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## Three Traditions in Science

Different ways of doing scientific work

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## The Whig Interpretation of History

- Seeing (British) history as a battle between
  - the progressive, forward-looking Whigs*and*
  - the reactionary, backward-looking Tories.

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## Herbert Butterfield

- *The Whig Interpretation of History*
  - London, 1931.
- Butterfield showed that the “whig interpretation” was a fundamental problem in writing political history.

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## The Whig Interpretation of Science

- The same flaw occurred in writing the history of science.
- Even more acute in the history of science because of the inevitable conclusion that present day science is right and past science was wrong.

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## Hugh Kearney

- *Science and Change, 1500-1700.*
  - New York, 1971.
- An attempt to combat a whig interpretation of the scientific revolution.

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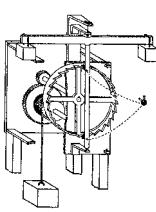
## Kearney's Three Traditions in Science



□ The Organic.



□ The Magical.



□ The Mechanist.

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## The Organic Viewpoint

- Common sense.
- Empirical.
- Coherent and logical.
- The goal was to explain the purpose (why) of something in nature.
- Focus on cycles.
  - Life cycles.
    - Generation and corruption.
  - Planetary cycles.
- Ignored accident.



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## The Organic Tradition in Antiquity

- Aristotle
  - Biological interests
  - *History of Animals*
  - Purpose the ultimate cause
- Ptolemy
  - Cycles of the planets and the heavens
- Galen
  - *Physiology*

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## The Organic Tradition in the Middle Ages

- Dominated the Middle Ages and the early Renaissance, especially in Europe.
- Scholasticism, 14<sup>th</sup> century.
  - William of Ockham, Ockham's Razor.

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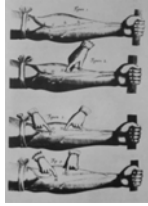
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## Padua in the 15<sup>th</sup> and 16<sup>th</sup> century



□ Andreas Vesalius  
■ *De Fabrica*, 1543



□ William Harvey  
■ *De Motu Cordis*, 1628

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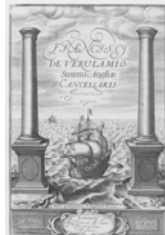
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## The Organic Tradition in the Scientific Revolution

- Spokesman:  
Francis Bacon
  - Popularized experiment (i.e. observation).
  - Criticized acceptance of authority.
  - Science as induction from particulars.
  - Ignored *mathematics*.



Title page of Bacon's *Great Instauration*

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## Bacon's "Idols"

- Idols of the Tribe
  - Limitations because we are human—feeble, poor eyesight, sense of touch, etc. These handicapped in understanding nature.
- Idols of the Den
  - Limitations due to education and society—preconditions, biases, blindspots.
- Idols of the Theatre
  - Limitations of philosophical systems that circumscribe and control human thought.
- Idols of the Market Place
  - Limitations and ambiguities imposed by words and language used for communication.

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## The Magical Viewpoint

- The search for secrets.
- Solving the riddle of nature.
- Hidden structures, forces.
- Magical powers.
- The scientist as wizard, sorcerer, high priest, soothsayer.



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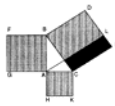
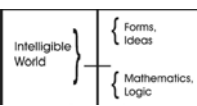
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## The Magical Tradition in Antiquity

- Pythagoras
  - Number magic
  - Secretive cult
- Plato
  - Upper part of the Divided Line
  - Mathematics the key to higher understanding.

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## The Magical Tradition in Antiquity, 2

- Hermes Trismegistus
  - A mythical figure.
  - Held that the Sun was God, or a symbol of God.
  - Light, the source of life.
  - Mathematical harmony in the cosmos.



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**The Magical Tradition in the Middle Ages and Renaissance**

- The Magical Tradition has never dominated, but has never been totally ignored.
- Neoplatonism.
- Hermeticism.
- Alchemy.
- Astrology.

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**The Magical Tradition viewed as out of touch**



- A painting by Pieter Breughel, the Elder, showing alchemists as irresponsible and oblivious to the outside world.

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**The Magical Tradition in the Scientific Revolution**

- Copernicus
  - The Sun the centre of the universe and the source of all life
  - Mathematics is for mathematicians.
  - Mathematical harmony trumps common sense.
- Giordano Bruno
  - The infinity of worlds.
  - The universe is magical.

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## The Magical Tradition in the Scientific Revolution, 2

- William Gilbert
  - *On the Magnet*.
  - Action at a distance.
- Paracelsus
  - The human body as a microcosm
  - Iatrochemistry.
- Johannes Kepler
  - Mathematical relationships are the ultimate secrets of the universe.

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## The Mechanist Viewpoint

- The world is (like) a machine.
- Understand the world through analogies to machines.
- Everything to be explained by combinations of pushes and pulls.
- No hidden forces or mysterious influences.
- Emphasis on “how” – not “why.”



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## The Mechanist Tradition in Antiquity and the Middle Ages

- Archimedes
  - Levers, pulleys, floating bodies, ingenious machines.
  - Archimedes asked *how* does it work?

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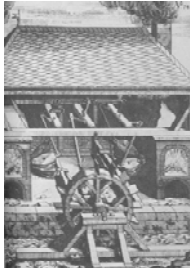
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## The Mechanist Tradition in Antiquity and the Middle Ages, 2

- In the Middle Ages
  - Craftsmen, builders of windmills, waterwheels, devices of all sorts.
  - What later became "engineers."



A water wheel operating a bellows

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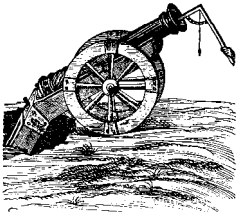
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## The Mechanist Tradition in the Scientific Revolution

- Niccolo Tartaglia
  - Cannonball trajectory.
  - Translated Archimedes and Euclid.

*L'altro d'effe che molto piu tiraria a doi ponti piu baffo di tal spora (quando era dinfa in v'acqua) come di fatto appare in d'effe.*



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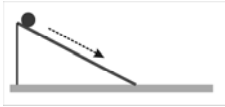

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## The Mechanist Tradition in the Scientific Revolution, 2

- Galileo
  - Simplify problem, make model, find mechanism.
  - Describe mathematically
  - Avoid system building

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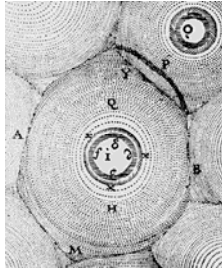
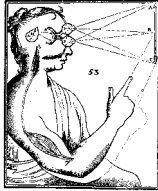
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### The Mechanist Tradition in the Scientific Revolution, 3

- René Descartes
  - Forces are occult



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### The Mechanist Tradition in the Scientific Revolution, 4

- Evangelista Toricelli and Blaise Pascal
  - Atmospheric pressure and the barometer
  - The Puy de Dôme experiment, carrying a barometer up the mountain and noting the fall in atmospheric pressure—the sea of air.
- Robert Boyle
  - Measurement in chemistry
  - Boyle's law,  $PV=K$

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### The Mechanist Tradition in the Scientific Revolution, 5

- The Royal Society of London for Improving Natural Knowledge
  - Founded in 1662
  - Patron, Charles II
  - Founded on Baconian precepts (build knowledge from observation), members became later committed to the mechanist viewpoint.



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## The Genius of Isaac Newton

- Newton combined the mechanist and the magical viewpoints.



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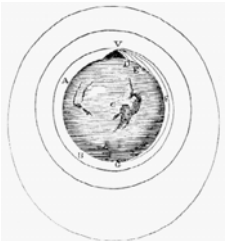
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## The clockwork universe—that needed winding up and resetting

- The world operates as a vast machine – the “clockwork universe.”
  - God (a supernatural and definitely *not* mechanical force) made things work when the mechanism failed.
  - The Universe is a riddle.
  - Gravity is *action at a distance*.



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## At the end of the Scientific Revolution

- Mechanism triumphs.
- The Organic viewpoint is in disrepute.
- The incompatibility of the Magical and the Mechanist views are forgotten or ignored.
- Mathematics is accepted as the language of science.
- The mechanical model is accepted as the ultimate explanation.

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