tethers" sperm (like a spider lying in wait in her web).*
 - *Egg's nucleus "interrupts" the sperm's dive and "clasps the sperm and guides its nucleus to the center".*

"New data did not lead scientists to eliminate gender stereotypes in their descriptions of egg and sperm. Instead, scientists simply began to describe egg and sperm in different, but no less damaging, terms."

- A less stereotypical view: the cybernetic model.

- *feedback loops*
- *flexible adaptation to change*
- *coordination of the parts within the whole*
- *evolution over time*
- *changing response to the environment*

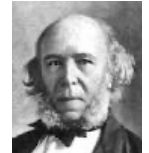
- 19th century interaction between social and natural sciences:

- *Malthus on population control of poor, Spenser on economic "survival of the fittest"...*
- *...influenced Darwin's concept of natural selection in Origin of Species...*
- *...which, in turn, was used to justify Malthusianism and social Darwinism.*

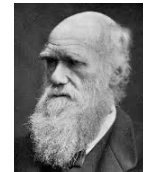
"What we are seeing now is similar: the importation of cultural ideas about passive females and heroic males into the 'personalities' of gametes. This amounts to the 'implanting of social imagery on representations of nature so as to lay a firm basis for reimporting exactly that same imagery as natural explanations of social phenomena'."



Thomas Malthus
(1766-1834)



Herbert Spencer
(1820-1903)



Charles Darwin
(1809-1882)