Foundations I
Fall, 2016
Prof. J.M. Tepper  Aidekman 109F  X 3618

Course Organization
Brief History of Neuroscience
Intro to Neurocytology
Foundations I (26:112:565:01) Fall 2016

Course coordinator: Juan Mena-Segovia (juan.mena@rutgers.edu)
Tuesdays and Thursdays (10:00-12:30). All classes in Room 202

TAs: Pinelopi Kyriazi (pak132@scarletmail.rutgers.edu)
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Required texts: Liqun Luo’s “Principles of Neurobiology”;
                Watson’s “Molecular Biology of the Gene”

2 exams – mostly objective – MC, fill-in TF, matching etc.
    best way to study is a) lecture notes b) handouts, c) assigned readings

TA hours/meetings by arrangement, use them any time, as often as you like

Must maintain B average in Foundations to maintain good standing in Program
A brief (and biased) history of neurophysiology
Ancient Egypt
c. 3300 B.C.

mummification

Canopic Jars

intestines  stomach  lungs  liver

The heart was considered to be the seat of intelligence and reason

brain hook

The function of the brain is to produce snot
Alcmaeon of Crota (5th Century B.C.)

“The brain is the seat of intelligence and sensation....”
“...every animate being is a living thing which can move itself only because it has a soul.”
René Descartes (1596-1650)

- founder of analytic geometry
- law of refraction
- conservation of momentum
- Cartesian coordinates
- “Cogito ergo sum”

polymath - an expert/genius in many different fields
René Descartes (1632)

The Royal gardens at Saint Germain

“...animals respond to external stimuli.”

Traite de l’homme (1664)
Luigi Galvani (1791)

animal electricity
Alessandro Volta (1793)
Voltaic Piles

no animal electricity - external electrical stimulation
Advances in science often occur by leaps and bounds as a result of the discovery of new technologies.

The invention of the galvanometer - April 21, 1820
Leopold Nobili (1825)

improved the galvanometer by adding a second winding in the opposite direction to cancel out interference
Johannes Müller (1826)

“Law of Specific Nerve Energies”

‘... the kind of sensation following stimulation of a sensory nerve does not depend on the mode of stimulation but upon the nature of the nerve itself...’
“injury current”
“The motor nerve is not stimulated by the absolute value of the current-density at any given moment, but by its variations from one instant to another, and the effect produced by these rapid changes increases with their rapidity and their greatness in a given time.”
“If I do not greatly deceive myself, I have succeeded in realizing in full actuality (albeit under a slightly different aspect) the hundred years’ dream of physicists and physiologists, to wit, the identity of the nervous principle with electricity.”
Herman Von Helmholtz (1850)

- first measurement of action potential propagation
- inferred synaptic delay
- theory of color vision
- place theory of pitch perception
- Law of Conservation of Energy

another polymath
Richard Caton (1875) recorded “...feeble currents of varying direction...” from surface of the skull.

EEG

Stay away from low profile journals!!
Santiago Ramon y Cajal (1852-1934)
Nobel Prize in Physiology and Medicine, 1906

- neuron doctrine
- law of dynamic polarization
- synapses
“As nature, in order to assure and amplify the contacts, has created complicated systems of pericellular ramifications (systems which become incomprehensible within the hypothesis of continuity), it must be admitted that the nerve currents are transmitted from one element to the other as a consequence of a sort of induction or influence from a distance.”

S. Ramon y Cajal, Nobel Lecture, 1906
Camillo Golgi (1843-1926)

Nobel Prize in Physiology and Medicine, 1906

“reazione nera” - the black reaction, i.e. Golgi Stain

the Golgi Apparatus

neuronal syncitium
“It may seem strange that, since I have always been opposed to the neuron theory - although acknowledging that its starting-point is to be found in my own work - I have chosen this question of the neuron as the subject of my lecture, and that it comes at a time when this doctrine is generally recognized to be going out of favour...”

“...I shall therefore confine myself to saying that, while I admire the brilliancy of the doctrine which is a worthy product of the high intellect of my illustrious Spanish colleague, I cannot agree with him on some points of an anatomical nature...”

C. Golgi, Nobel Lecture, 1906
“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.” - C.S. Sherrington, 1906
Otto Loewi (1873–1961)
Nobel Prize in Physiology and Medicine, 1936

"The night before Easter Sunday, I woke, turned on the light and jotted down a few notes on a tiny slip of paper. Then I fell asleep again. It occurred to me at six o'clock in the morning that during the night I had written down something most important, but I was unable to decipher the scrawl.

The next night at three o'clock, the idea returned. It was the design of an experiment to determine whether or not the hypothesis of chemical transmission that I had uttered seventeen years ago was correct. I got up immediately went to the laboratory and performed a simple experiment on a frog heart according to the nocturnal design."
Abb. 1. Esculenta. 1. Ringer. 2. Ringer aus 15' Vagusreizperiode. 3. Ringer aus 15' Normalperiode. 4. +0,1 mg Atropin.
Hodgkin and Huxley
Nobel Prize in Physiology and Medicine, 1963

A.F. Hodgkin

A.L. Huxley

squid

voltage clamp amplifier
quantitative description of ionic currents
Sir John Eccles (1903 -1997)
Nobel Prize in Physiology and Medicine, 1963

Eccles and Sherrington, 1936
Sir John Eccles (1903 -1997)
Nobel Prize in Physiology and Medicine, 1963

Fig. 17 A—C. A. A series of EPSPs set up in a frog sympathetic ganglion cell. Membrane potential was changed from the resting level (−70 mV) by steady current through the recording microelectrode, the actual potential being indicated in mV on each record. Note spike potentials in addition at −22 to −70 mV. Temperature 24—26° C (Nishi and Kosaka 1960). B. EPSPs set up in a cat biceps-semimembranosus motoneurone at various levels of membrane potential as indicated. Each record is formed by the superposition of about 20 faint traces. The membrane potential was shifted to the indicated values from its resting value of −60 mV by steady currents through the other barrel of the double micro-electrode (Cozza, Eccles and Pavk 1955b). C. Formal electric diagram of a postsynaptic membrane with areas of excitatory synapses as shown on the right side. Further description in text and in Table 2.

Eccles, The Physiology of Synapses
Neher and Sakmann
Nobel Prize in Physiology and Medicine, 1991

Erwin Neher  Bert Sakmann

patch clamp recording
The Nobel Prize in Chemistry 2008

Osamu Shimomura

Martin Chalfie

Roger Y. Tsien

"for the discovery and development of the green fluorescent protein, GFP".
Introduction to Neurocytology
Introduction to Real Neurocytology
spiny dendrites

aspiny dendrites
local axon collaterals

dendrites

soma/cell body

50 μm
2.3 µm

nucleus

nuclear indentation

nucleolus

nucleus
Parts of a synapse

- presynaptic bouton
- postsynaptic dendrite
- large dense core vesicle
- active zone
- synaptic vesicle
- mitochondrion
Gray's Type II
(symmetric)

pleomorphic vesicles

At₂

Gray's Type I
(asymmetric)

small round vesicles

sp

At₁
Gray's type I (asymmetric, 30 nm cleft, small [30-40 nm] round vesicles) = excitatory, usually made onto the heads of dendritic spines, dendritic shafts or occasionally, somata.

Gray's type II (symmetric, 20 nm cleft, small or pleomorphic vesicles) = inhibitory, almost never on the heads of dendritic spines, often spine shafts, dendritic shafts, or somata.
large (40-50 nm) dense core vesicle
small (30-40 nm) electron lucent vesicle
Dendrodendritic synapse

Somatodendritic synapse

Olfactory bulb
perforated synapse - two active zones