A Transitional Model of Brain Function in the long 18th Century:
In between the geography of medieval cell doctrine and the geography of modern neuroscience.
Pierre Gassendi (1592-1655)
Thomas Willis (1621-1675)
Newton, Isaac (1642-1727)
contra: hydraulics (Descartes)

- Gassendi contributed conceptual idea of movement, explosions in nerves
- Willis contributed anatomical and physiological evidence
- Newton related the electrical or vibration model of nerve transmission to physics of sound and light
Pierre Gassendi
Pierre Gassendi (1592–1655)

In the decade before his death, Gassendi compiled all of his learning into a lengthy Latin treatise, the *Syntagma Philosophicum*, published in 1658. This book was abridged by Francois Bernier into a more readable French version, the *Abrégé de la philosophie de Gassendi* (Bernier, 1684).
(Gassendi) I know that most people attribute [muscular contraction and tonic movements] to spirits that come from the brain, which are transmitted with such impetuousness, and in such great abundance, that they inflate the nerves and the fibers like a kind of wind, or impetuous blowing, and by the disposition of the machine, compel the muscle to tense itself, and the tendon to retract itself, such that the movement will follow.
But it is much more probable that the tendon, as I have said, should be able by itself to execute the commanded movements, and that the spirits which come from the brain are destined only to signify the commandment to the muscle, so that having been excited thereby, and alerted, the muscle should act by the natural force which it has. (Gassendi)
Thomas Willis
- Correlated anatomy and physiology with clinical findings and neuropathology by relating altered behavior to abnormalities in the brain
- Considered a great neuroanatomist; sometimes called “father of neurology”;
- Rejected ventricular theory in favor of brain substance but continued humoral doctrine
• Proposed that higher cognitive functions derive from convolutions of cerebral cortex
• Idea of nerve impulses derived from Gassendi
• Idea of nerve impulses influenced Newton
• Noted humans have a larger cerebral cortex than animals. (systematically explored comparative anatomy)
  • This accounts for their cognitive difference
  • Gyri and sulci related to superior intellect

• Extends ideas of Cerebral Anatomy
  • Corpus striatum received all sensory information
  • Corpus callosum was associated with imagination and the cerebral cortex with memory.
(I. Newton.)

And now we might add something concerning a certain most subtle Spirit which pervades and lies hid in all gross bodies; by the force and action of which Spirit the particles of bodies mutually attract one another at near distances, and cohere, if contiguous; and electric bodies operate to greater distances, as well repelling as attracting the neighbouring corpuscles; and light is emitted, reflected, refracted, inflected, and heats bodies; and all sensation is excited, and the members of animal bodies move at the command of the will, namely by the vibrations of this Spirit, mutually propagated along the solid filaments of the nerves, from the outward organs of sense to the brain, and from the brain into the muscles. But these are things that cannot be explained in few words, nor are we furnished with that sufficiency of experiments which is required to do an accurate determination and demonstration of the laws by which this electric and elastic Spirit operates. (Principia, p. 443)
Willis, Steno, Unzer, Prochaska, Swedenborg → structural models
Emanuel Swedenborg

1938 Swedish stamp (Scott, A48)
Human Body

Major Physiological Discoveries

- Attributed psychic functions, like consciousness, perception, sensation, and thought, to the gray matter on the surface of the brain, the cerebral cortex.
- Showed the relation of the parts of the brain controlling the muscles of the various parts of the body.
- Said that the gray matter in the center of the brain controlled many of the complicated, but unthinking acts performed by the body.
- Was the first to show that the surface of the brain is connected through nerve fibers with every part of the body.
- He attributed the primary function of nervous control to little oval particles in the gray matter of the brain.
Cerebral Cortex Observations

- Emanuel Swedenborg was able to use the available scientific literature, autopsies, and observations pertaining to research with animals to arrive at his own conclusions regarding the brain.
- For his part, Emanuel was very successful. He identified the brain's two glands, naming the pineal gland the epyphysis while identifying the pituitary gland as the hypophysis.
- Basing his inspections off the work of Herman Boerhaave, Swedenborg was able to postulate about the true purpose of the cerebral cortex. (gray matter)
- By studying the work on brain lesions conducted by Antonio Pacchionis, Swedenborg was able to deduce that injuries to the cerebral cortex paralyzed the muscles.
- Swedenborg understood that outside pressure on the cerebral cortex was significant. He reasoned that this pressure resulted in decreased blood flow through the cerebral cortex. This loss of blood circulation accounted for the loss of feeling and movement in the effected body area.
• After reading the work of Leeuwenhoek and Malpighi, Swedenborg asserted that there was a connection between cerebral cortex and the white matter. Swedenborg said:
  – “These effects could never have been born ... if there was not a connection and perceptual communication between the white substance and the fibrils.”
  – “If we study the cerebral cortex under a microscope, it is clear that the nerve fibers come forth from it like streams from a fountain. This is confirmed also by the observation that diseases that attack the brain when the brain has been injured... that these injuries can be spread through the fibers that lead from the cerebral cortex to the muscles and that damage arises in the muscle movements thereby.”
Cortex III

- Swedenborg advocated for the belief that the cerebral cortex had higher and lower functions, controlled by different regions. Some areas received sensory information while other areas delivered motor impulses.
- Swedenborg used Thomas Willis’s illustration of the brain to locate the prominent brain fissures. He placed much importance on the corpus striatum, indicating it was very important to localization theory.
- Brain localization was not an entirely new idea at the time. What was new was Swedenborg’s localization of everything to the cerebral cortex.
- Swedenborg indicated the frontal lobe as being the most important when he said “It is from the frontal lobes that all the fibers go to the bodies kingdom. All perceptual affects the forward parts of the brain and conscious movements begin in this region”
Gassendi, Newton, Hartley, Bonnet → functional models
(Hartley) These vibrations are Motions backwards and forwards of the small Particles; of the same kind with the Oscillations of Pendulums; and the Tremblings of the Particles of sounding Bodies. They must be conceived to be exceedingly short and small, so as not to have the least Efficacy to disturb or move the whole Bodies of the Nerves or Brain. For that Nerves themselves should vibrate like musical Strings is highly absurd; nor was it ever asserted by Sir Isaac Newton, or any of those who have embraced his Notion of the Performance of Sensation and Motion, by means of Vibrations.
Any sensations $A$, $B$, $C$, &c. by being associated with one another a sufficient Number of Times, get such a Power over the corresponding Ideas $a$, $b$, $c$, &c. that any one of the Sensations $A$, when impressed alone, shall be able to excite in the Mind $b$, $c$, &c. the Ideas of the rest (p. 65) Thus the Sight of Part of a large Building suggests the Idea of the rest instantaneously; and the Sound of the Words which begin a familiar Sentence, brings the remaining Part to our Memories in Order, the Association of the Parts being synchronous in the first Case, and successive in the last. (p. 66)
Hartley (reminiscent of Gassendi’s ideas)
The Impulse, Attraction, or whatever else be the Action of the Object, affects both the Nerves and the Æther; .... And the Result of these Actions, upon the Whole, may be supposed such a Compression or Increase of Density in the Æther, as must agitate its Particles with Vibrations analogous to those which are excited in the Air by the Discharge of Guns, by Thunder-claps, or by any other Method of causing a sudden and violent Compression in it. (p. 21)
Neural Coding; internal representation no longer has to look like the object

Secondly, We are to conceive, that the Vibrations thus excited in the Æther will agitate the small Particles of the medullary Substance of the sensory Nerves with synchronous Vibrations, in the same manner as the Vibrations of the Air in Sounds agitate many regular Bodies with corresponding Vibrations or Tremblings. (Observations, pp. 21-22)
Vibratiuncles

PROP. 9.
Sensory Vibrations, by being often repeated, beget in the medullary Substance of the Brain, a Disposition to diminutive Vibrations, which may also be called Vibratiuncles and Miniatures, corresponding to themselves respectively.

This Correspondence of the diminutive Vibrations to the original sensory ones, consists in this, that they agree in Kind, Place, and Line of Direction; and differ only in being more feeble, i.e. in Degree.
Charles Bonnet, by Jens Juel (1777)
• Intellectual influences on Bonnet incl.: Isaac Newton, John Locke, Wilhelm von Leibniz, Pierre Gassendi, Thomas Willis, Anton Leeuwenhoek

• Bonnet’s contributions to psychology can be found in his *Essai de Psychology* (1754) and his *Essai analytique sur les facultés de l’âme* (1760).
«Although we don't know what the nature of an idea is as manifested in the soul, because we are absolutely unaware of the actual nature of the soul itself, we do know how the soul works because we know that objects imprint on the Brain certain ideas that cause movements. These movements are thus a sort of natural sign of ideas that they have excited; if a special Intelligence could observe these movements in the Brain it could read them as in a book».

Charles Bonnet,
Essai de Psychologie, 1754
(author’s translation)
“I will try to offer a few principles based on experience: I will draw from these principles only the most direct consequences. I wish this little piece of work would have been a *Geometric* and *Experimental Psychology*.

Charles Bonnet,
Essai analytique sur les facultés de l’âme, 1760
(author’s translation)

*Geometric, i.e., mathematical, methodological*
• According to Bonnet, the psychological life rests on nerves fibers, which are the substrate for sensation, association of ideas and habits. To understand brain mechanisms is to understand cognitive functioning.
• Bonnet argued that nerves are solid
• Sensory experience caused “movements” in the nerves
• These movements were called “impressions” or “vibrations”
• They reach the brain to cause sensations
• Impressions/vibrations induce a structural change in the nerves
• The biological basis of memory is found in a collection of nerve fibers; a single fiber is analogous to a cell or a unit; each fiber has a primitive, molecular structure; these parts determine its type or role and they are specific to each sense, specific to each activity (Law of Specific Nerve Energies) (Bonnet’s metaphors: branches of a tree; different colors in a sunbeam)
• There is a network of fibers for memory; the fibers communicate with each other via vibrations or ‘shaking’ (ébranler); points of connection called nodes (noeuds) where “features are in common”

• Each collection of fibers is (structurally) different for different ideas
• Preservation of a memory is a molecular or structural change; it is a code, not a virtual image; memory, recall and recognition are change-of-state of nerve fibres

• Vibrations (“shaking”) change the molecular structure of fibers
• Novelty is more salient than that which is familiar; saliency increase intensity

• Memory loss (as in aging) is a structural rearrangement or deterioration of the original (learned/acquired) structure of the nerve fiber bundles

• Pres du fin
Psychology as a Science

- Bonnet understood that psychology was an empirical science, not a subtype of rational philosophy or metaphysics.

- Although he never performed an “experimental study” per se, he believed that psychology could be an experimental science. He believed that thought processes could be expressed mathematically.

- Bonnet was among the firsts to use the words “psychologie expérimentale”, “psycho-physique” and “psychometre”.

Bonnet’s influence

- Bonnet formulated hypotheses, used a vocabulary, made assertions, asked for evidence, and answered questions that are at the basis of modern systems of cognitive psychology.

- Bonnet’s ideas spread in Europe, mainly in France and Germany
  - Bonnet’s theory of fibers and physiological psychology opened the way to German “Fibernpsychologie”.
  - Bonnet’s anticipated much of Wilhelm Wundt’s physiological psychology.

- Bonnet was the first to observed a case of conscious hallucination in the elderly, know as the « Charles Bonnet syndrome ». 