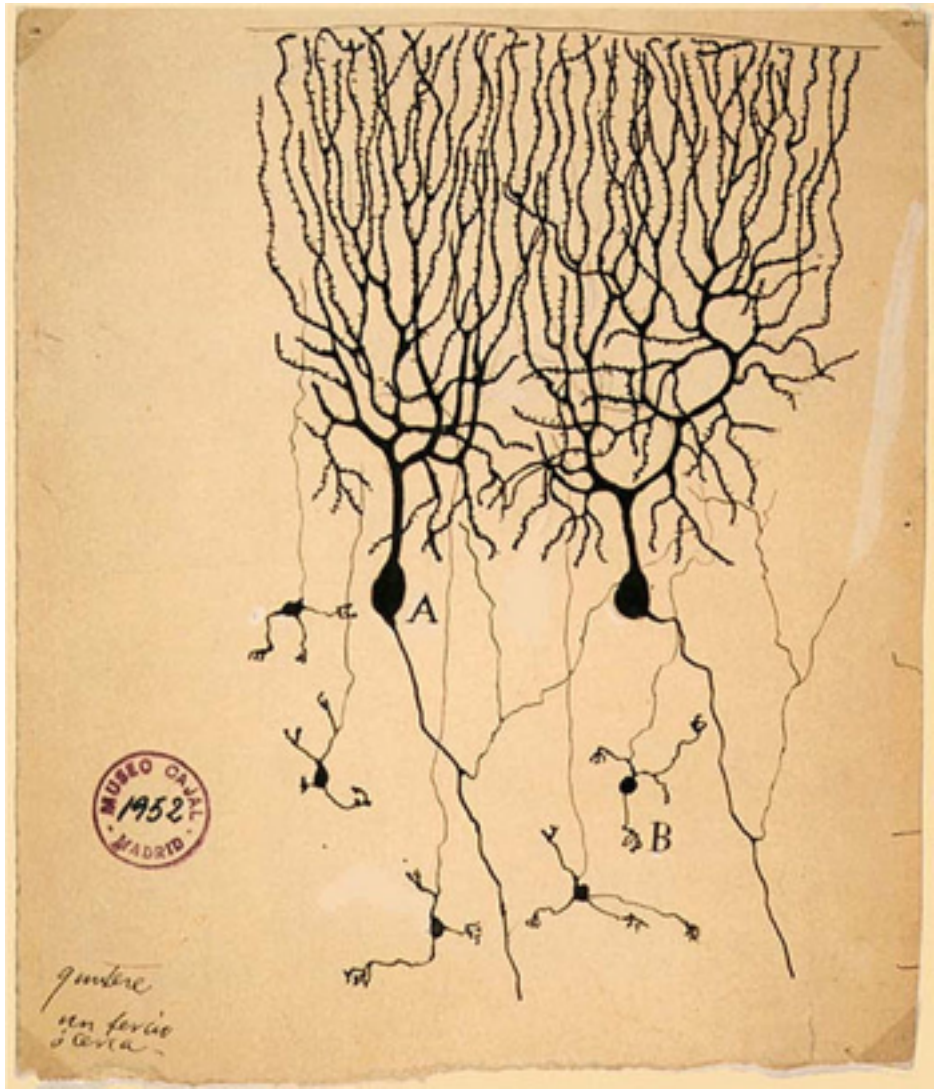
Welcome to Biology 130 Introduction to Neuroscience

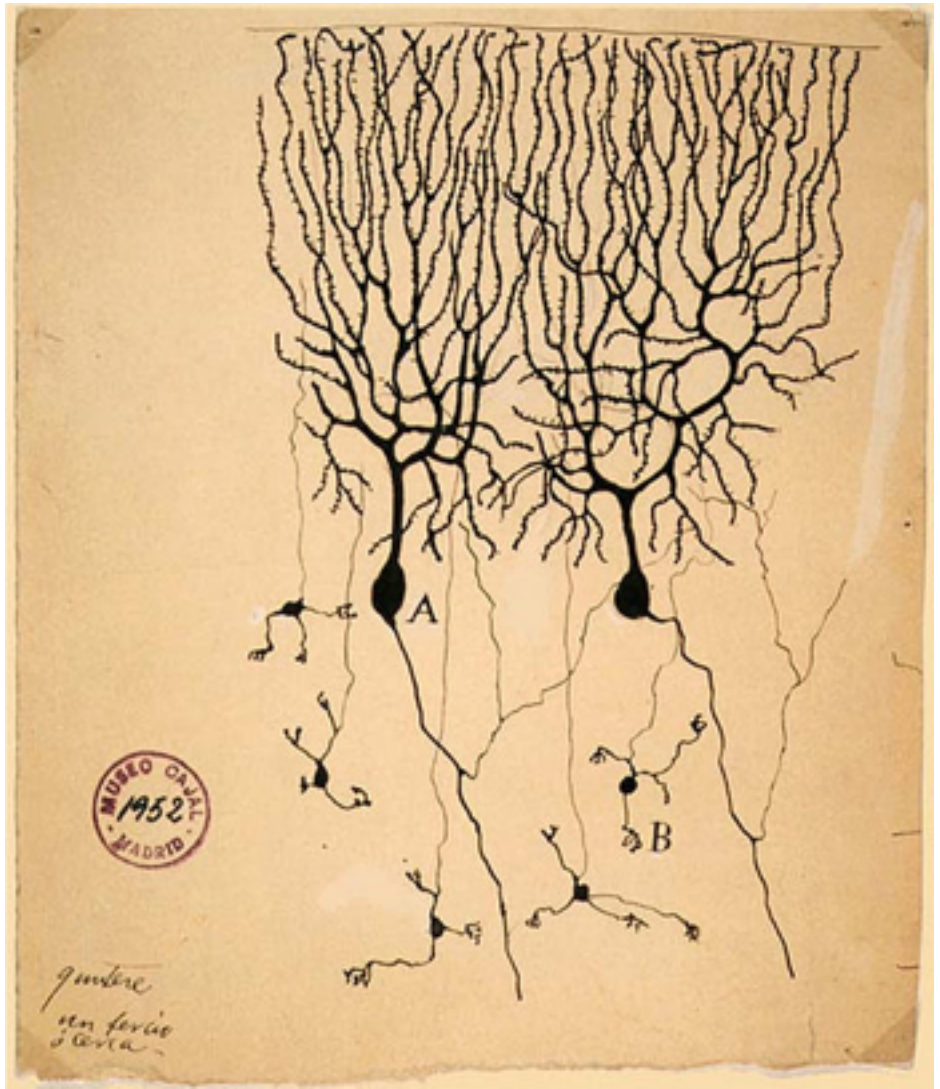


Today:
Course organization
Motivation and philosophy
A bit about your instructors
The history of neuroscience

Tom Daniel, Biology, Program in Neuroscience
Bill Moody, Biology, Program in Neuroscience
Eric Pederson, Bioengineering, BPSD

Course organization

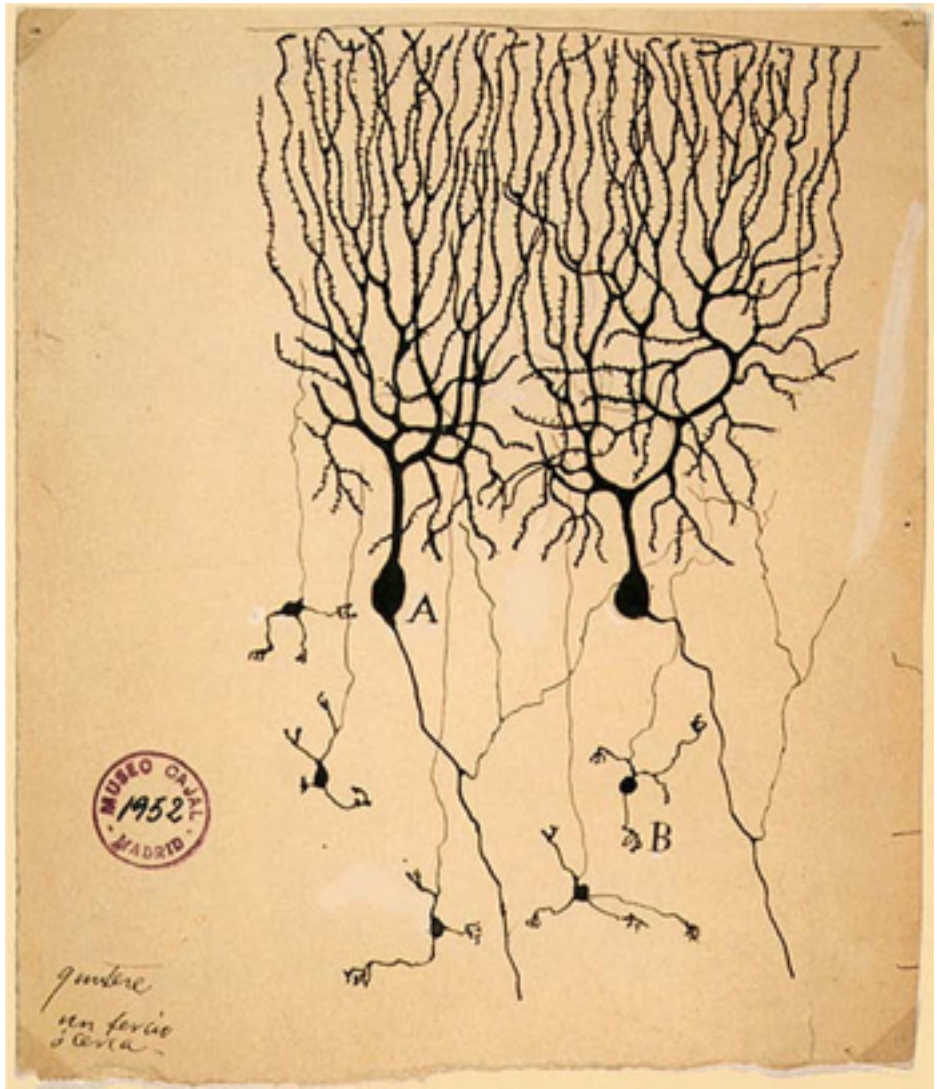
http://faculty.washington.edu/danielt/Neuro-site/



No sections meet this week

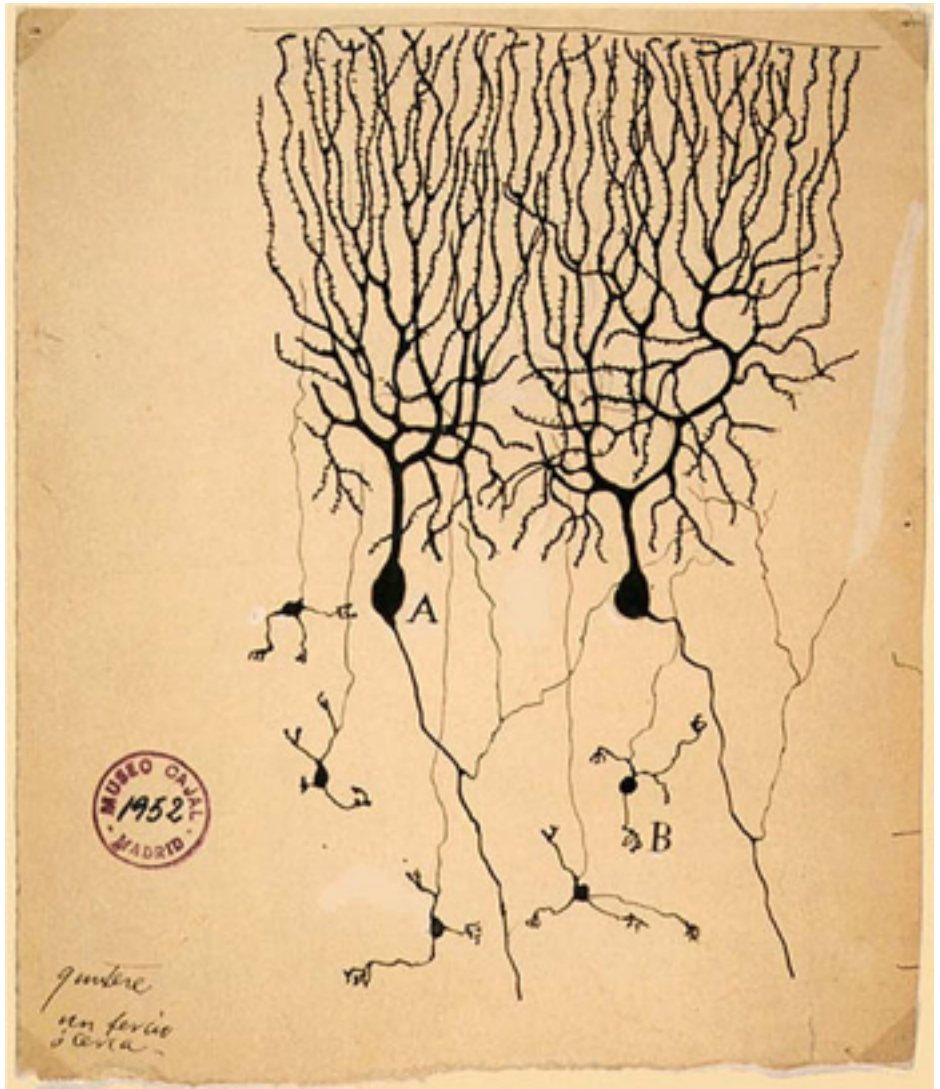
- 2 lectures/week with
  - 2 polling questions each lecture
- 1 discussion section/ week with
  - Pre and post-assignments
- A final poster project at the end
- No exams…..

Motivation



- All living systems acquire, process, store and transmit information.
- Neural systems do so with amazing speed, diversity, precision.
- Understand the underlying processes.
- How does the brain compute?
- Be able to critically evaluate evidence on emergent topics relevant to society
- Be able to communicate science to a more general audience.

Motivation



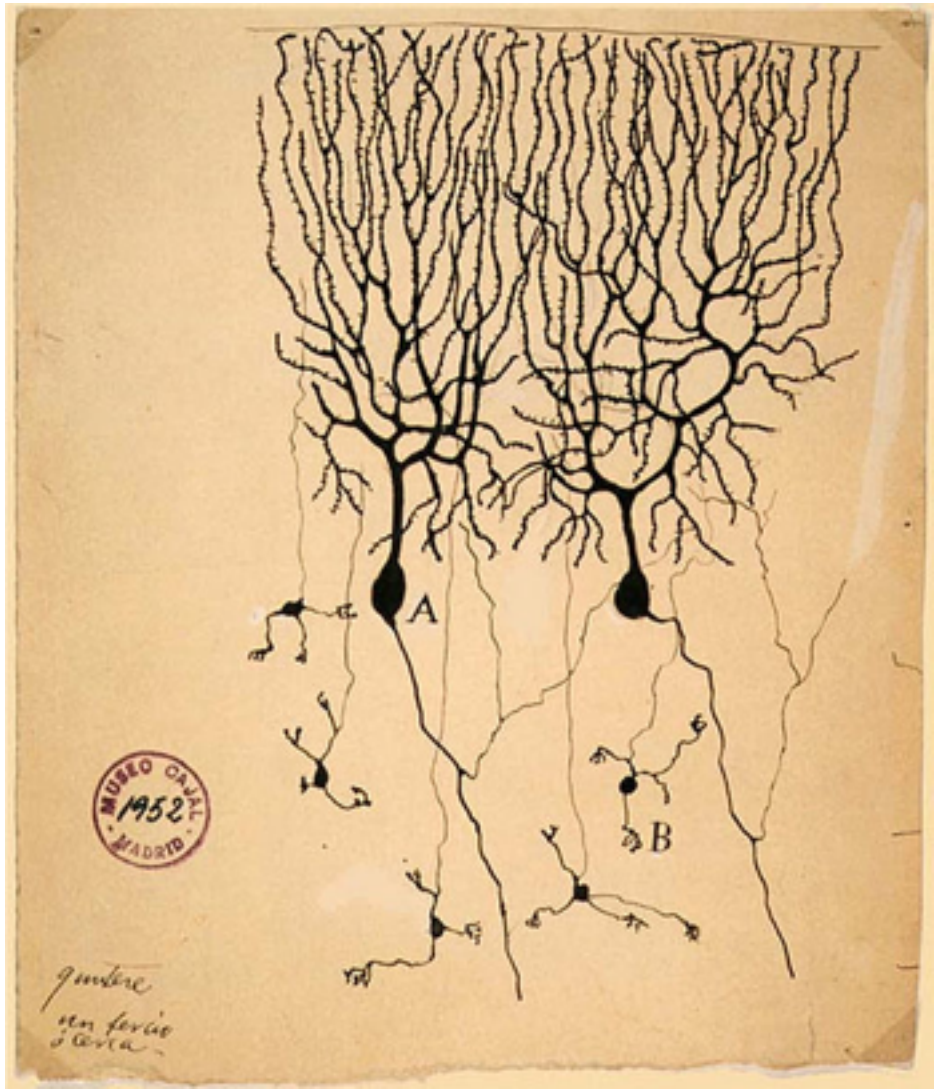
".. if we want to make the best products, we also have to invest in the best ideas... Today, our scientists are mapping the human brain to unlock the answers to Alzheimer's... Now is the time to reach a level of research and development not seen since the height of the Space Race. We need to make those investments." (President Barack Obama, 2013 State of the Union Speech).

About 200 faculty in solution at the UW

In the College of Arts and Sciences, The School of Medicine, The College of Engineering

Motivation

http://pollev.com/biol130



What is your motivation?

A. General interest/curiosity
B. The course was open
C. Need principles of neuroscience for my future
D. Natural world distribution credit
E. All of the above
F. None of the above

Scope

Affective Neuroscience
Behavioral Neuroscience
Cellular Neuroscience
Clinical Neuroscience
Cognitive Neuroscience
Computational Neuroscience
Developmental Neuroscience
Evolutionary Neuroscience
Molecular Neuroscience
Neurolinguistics
Neuroengineering
Neuroethology

Neuroimagining
Neurophysiology
Systems Neuroscience
Cultural Neuorscience
Neuroinformatics
Neuroeconomics
Neuroendocrinology

Scope

Atoms

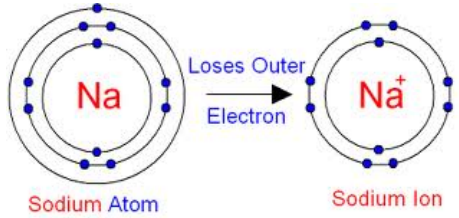
Molecules

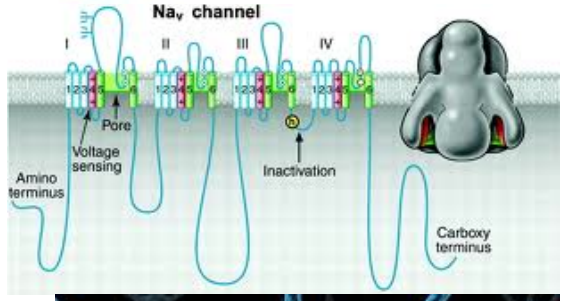
Cells

Organs

Organisms

Societies





Scope

300 neurons

100,000 neurons

1 million neurons

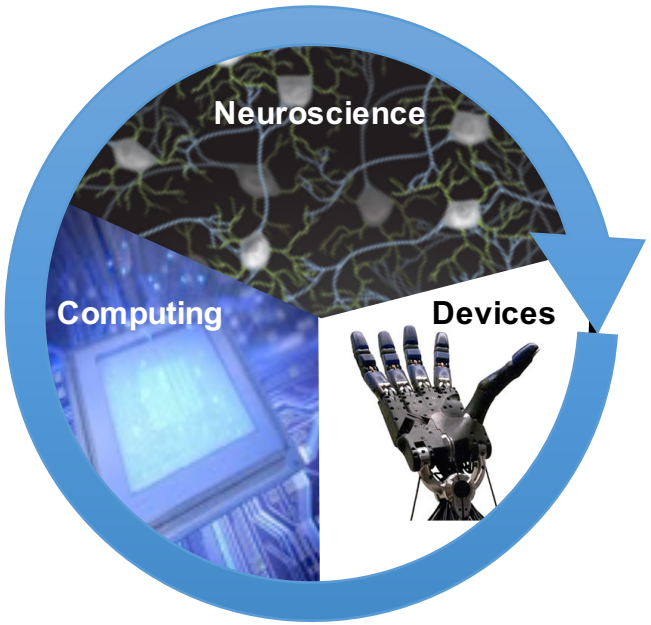
10 million neurons

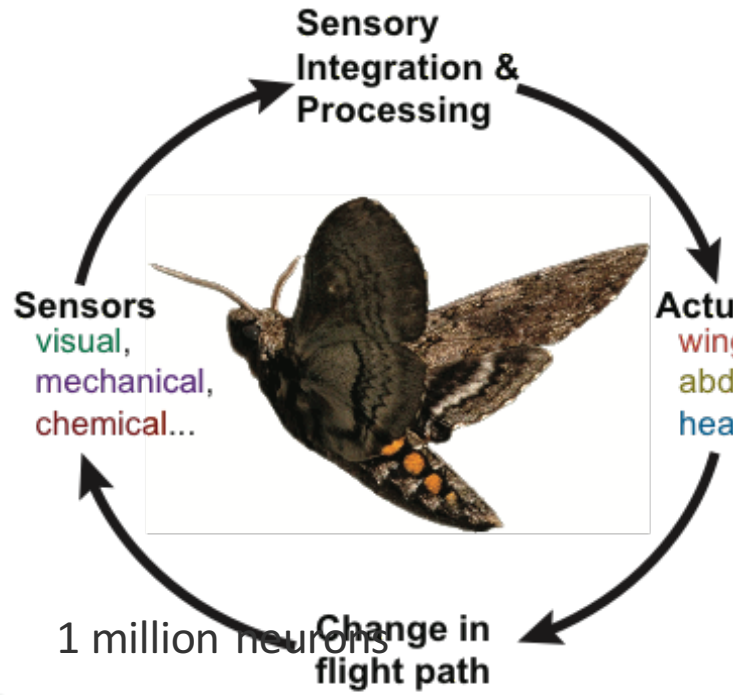
100 billion neurons

Scope

300 neurons

100,000 neurons



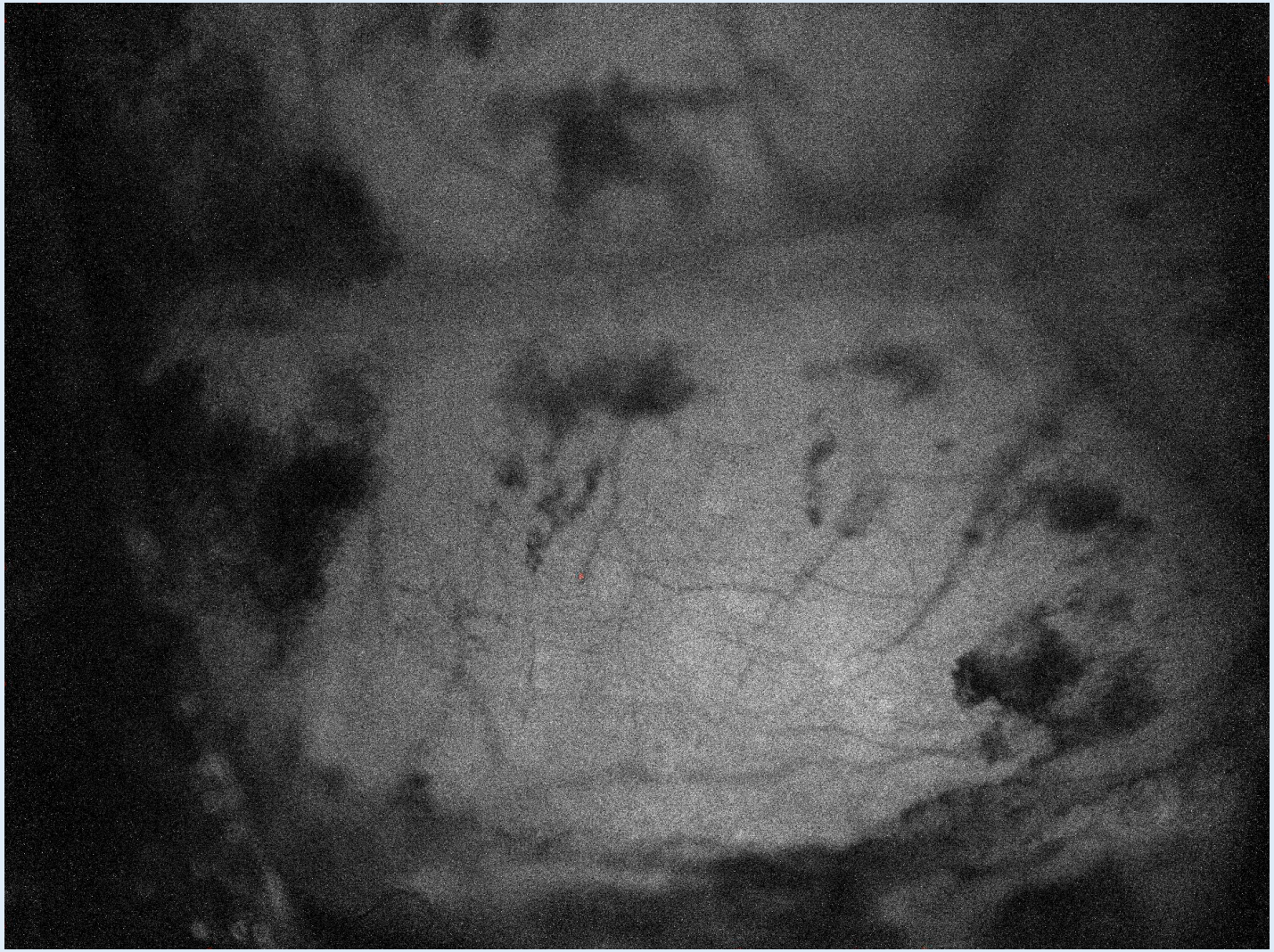


1 million neurons

10 million neurons

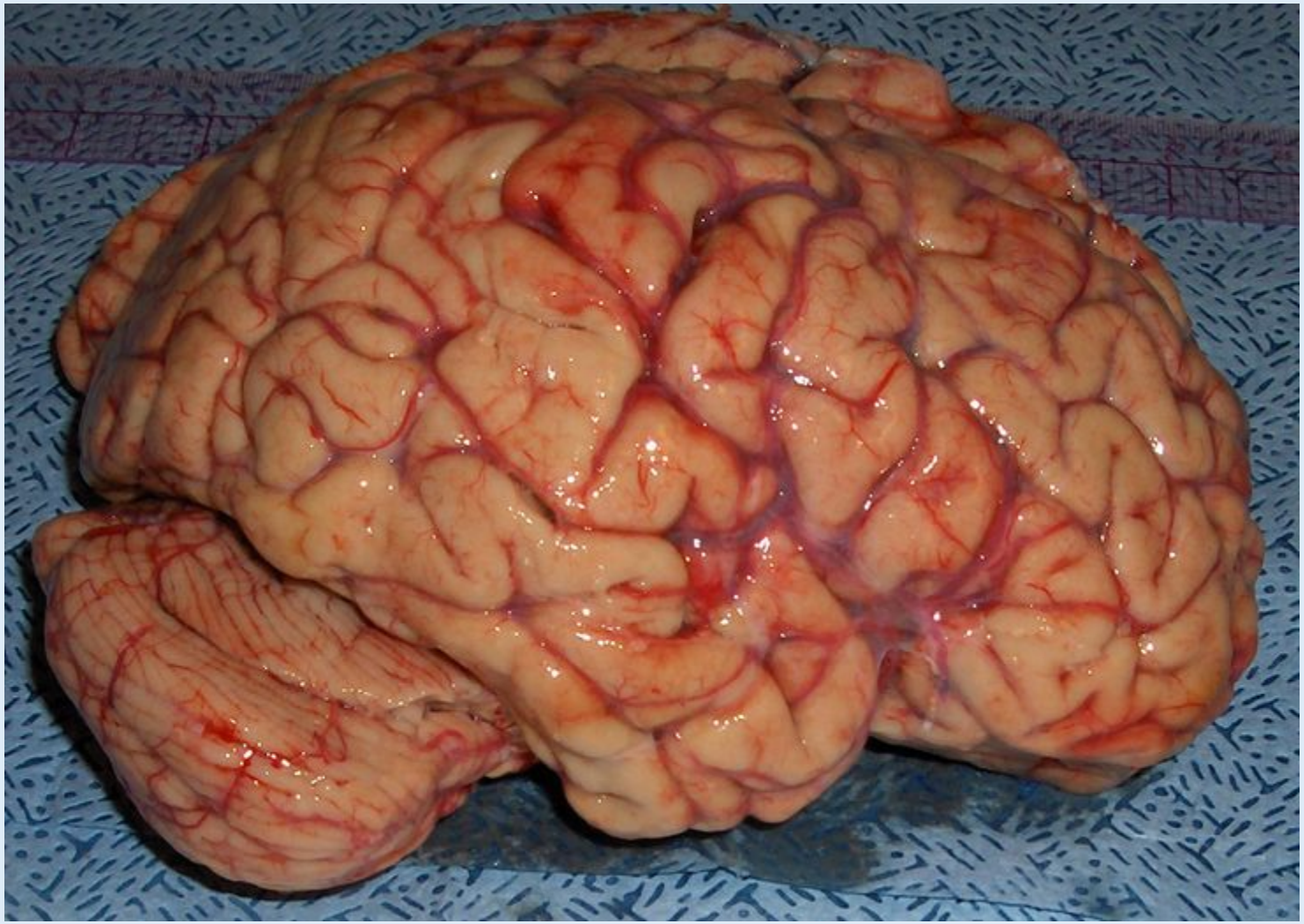
100 billion neurons

In vivo through-skull imaging of sensory responses



Ai93-Cux2-CRE-CAMK2tet mouse
GCaMP6f targeted to superficial layers
P6

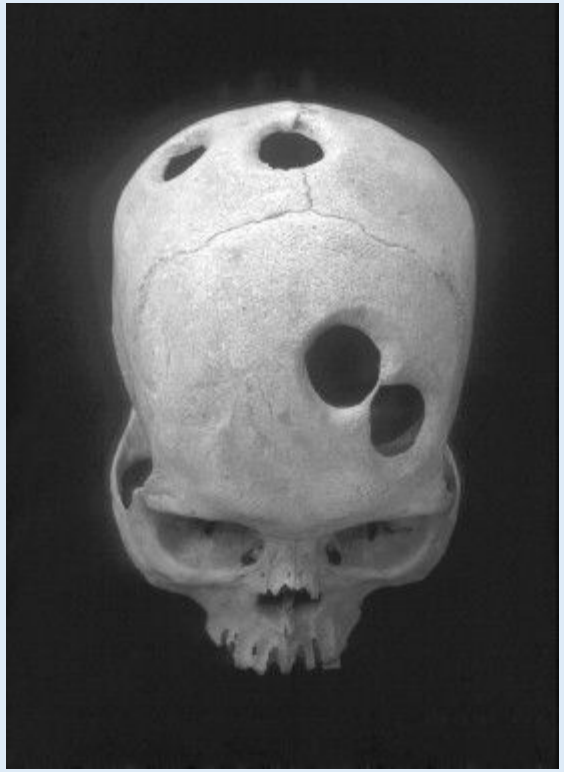
A Brief and Selective History of Neuroscience …



… concentrating on these concepts

1. The brain and nervous system control behavior.
2. Different functions are regionalized in the brain.
3. Information processing in the nervous system occurs by electrical signals.
4. The nervous system is composed of separate cells (neurons).
5. Neurons communicate at synapses using chemical neurotransmitters.

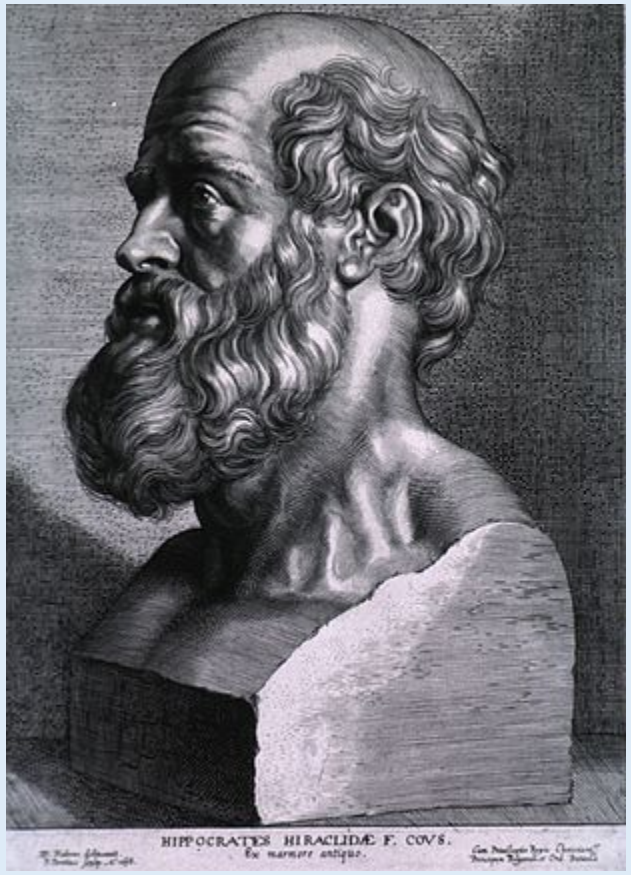
Trephination: Drilling holes in the skull



Used as far back as Neolithic era to treat seizures, mental disturbances, migraine, and head injury.

Ancient skulls show bone healing (figure) indicating substantial post-surgery survival times.

Hippocrates and Epilepsy



Hippocrates (5th century BCE) argued against the idea that epilepsy was possession by the gods.

He argued it was a medically treatable problem originating in the brain.

He rejected the term “sacred disease” and used “great disease”, giving rise to the term “grand mal”.

"I am about to discuss the disease called 'sacred.' It is not, in my opinion, any more divine or more sacred than other diseases, but has a natural cause, and its supposed divine origin is due to men's inexperience and to their wonder at its peculiar character."

Luigi Galvani and Animal Electricity

Galvani, ca 1780

Noted that frog muscle twitched when touched with a scalpel that carried static electricity.

Coined the term ‘Animal Electricity’ to describe his theory that muscle movement was caused by electrical energy in body fluids.

Mary Shelley read Galvani’s research in the summer before she wrote “Frankenstein”. The idea that electricity could reanimate dead tissue appeared in the novel.

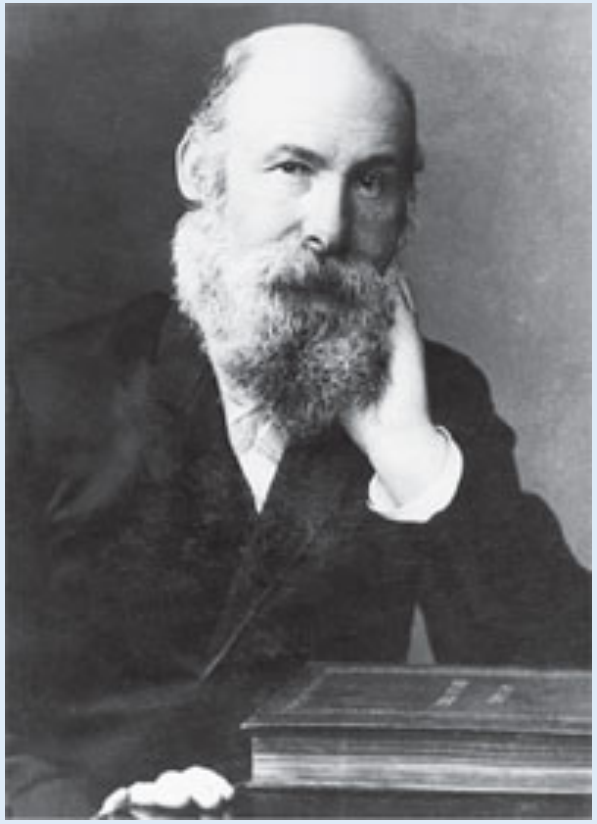
Emile du Bois-Reymond

1841

Measured a change in voltage during the action potential.

'If I do not greatly deceive myself, I have succeeded in realizing..the hundred years' dream of physicists and physiologists, to wit, the identity of the nervous principle with electricity.'

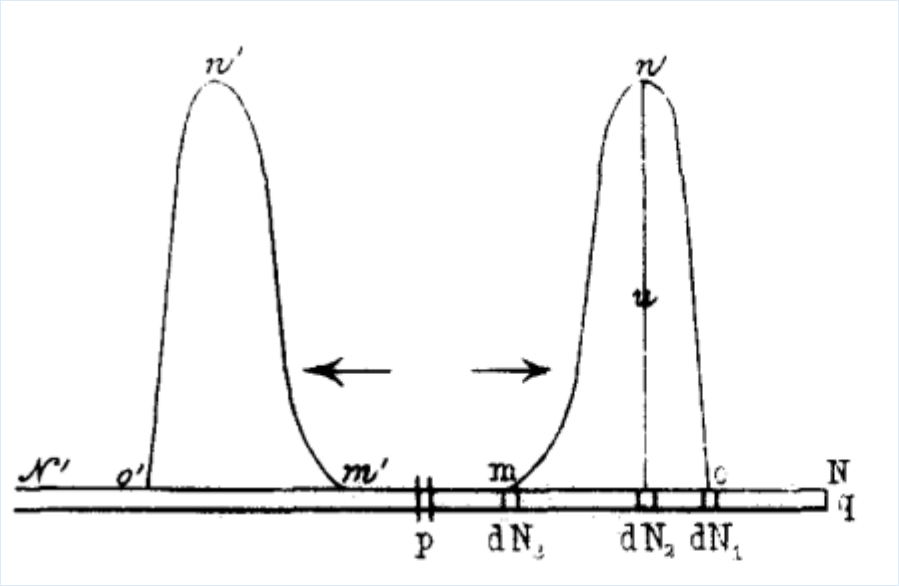
Julius Bernstein (student of Bois-Reymond)



1868

Figured out how to measure a fast event (action potential) using a slow device (galvanometer).

Made first record of an action potential:



Hermann von Helmholtz

1848

Coined the term ‘psychophysics’.

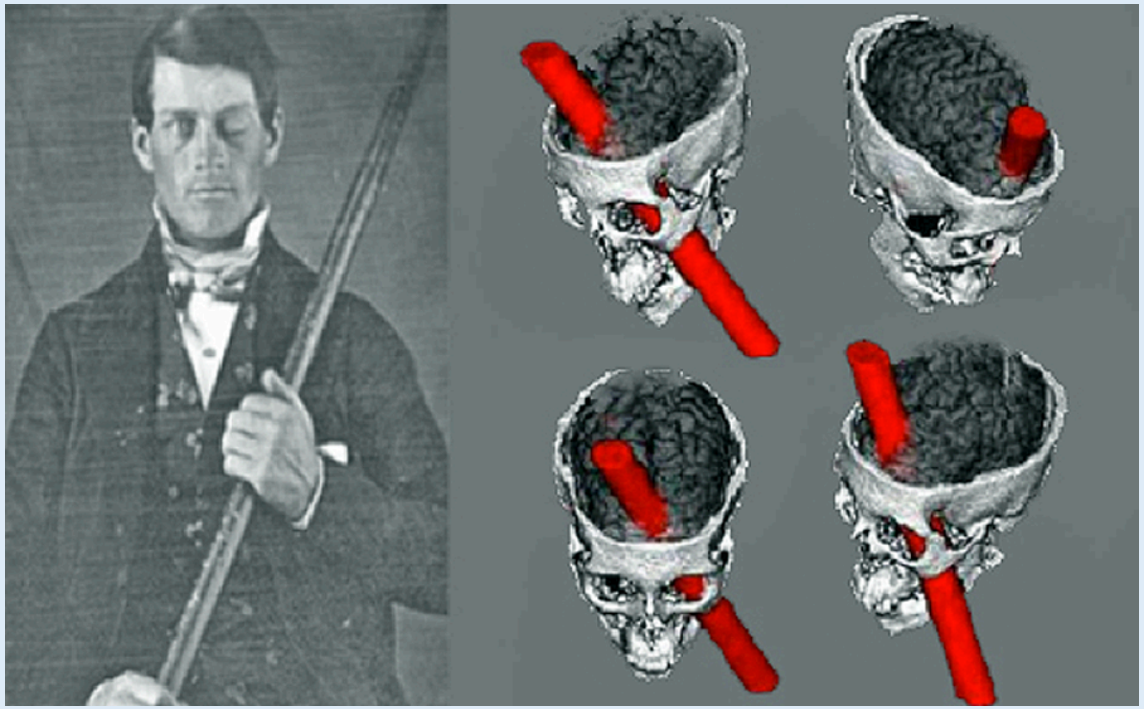
Measured relation between physical reality of a sensory stimulus and a person’s perception of that stimulus.

Developed theories of depth, motion, and color perception.

Used a galvanometer* to measure the propagation speed of the nerve impulse (action potential) to show that it was not the instantaneous spread of electricity as in a wire.

*Wonder where that name came from?

Symptoms of Brain Injury: Phineas Gage



Tamping a dynamite charge for blasting right of way for the Rutland and Burlington Railroad in Cavendish, Vermont.

Charge exploded and drove the tamping iron through Gage's head.
It came out the other side and landed 80 feet away.

1848


KABOOM!

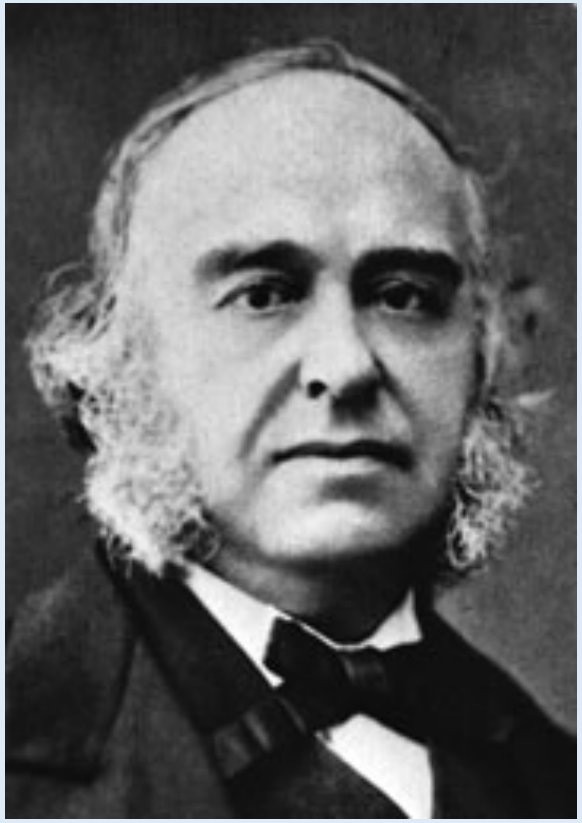
When I drove up he said, "Doctor, here is business enough for you." I first noticed the wound upon the head before I alighted from my carriage, the pulsations of the brain being very distinct. The top of the head appeared somewhat like an inverted funnel, as if some wedge-shaped body had passed from below upward. Mr. Gage, during the time I was examining this wound, was relating the manner in which he was injured to the bystanders. I did not believe Mr. Gage's statement at that time, but thought he was deceived. Mr. Gage persisted in saying that the bar went through his head. Mr. G. got up and vomited; the effort of vomiting pressed out about half a teacupful of the brain, which fell upon the floor.

After 2 weeks, Dr. Harlow: 'Cut off the fungi which were sprouting out from the top of the brain."

he was gross, profane, coarse, and vulgar, to such a degree that his society was intolerable to decent people

His friends said that "He was no longer Gage."

Paul Broca: Control of speech by the brain



1861

Examined a patient who had lost the ability to speak.

Localized the damage by autopsy (above).

This speech control area is now called Broca's Area.

The area damaged in Broca’s patient controlled

A. Walking
B. Speech
C. Vision
D. Hearing

Santiago Ramon y Cajal, Camillo Golgi, and the Neuron Doctrine

Santiago Ramon y Cajal

"The nerve cells are morphological entities, neurons. **We applied Golgi's method**, firstly in the cerebellum and then in the spinal cord, the cerebrum, the olfactory bulb, the optic lobe, the retina and so on of embryos and young animals, and our observations revealed, in my opinion, the terminal arrangement of the nerve fibres. "

Nobel Lecture, 1906

Santiago Ramon y Cajal, Camillo Golgi, and the Neuron Doctrine

Camillo Golgi

At this point, while I shall come back to this question later, I must declare that when the neuron theory made, by almost unanimous approval, its triumphant entrance on the scientific scene, I found myself unable to follow the current of opinion.

Nobel Lecture, 1906

Sir Charles Sherrington and the Synapse

Studied spinal reflexes.
Coined the terms ‘neuron’ and ‘synapse’.
Proposed two kinds of interactions between neurons:
Excitatory and Inhibitory
Showed that movement requires excitation of some muscles and inhibition of others.

“In view, therefore, of the probable importance physiologically of this mode of nexus between neurone and neurone it is convenient to have a term for it.
The term introduced has been synapse.”

The structure named by Sherrington at which neurons communicate with one another is called the

A. Brain
B. Axon
C. Synapse
D. Dendrite

Edgar Adrian (1st Baron Adrian)

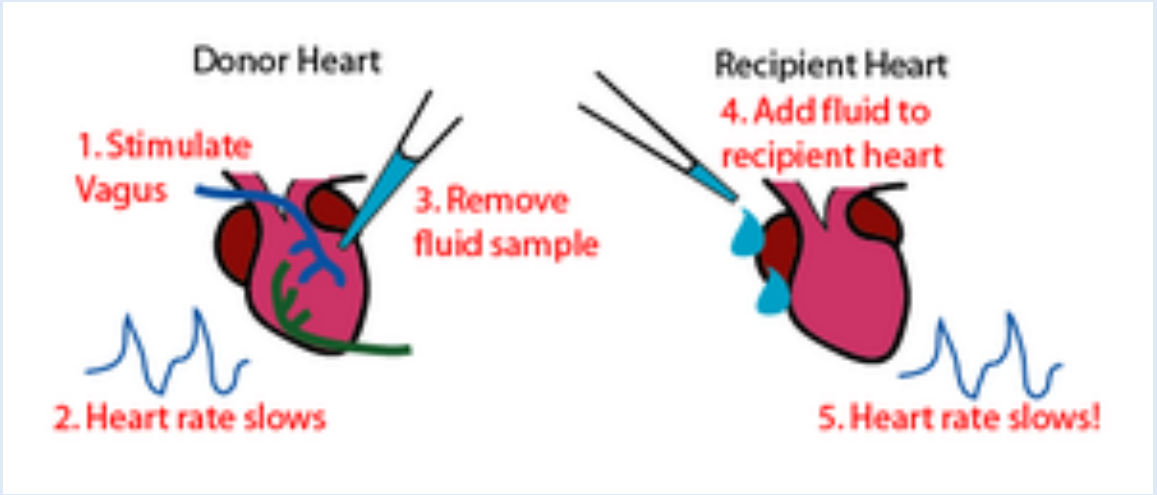
1928

Sensory information coded by frequency of action potentials, not by their amplitude.

"I had arranged electrodes on the optic nerve of a toad in connection with some experiments on the retina. The room was nearly dark and I was puzzled to hear repeated noises in the loudspeaker attached to the amplifier, noises indicating that a great deal of impulse activity was going on. It was not until I compared the noises with my own movements around the room that I realised I was in the field of vision of the toad's eye and that it was signalling what I was doing."

Otto Loewi and neurotransmitters

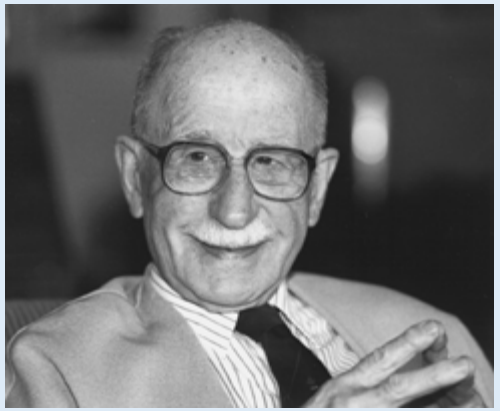
1921



Called the chemical ‘vagusstoffe’.
Now known as acetylcholine.

Designed the experiment in a dream.

Direct Brain Stimulation: Wilder Penfield and Herbert Jasper



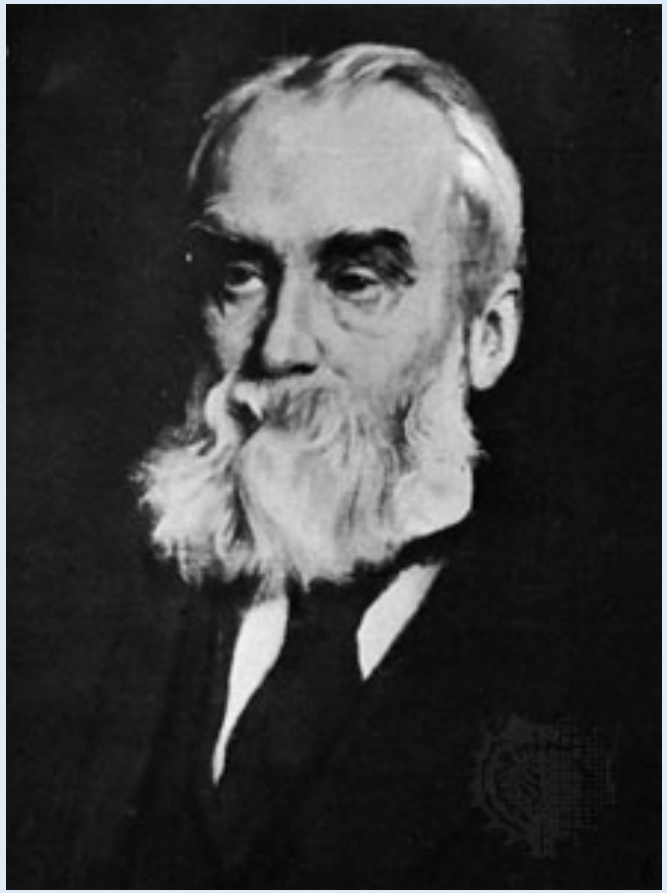
The first instance occurred in 1934 when a patient informed Penfield that she was re-living a earlier experience in her life during temporal lobe surgery.* She reported that "she saw herself as she had been while giving birth to her baby."

One of Penfield's patients heard a specifc music selection being performed by an orchestra "when a point on the superior surface of the right temporal lobe was stimulated after removal of the anterior half of the lobe." The sound was so clear that the patient believed that there was a phonograph in the operating room. As the same point was restimulated the music began at the same spot in time where it had previously begun.

Deduced the 'homunculus', the map of the body as represented on the sensory and motor areas of the brain.

1951

Hughlings Jackson: Body representation in the motor part of the brain



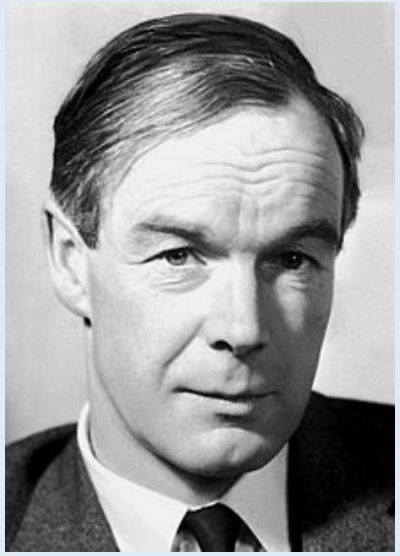
1874

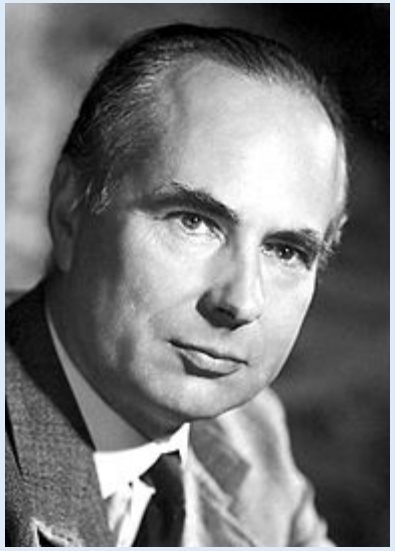
"I think the mode of beginning makes a great difference as to the march of the fit. When the fit begins in the face, the convulsion in involving the arm may *go down* the limb … When the fit begins in the leg, the convulsion marches up; when the leg is affected after the arm, the convulsion marches *down* the leg."

Deduced from this that there is a spatial map of the body in the motor cortex of the brain, with neurons serving adjacent parts of the body being adjacent to each other in the brain.

The progression of a motor seizure across the body is called the "Jacksonian March".

Hodgkin and Huxley: Mechanism of the Action Potential





Showed that the action potential requires entry of sodium ions.

Proposed membrane proteins called ‘ion channels’.

Proposed the mechanism by which the action potential is always the same size and shape in a given neuron.

Proposed mechanism by which the action potential propagates down the axon without losing amplitude.

Bernard Katz and quantal theory of transmitter release

Transmitter release requires entry of calcium ions into the neuron.

Transmitter is released in multimolecular packets in the neuron known as vesicles.