Metaphors and Historical Conceptions of the Brain

"The brain, the masterpiece of creation, is almost unknown to us." -- Nicolaus Steno, 1669

Philosophy of Neuroscience

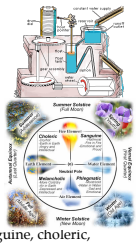
- The neurosciences, resulting from the integration of the brain sciences (neuroanatomy, neurophysiology, genetics, etc.) beginning in the 1960s, study aspects of brains and nervous systems
- Philosophy *of* neuroscience studies the neurosciences and the scientists working in them
  - What counts as an explanation?
  - What sorts of evidence is possible about the brain?
  - What role do representations play in neural explanations?
  - How can conscious phenomena be linked to the brain?

The Human Brain: 3 Pounds of What?

- What does the brain do?
- What are its parts?
- What do they do?
- How are these parts organized?

- To study the brain scientists need tools
- But equally, they need ideas in terms of which they can describe what they discover
  - In developing ideas for new domains we typically draw on domains we already know
    - Metaphors are a means to achieve this

Hydraulic Metaphors of the Body



- Grounded in the water technology of the Greeks
  - Water clock
- Applications to physiology
  - Hippocrates--four humors: black bile yellow bile, phlegm, and blood
  - Must be kept in balance
    - Otherwise, disease results
- Galen
  - linked humors to temperaments: sanguine, choleric, melancholic, phlegmatic
  - Nerves: conveyed animal spirits (fine fluid) between tissues dominated by the humors

Descartes

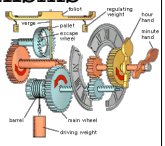
- Descartes advocated a mechanical account of the physical universe and living organisms
  - Only the human mind was excluded as being of a very different substance
- Nervous system transported animal spirits to and from the brain, which modulated their movement
- Many phenomena we take to be mental were physical for Descartes, regulated by the flow of fluids through the nerves:
  - ... the reception of light, sounds, odors, tastes, warmth, and other like qualities into the exterior organs of sensation; the impression of the corresponding ideas upon a common sensorium and on the imagination; the retention or imprint of these ideas in the Memory; the internal movements of the Appetites and Passions; and finally, the external motions of all the members of the body ... I wish that you would consider all of these as following altogether naturally in this Machine from the disposition of its organs alone, neither more nor less than do the movements of a clock or other automaton from that of its counterweight and wheels ....

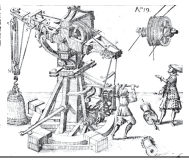
Freud

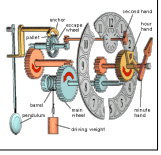
- Initially set out to develop a neural account of mental function, but found it failed to help him understand the conditions of his psychiatric patients
- Psychodynamic accounts of the struggles within the unconscious mind
  - Mind contains desires, some of which are unacceptable
    - These may be repressed, but, like steam pressure, can only be held down so long without exploding
      - must be re-channeled into safe areas

Clocks and Other Early Modern Mechanisms

- Weight driven clocks were developed in the 13th century
- Pendulum clocks appeared in the 17th century
- Practical machines for lifting weights 14th and 17th century

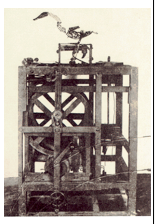


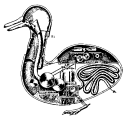




Mechanical Life

- Jacques de Vaucanson's (1739) mechanical duck, created as an entertainment piece
- Although biological organisms are not composed out of metal parts, the idea that they are machines captivated many biologists
  - Crucial idea that diverse parts, each performing its own operation, work together to achieve the activities of living organisms
  - Example: cells viewed as factories with different organelles performing different tasks

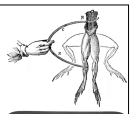


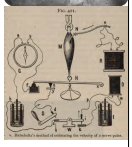


Applying the Mechanical Metaphor to Thought

- Hobbes: ideas and associations result from minute mechanical motions in the head
- La Mettrie in *L'Homme machine* (1748): went beyond Descartes to treat the whole human (mind as well as body) as a machine
  - human body is "a machine that winds its own springs - the living image of perpetual motion ... man is an assemblage of springs that are activated reciprocally by one another."

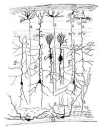
Electricity and Animal Electricity

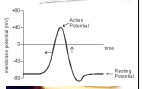




- Electricity at first a curiosity--static electricity generators to shock people
- The ability of electricity to cause muscle contraction played an important role in Galvani's and Volta's pioneering research on electricity in the 1790s
- Researchers such as du Bois Reymond developed the galvanometer to measure electric currents in animals--frogs and humans
- Helmholtz: measured the speed of electrical transmission
- Nerve electricity linked with chemical processes involved in the generation of action potentials at the beginning of 20th century

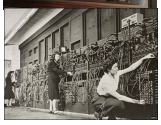
Telegraph and Telephone Metaphors





- The first microscopic images of neurons emphasized their axons and dendrites
  - Helmholtz developed the telegraph metaphor
- Hodgkin and Huxley borrowed the mathematics developed for signal propagation in wires to model the generation of action potentials
- Telephone switchboard model of brain activity gained currency in the 20th centuury

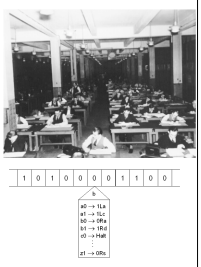
The Computer Metaphor



- In the 19th century Charles Babbage designed the difference engine to tabulate polynomial functions (only actually built in the 20th century)
- World War II provided incentives to perform complex calculations quickly, leading to the creation of ENIAC (commissioned in 1946)
  - Soon after von Neumann and others developed computers that employed stored programs

Human Computers

- The model that Turing employed in developing the idea of computation was the human activity of calculation
- The Turing Machine metaphorically extended the idea of applying rules to symbols on paper to a machine
  - Finite state device reads, applies rules, and writes numbers on a tape
  - The surprising result is that such a device can compute any computable function



Applying the Computer Model to the Brain

- Boole articulated the idea that thought consists of the application of rules to symbols
  - With the advent of computers in the 1950s, the idea that computers could think became very attractive
- Artificial intelligence developed as a field
  - Newell and Simon's Logic Theorist served as an exemplar
  - Winning the world chess championship became the holy grail.
- While especially prominent in cognitive science, the idea that the brain computes became attractive to parts of neuroscience
  - The idea of a central processor manipulating symbols seems problematic
    - Rather, theorists often view individual brain areas as computing functions

Neural Network Models

- Pitts and McCulloch (1943) proposed that neural networks could implemented logic functions
- They and others soon came to focus on combining information in ways not dependent on logic
  - Rosenblatt's perceptron--connections between inputs and outputs enable generation of output function
    - These connections can be "learned"