

UiO : Department of Physics
University of Oslo

FYS 4250

Lecture 12

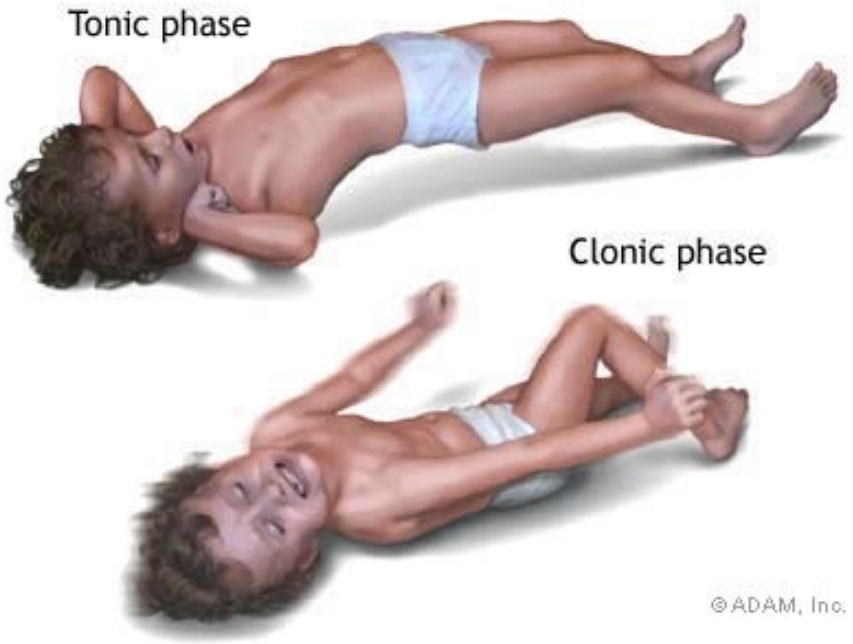


Case 12



- Paramedics are sent for the international terminal of the airport, to a 30-year-old male in a full tonic-clonic seizure.

Case 12



http://graphics8.nytimes.com/images/2007/08/01/health/adam/19076.jpg

- His medical history is unknown, but the first thing is to protect him from injury and make sure his airways are open. 10 mg of diazepam is administered, but the patient continues to seize until his arrival to the ED.

Case 12



Case 12



Patients vital signs at arrival:

- Blood pressure 220/117 mmHg, heart rate 128 beats per minute, respiratory rate 22 breaths per minute, oxygen saturation of 100%, temperature 38.2°C.

The examination shows that he has blood-tinged sputum around his mouth and his teeth are clenched. He is tachycardic with normal heart sounds, benign abdomen and normal lungs. ECG reveals a sinus tachycardia with no acute ST changes, a CT-caput, chest X-ray and lumbar puncture are all within normal range.

What is the most likely diagnosis?

Case 12



When the doctors find his medical record, there is no sign of previous episodes of epilepsy, or any medical history at all. Still he has all the typical signs of a status epilepticus seizure. The strong hypertension is surprising as a tonic-clonic seizure typically results in a mild hypertension. Their main focus is to manage the ABC (Airways, Breathing, Circulation), and the use of benzodiazepines and antiepileptic agents in order to control the seizures and hypertension. Oxygen is given, and the vital signs are assessed.

What is your next step?

Membrane potential

Nernst equation for potassium K (Nor - Kalium):

$$E_K = \frac{RT}{nF} \ln \frac{[K]_o}{[K]_i} = 61.5 \log_{10} \frac{[K]_o}{[K]_i} \quad [mV]$$

across a cell membrane with active channels pumping K ions into the cell.

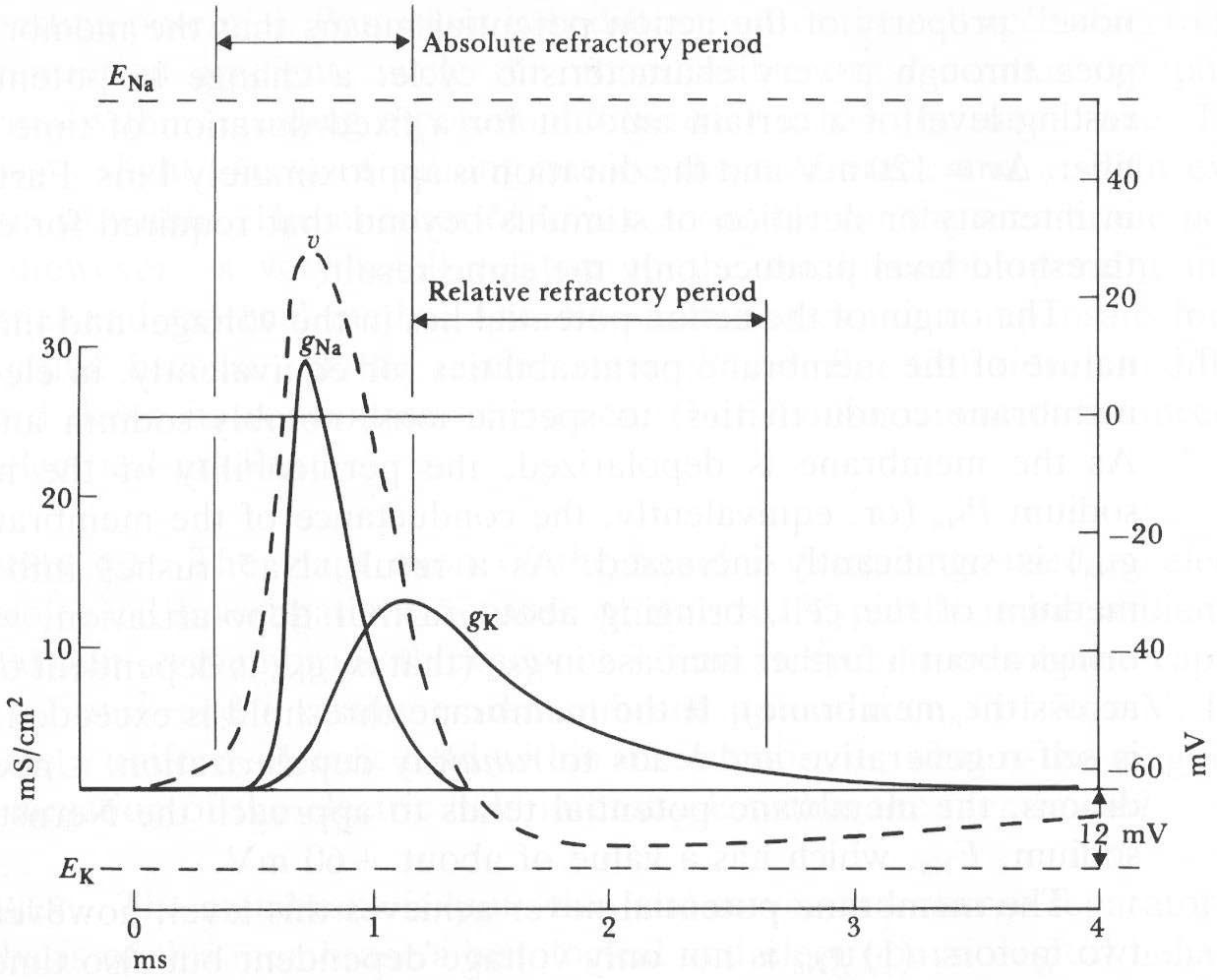
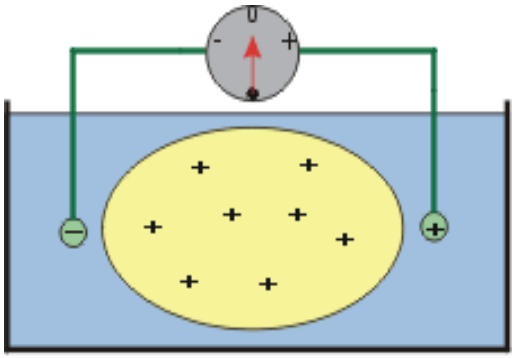
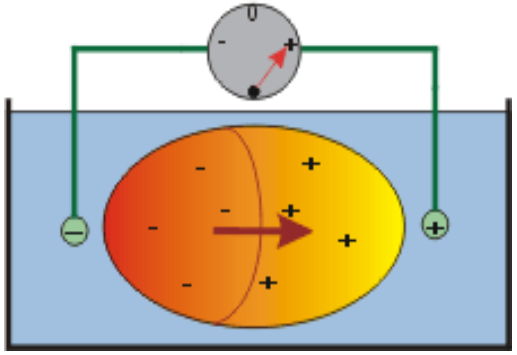


Figure 4.2 Theoretical action potential v and membrane ionic conductance changes for sodium (g_{Na}) and potassium (g_K) are obtained by solving the differential equations developed by Hodgkin and Huxley for the giant axon of the squid at a bathing medium temperature of 18.5°C. E_{Na} and E_K are the Nernst equilibrium potentials for sodium and potassium across the membrane. (Modified from A. L. Hodgkin and A. F. Huxley, "A Quantitative Description of Membrane Current and Its Application to Conduction and Excitation in Nerve," *Journal of Physiology*, 1952, **117**, p. 530.)

Action potential, excitable cell

The volume conductor





A single active cell is immersed in a volume conductor (= body fluids, filled with ions). This is a problem of two parts:

1. The bioelectric source
2. The bathing medium or electrical load

1. The bioelectric source = active cell bathed by a volume conductor.

2. The magnitude of the field potential in a large bathing medium falls off exponentialley with increasing radial distance from the active fiber

Changes in the properties (eg. Resistivity) of the volume conductor can impact on the field potential magnitude

https://www.cvphysiology.com/Arrhythmias/A014

Volume conductor fields

A single active cell immersed in a volume conductor will be influenced by the volume conductor (Volume conductor = body fluids, or a salt solution simulating this)

For a simple monophasic action potential, the associated potential waveform is:

1. Triphasic in nature
2. Of greater spatial extent than the action potential
3. Much smaller in magnitude

What is the result? Inhomogenous multilayer volume conductors in the body (blood, bone, muscle fibers ++) will alter the current flow. We have to assume homogenous volume conductor and anisotropic properties + passive conduction.

- The size of the signal picked up depends on the volume impedance and position of the elctrodes
- Signals from the source will be filtered before entering the electrodes

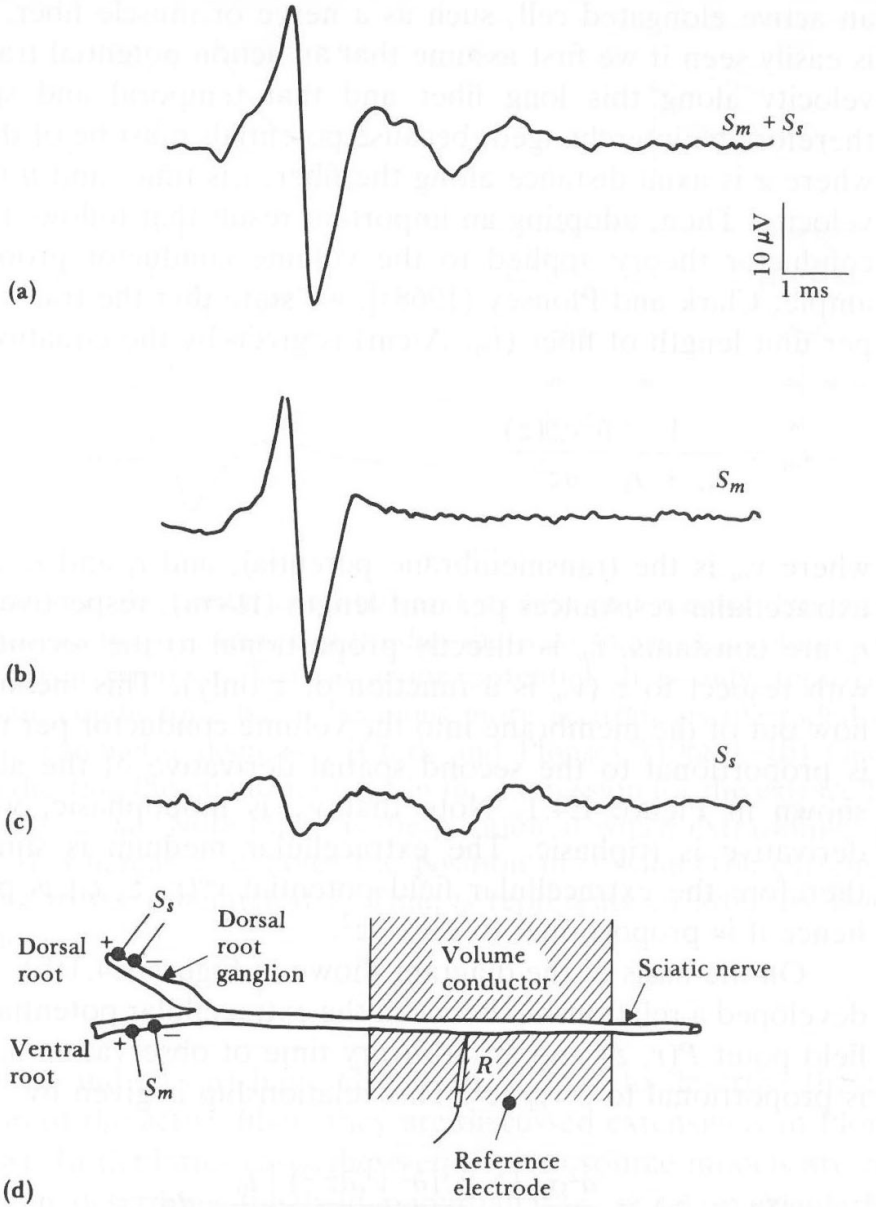


Figure 4.5 Extracellular field potentials (average of 128 responses) were recorded at the surface of an active (1-mm-diameter) frog sciatic nerve in an extensive volume conductor. The potential was recorded with (a) both motor and sensory components excited ($S_m + S_s$), (b) only motor nerve components excited (S_m), and (c) only sensory nerve components excited (S_s).

Summing up in the nerve-cell

Both motorical and sensorical fibers are excited simultaneously by electrical stimulus.
Dorsal root is sensoric
Ventral root is motoric, dorsal root is nervous
Stimulation of the many large diametric motoric fibers will give the largest extracellular response.
Stimulation of sensoric fibers will excite two groups of sensoric fibres.

The extracellular potential diminishes in amplitude and high-frequency contents as field point is moved to larger radial distances from the surface of the trunk



How to measure action potential
Axon in invertebrate animals

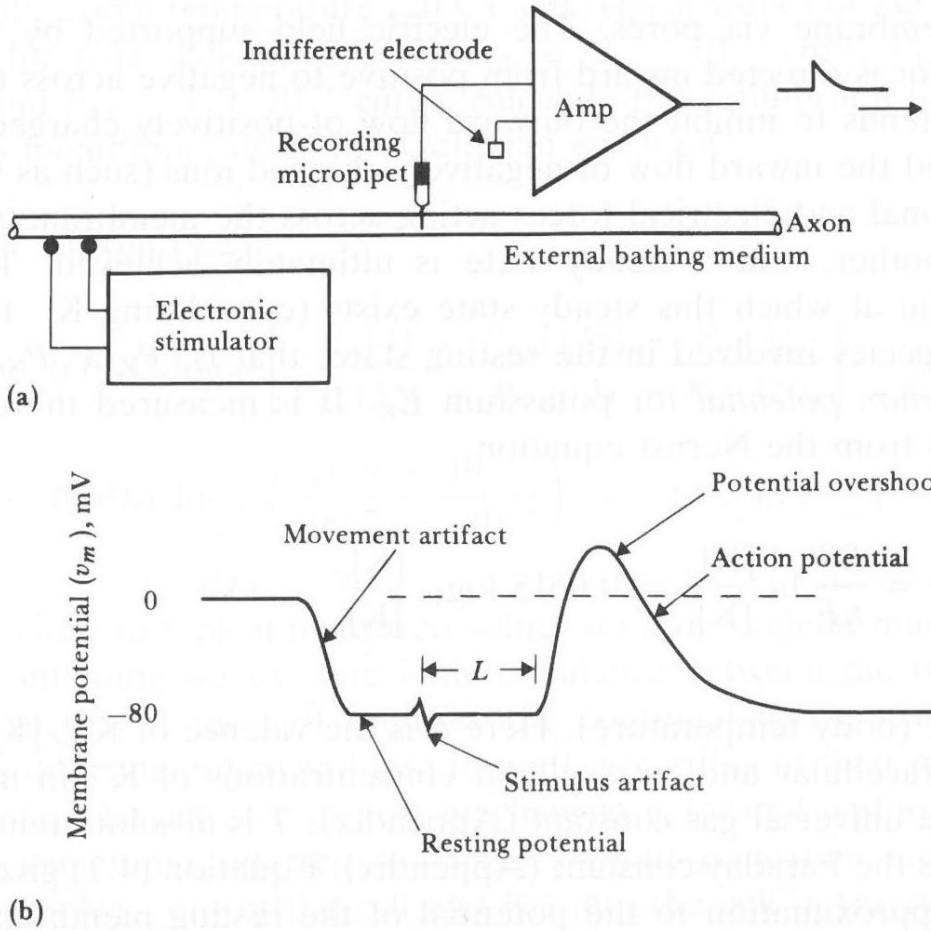
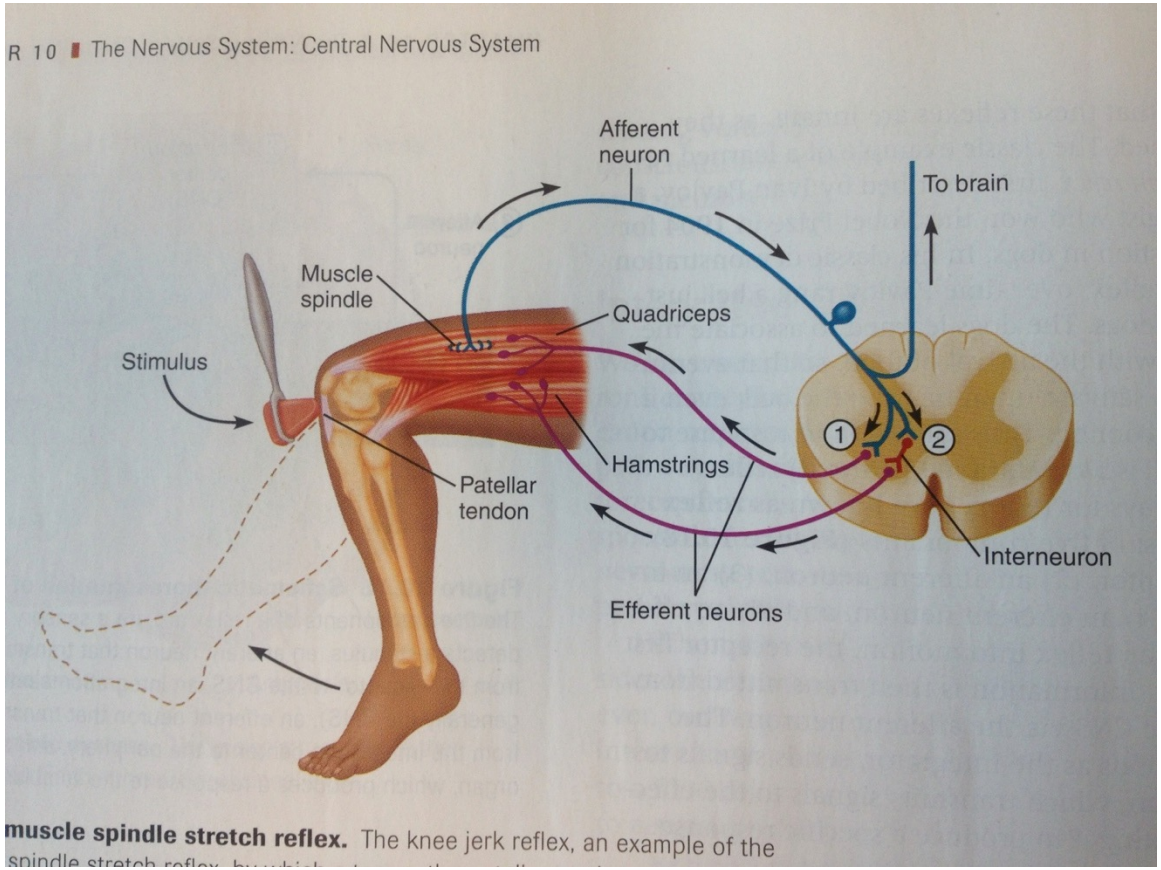
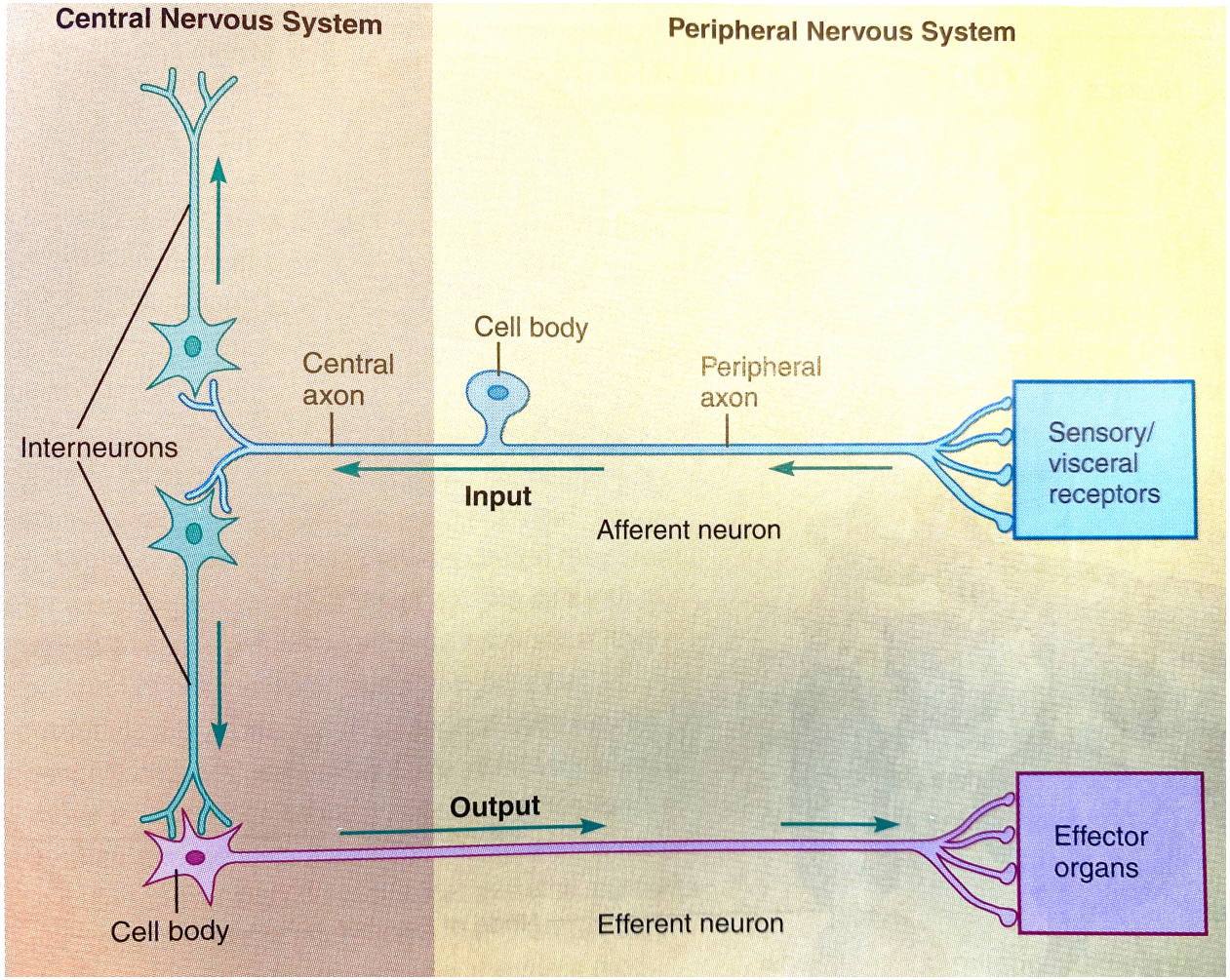


Figure 4.1 Recording of action potential of an invertebrate nerve axon (a) An electronic stimulator supplies a brief pulse of current to the axon, strong enough to excite the axon. A recording of this activity is made at a downstream site via a penetrating micropipet. (b) The movement artifact is recorded as the tip of the micropipet drives through the membrane to record resting potential. A short time later, an electrical stimulus is delivered to the axon; its field effect is recorded instantaneously at downstream measurement site as the stimulus artifact. The action potential proceeds along the axon at a constant propagation velocity. The time period L is the *latent period* or transmission time from stimulus to recording site.

Reflex


R 10 The Nervous System: Central Nervous System
Afferent neuron
To brain
Muscle spindle
Quadriceps
Stimulus
Hamstrings
Patellar tendon
Interneuron
Efferent neurons
1
2
muscle spindle stretch reflex. The knee jerk reflex, an example of the



Functional classes of neurons, afferent neurons gather data while efferent neurons output data, note the different location of the cell body depending on the type.

Source: Principles of human physiology, Germann and Stanfield

Muscle control

Reflex arc

- Sense organ
- Sensory nerve, sending information
- CNS, integratorstation. Evaluated -> Motoric decision can be implemented
- Motor nerve, communicating with peripheral muscle
- Effector organ, like skeletal muscle fibers.

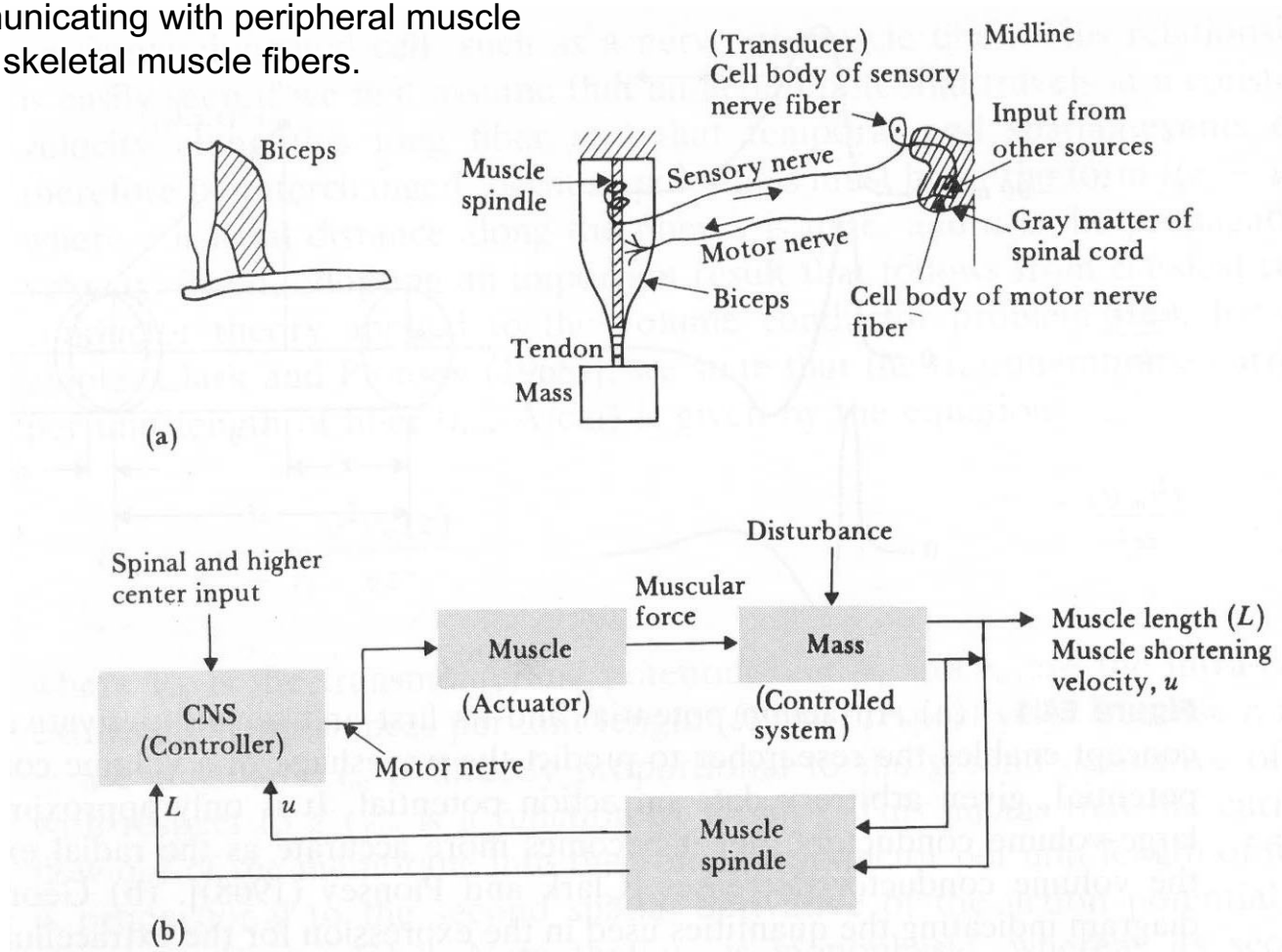
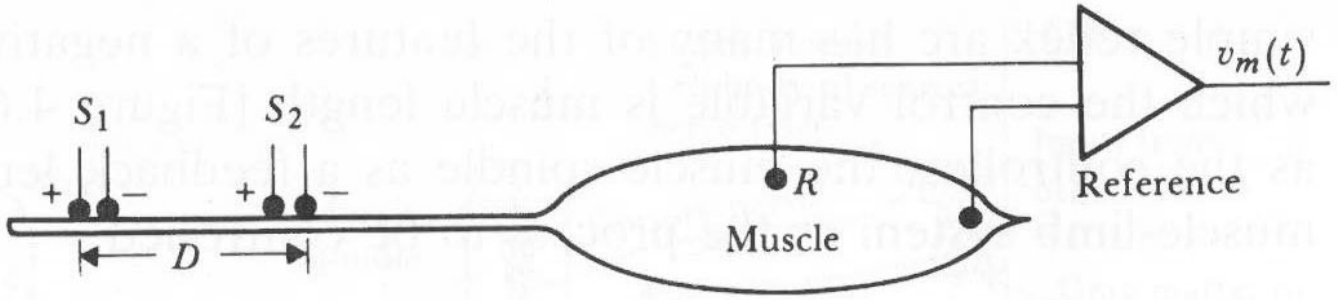
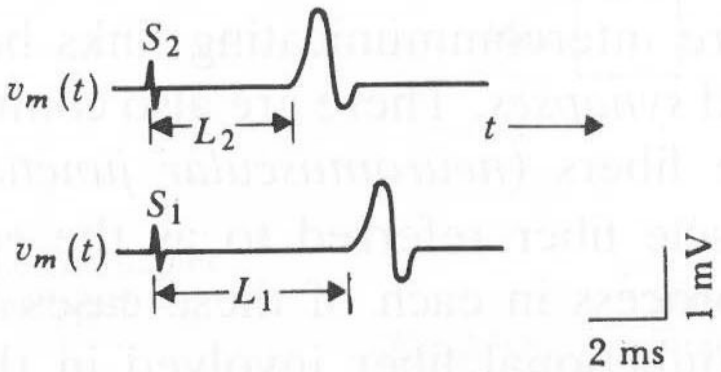


Figure 4.6 Schematic diagram of a muscle-length control system for a peripheral muscle (biceps) (a) Anatomical diagram of limb system, showing interconnections. (b) Block diagram of control system.

Neural velocity

Nerve stimulation at two different sites, subtraction of the shorter latency from the longer latency gives conduction time

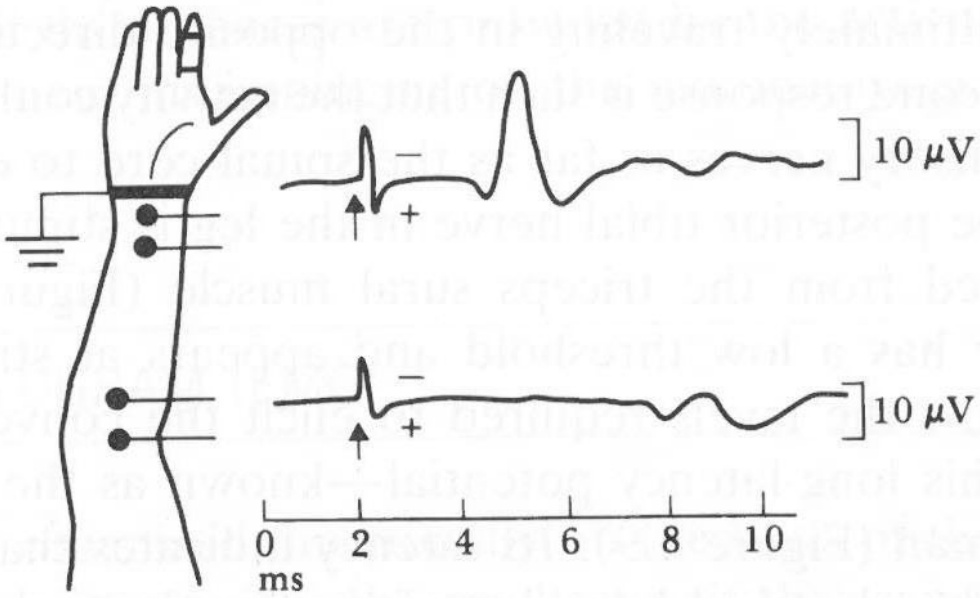




$$\text{Velocity} = u = \frac{D}{L_1 - L_2}$$

Figure 4.7 Measurement of neural conduction velocity via measurement of latency of evoked electrical response in muscle. The nerve was stimulated at two different sites a known distance D apart.

Neurography



Amp:
High gain
High input imp
Good CMRR
Low amp noise

Figure 4.8 Sensory nerve action potentials evoked from median nerve of a healthy subject at elbow and wrist after stimulation of index finger with ring electrodes. The potential at the wrist is triphasic and of much larger magnitude than the delayed potential recorded at the elbow. Considering the median nerve to be of the same size and shape at the elbow as at the wrist, we find that the difference in magnitude and waveshape of the potentials is due to the size of the volume conductor at each location and the radial distance of the measurement point from the neural source. (From J. A. R. Lenman and A. E. Ritchie,

H-reflex

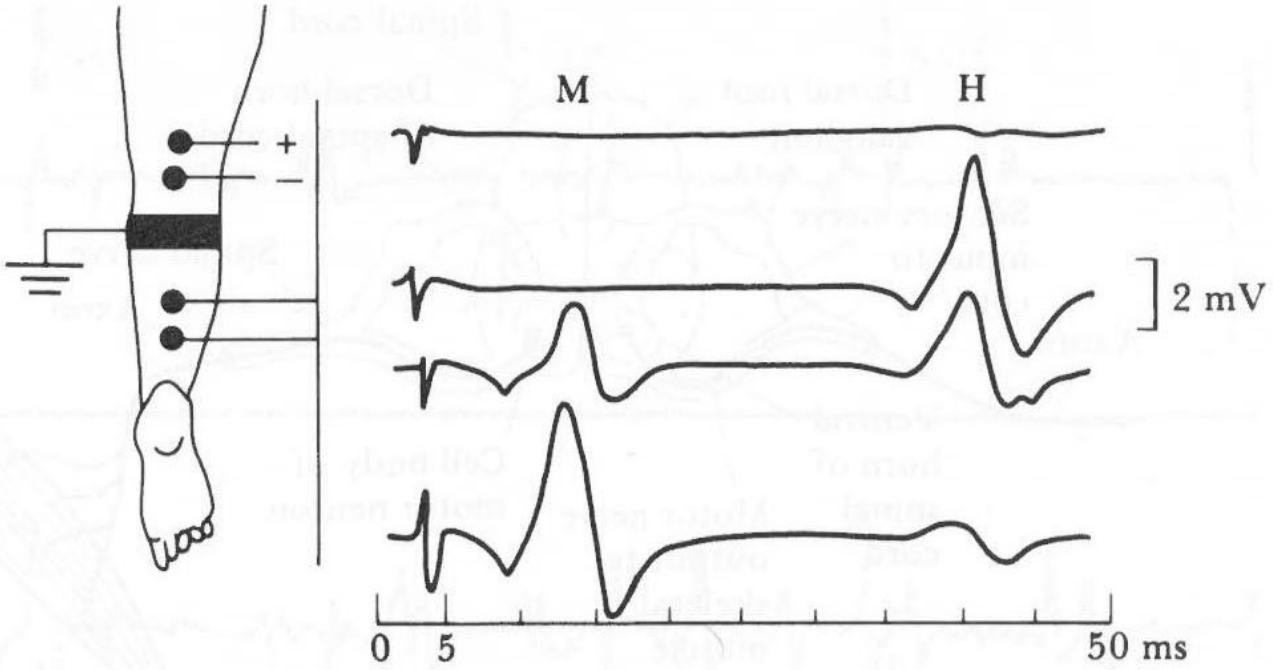
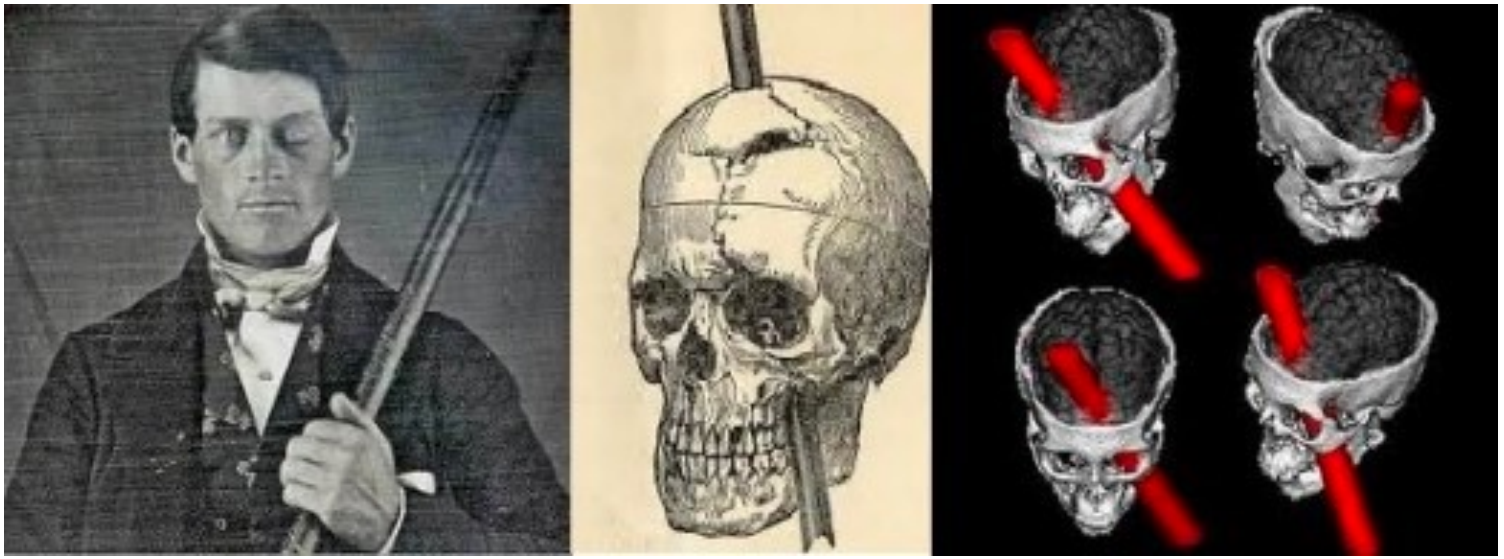


Figure 4.9 The H reflex The four traces show potentials evoked by stimulation of the medial popliteal nerve with pulses of increasing magnitude (the stimulus artifact increases with stimulus magnitude). The later potential or H wave is a low-threshold response, maximally evoked by a stimulus too weak to evoke the muscular response (M wave). As the M wave increases in magnitude, the H wave diminishes. (From J. A. R. Lenman and A. E. Ritchie, *Clinical Electromyography*, 2nd ed., Philadelphia: Lippincott, 1977; reproduced by permission of the authors.)

The discovery of the brain-functions
E.g. Phineas Gage (1823-1860)



Railway worker, iron rod accident with gun powder

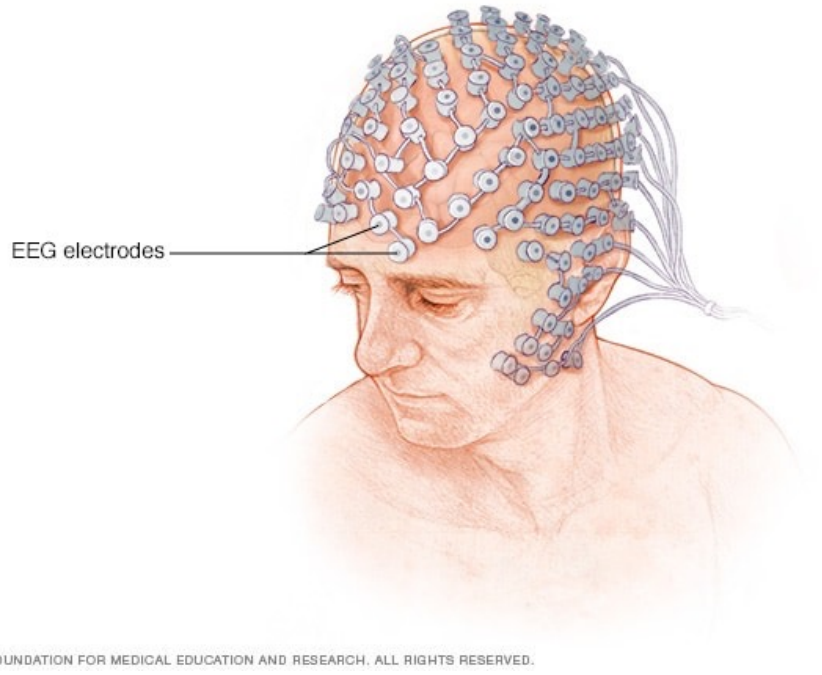
Changing personality, from even-tempered and sound in judgment to impulsive, hot-headed, irresponsible

https://hubpages.com/education/Phineas-Gage-Personality-Is-All-In-Your-Head

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Electroencefalography (EEG) and Magnetoencefalography (MEG)

EEG and MEG





Sciencephoto.com

EEG – Measuring electrical activity on the scull
MEG – Measuring changes in magnetic flux outside the brain

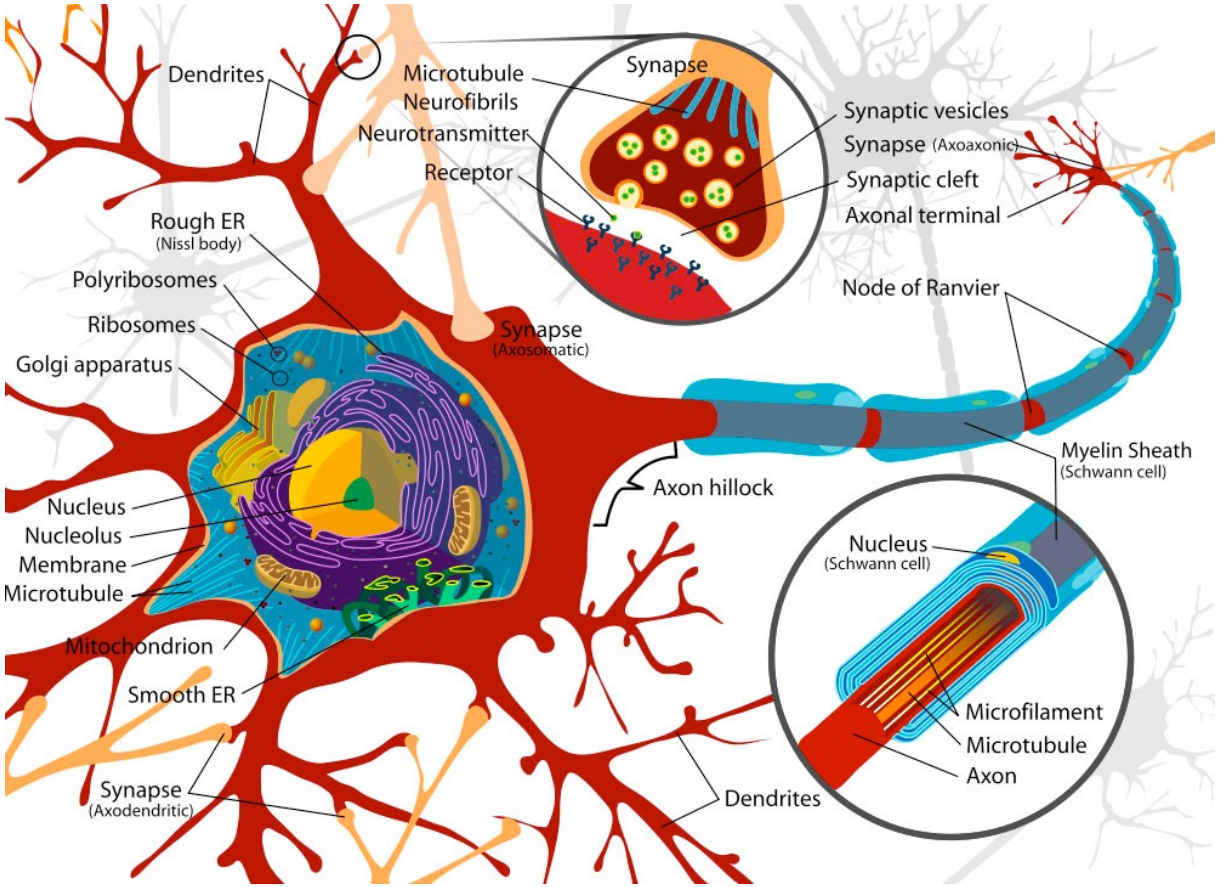
The Neuron



https://www.youtube.com/watch?v=6qS83wD29PY

Neuron (Nerve cell)

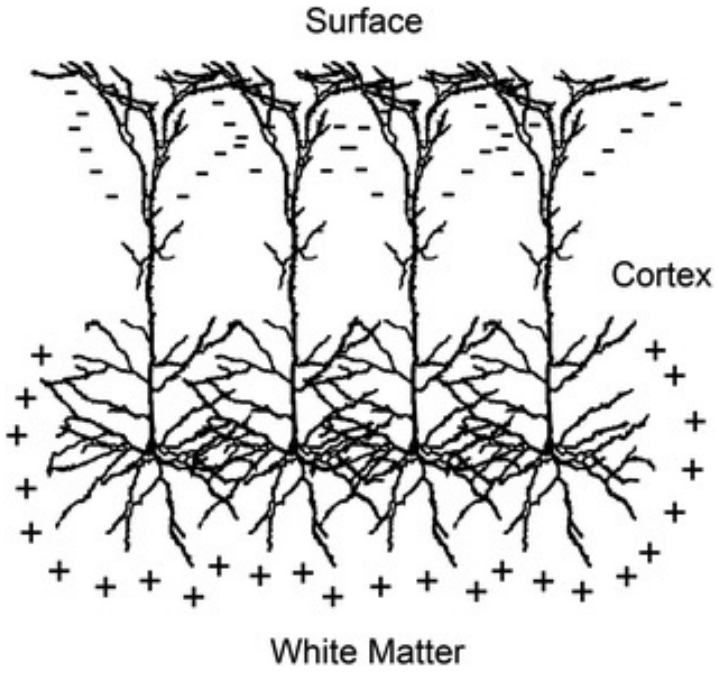
Dendrite recieve information
Axon send information



http://paleozonenutrition.com/wp-content/uploads/2012/02/nerve-cell.jpg

Neuron stimulate other neurons through synapses, depending on the stimulus and the neuron, graded potentials can cause hyperpolariation or depolarisation

Aligned pyramidal neurons forms a dipole



Pyramidal cells aligned in the cortex will effectively create a dipole to the surface. At least 6 cm^2 of synchroneous cortical activation is needed to detect an individual epileptic spike from scalp electrodes.

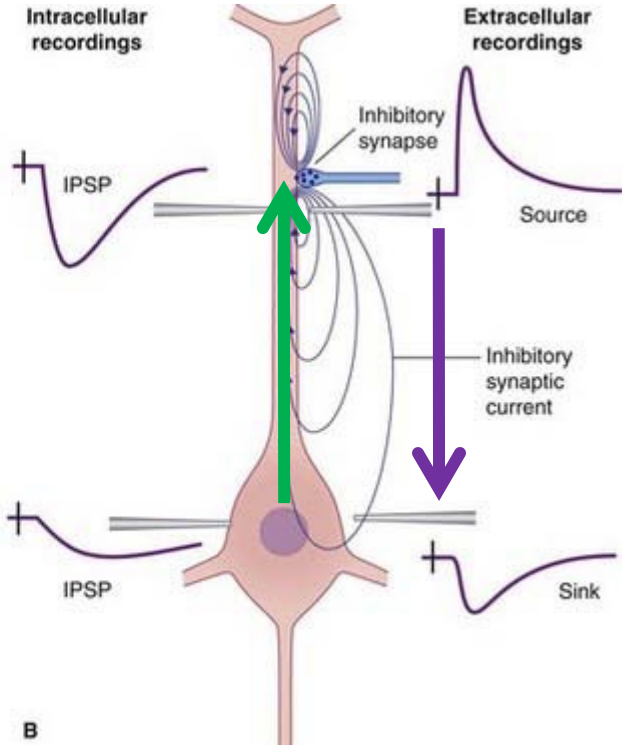
Due to the ionic flow in extracellular volume, there is noe build up of charge

MEG is more sensitive to intracellular currents, while EEG is more sensitive to extracellular

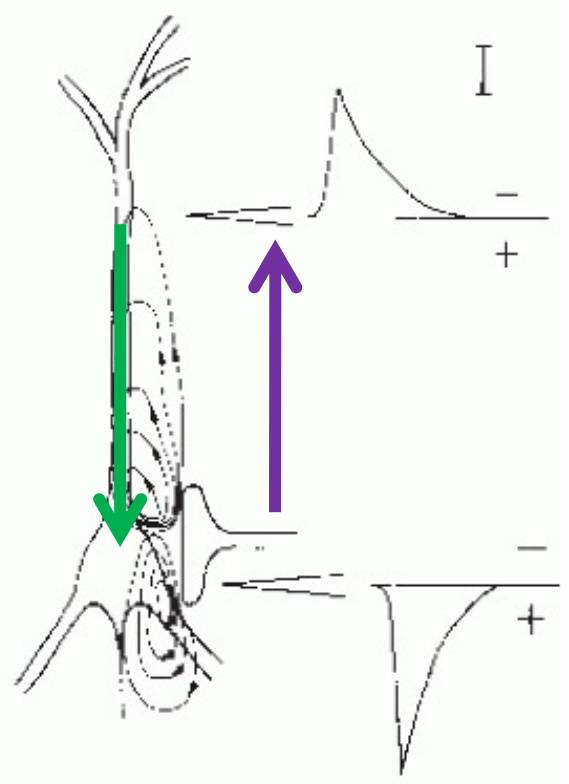
https://neupsykey.com/eeg-instrumentation-montage-polarity-and-localization/

Current flow direction depends on type and location of synaptic input

Inhibitory Post-Synaptic Potential (IPSP): influx of negative Cl- ions causes hyperpolarization of the postsynaptic cell



Direction of current flow depends on location of synapse



https://clinicalgate.com/electroencephalography/

From Lopes da Silva, Mag. Res. Imag., 2004

Source: James Bonaiuto Institut des Sciences Cognitives, CNRS, Lyon, France

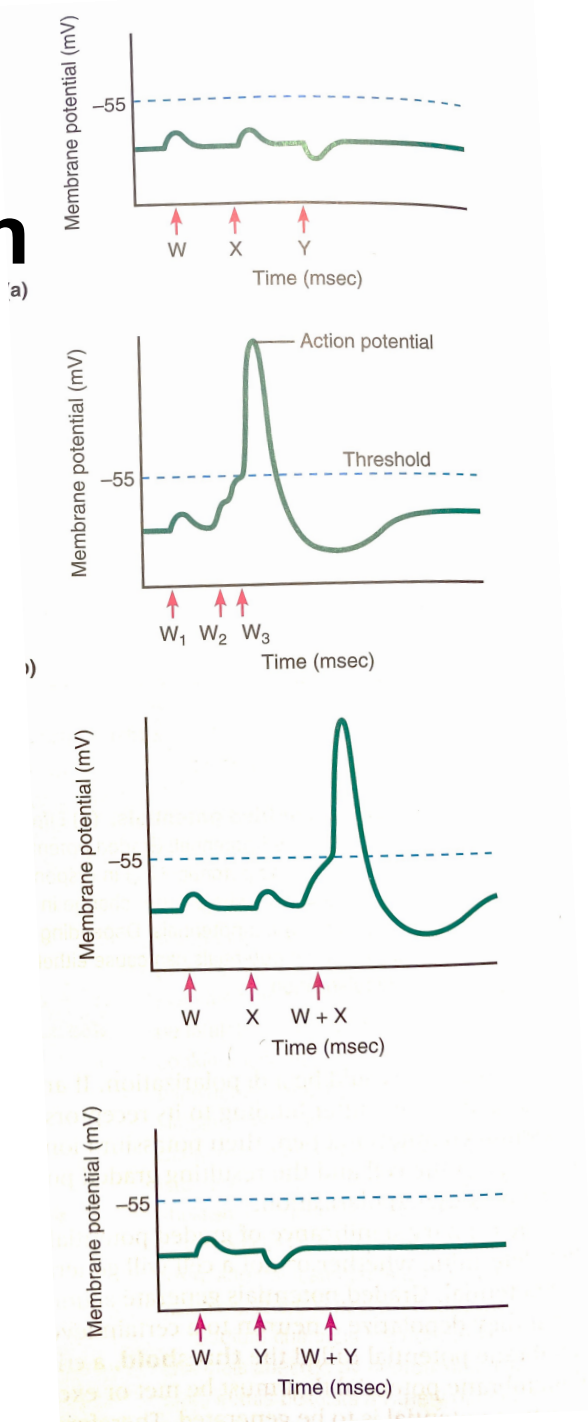
Temporal and spatial summation

Stimuli W, X and Y influence the membrane potential of a neuron. Stimuli W and X depolarize the cell while Y hyperpolarizes the cell (a).

b. Temporal summation of stimulus W results in depolarisation to above treshold -> generating action potential

c. Spatial summation of stimuli W and X resulting in depolarisation above treshold -> generating action potential

d. Spatial summation of stimuli W and Y resulting in no change in membrane and therefore no action potential

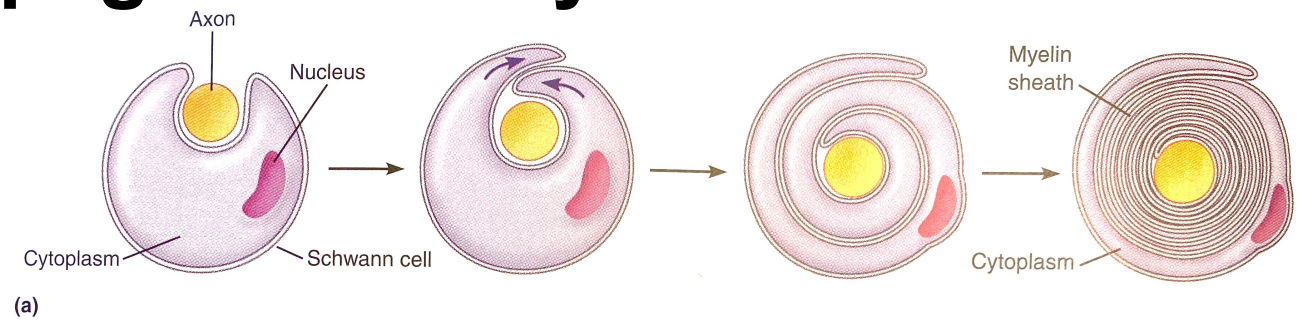


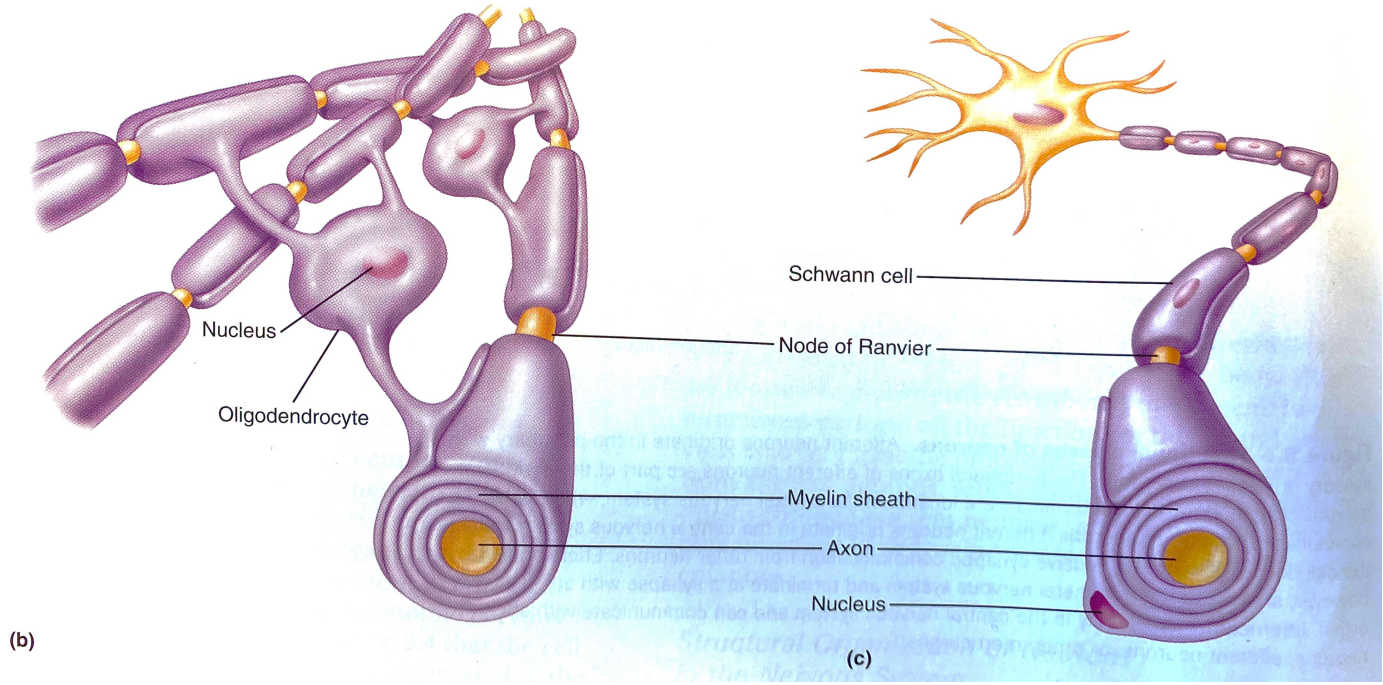
Source: Principles of human physiology, Germann and Stanfield

Signal propagation in myelinated cells

A myelin sheath with concentric layers of plasma membrane forms a layer of insulation aeround an axon.

Note the gap in the Node of Ranvier, one singel Schwann-Cell sheathes only one axon

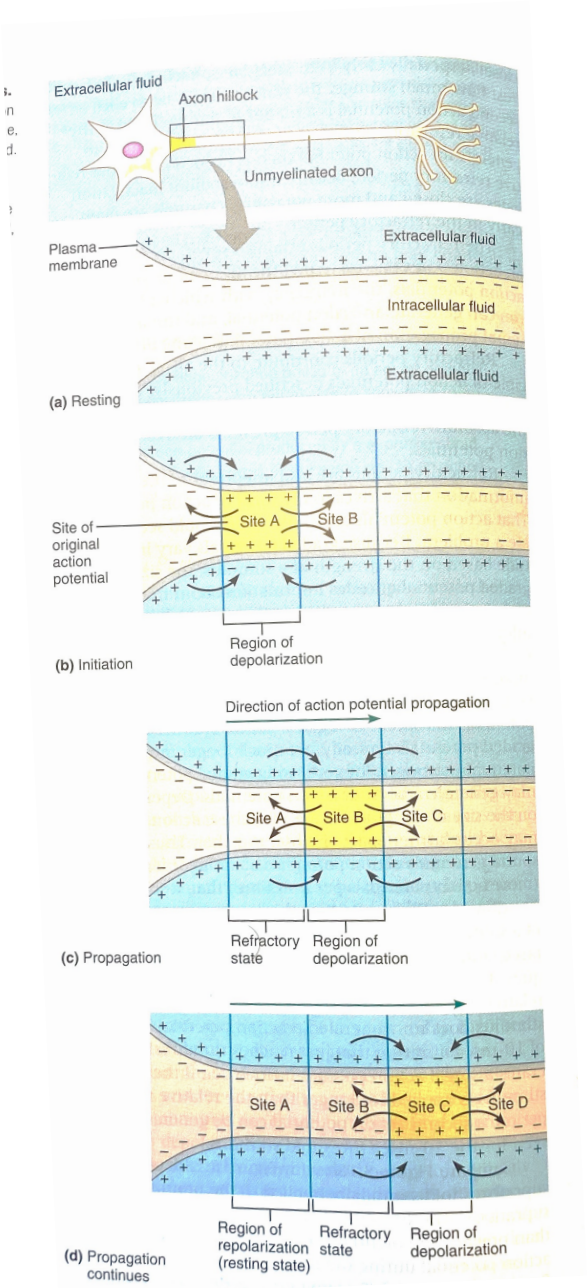




Source: Principles of human physiology, Germann and Stanfield

Propagation of action potentials in unmyelinated cells

a. Resting membrane potential
b. Initiation of conduction. An action potential occurs at site A on the membrane.The charge separation is a force for current to move. Local currents produced by ions moving are shown by arrows.
c. Propagation of conduction, current depolarizes the adjacent region of membrane to threshold, eliciting an action potential here
d. Continuation of propagation. Refrectory periods prevent action potentials from traveling in the reverse direction



Source: Principles of human physiology, Germann and Stanfield

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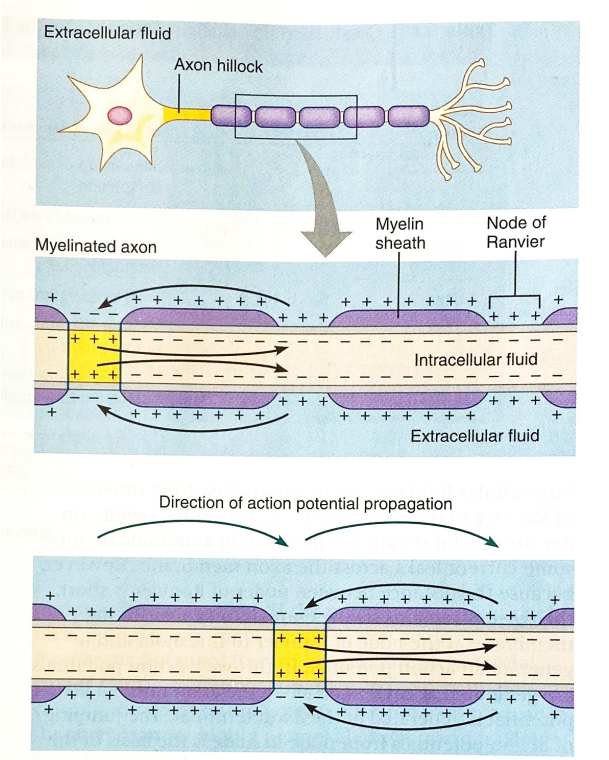
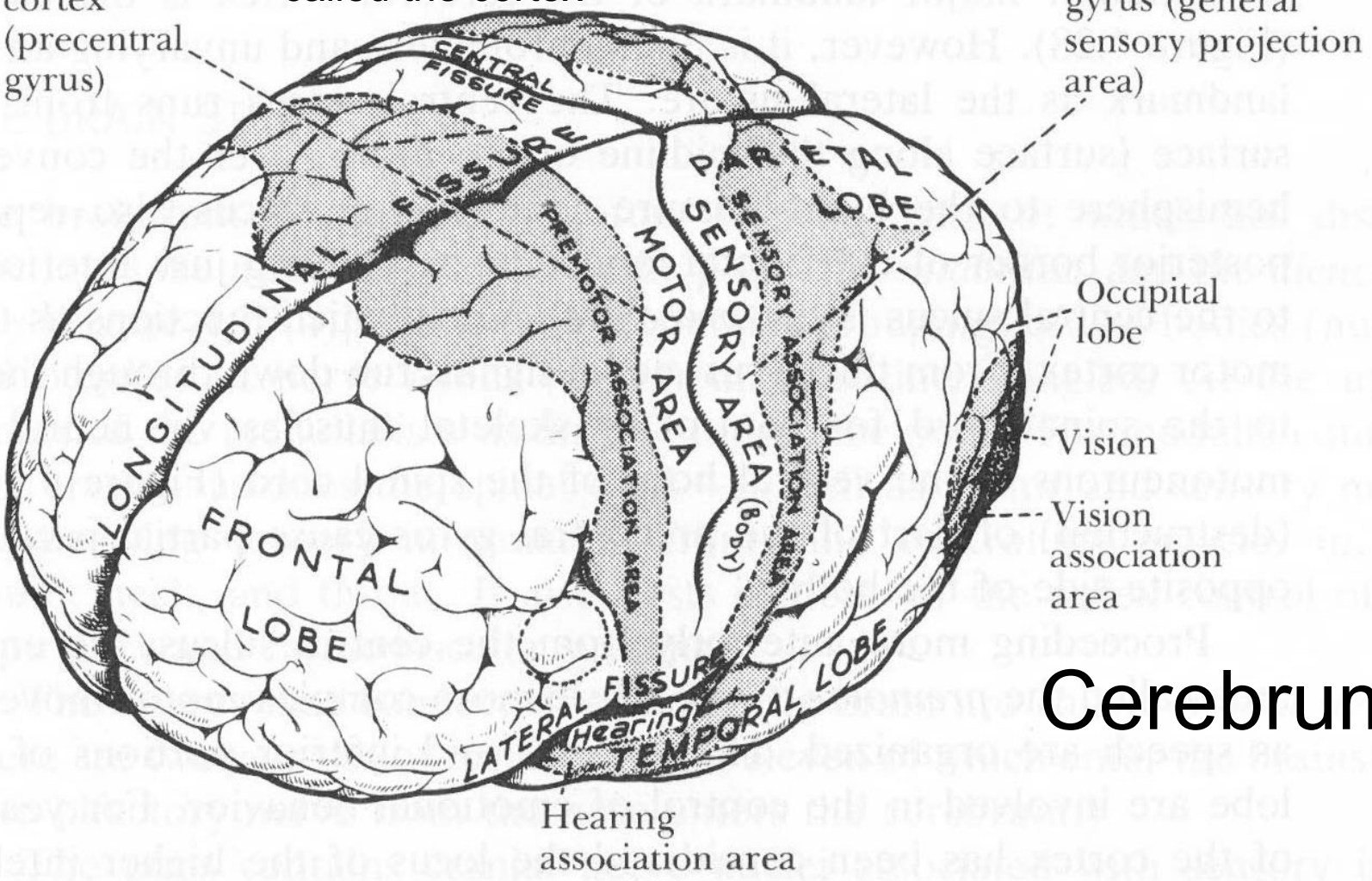


Figure 8.20 Saltatory conduction in myelinated axons. An action potential in a myelinated axon produces electrical gradients in the intracellular and extracellular fluids that are similar to those observed in unmyelinated axons (see Figure 8.19). However, because very little current flows across the membrane where myelin insulates it, the current must flow all the way to the next node of Ranvier, where it depolarizes this area of the membrane to threshold and initiates an action potential.

Source: Principles of human physiology, Germann and Stanfield

The surface layer of the hemisphere is called the cortex



Cerebrum

Figure 4.28 The cerebrum, showing the four lobes (frontal, parietal, temporal, and occipital), the lateral and longitudinal fissures, and the central sulcus. (From A. B. McNaught and R. Callander, *Illustrated Physiology*, 3rd ed., 1975. Edinburgh: Churchill Livingstone. Used with permission of Churchill Livingstone.)

The central nervous system

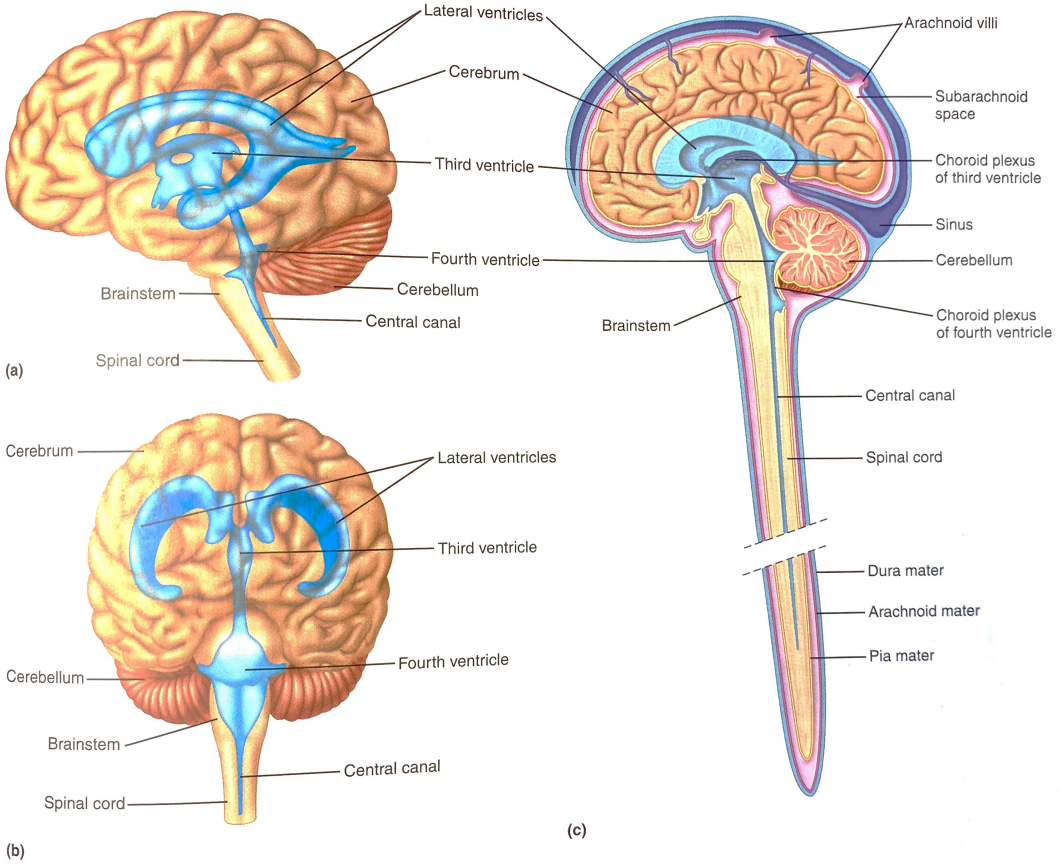


Figure 10.3 Ventricular system of the CNS. The brain's four ventricles—two lateral ventricles, the third ventricle, and the fourth ventricle—are continuous with the central canal of the spinal cord. (a) Lateral view. (b) Frontal view. (c) Relationships of the ventricles to other CNS structures. Note the presence of the choroid plexus within the ventricles.

The Nervous system



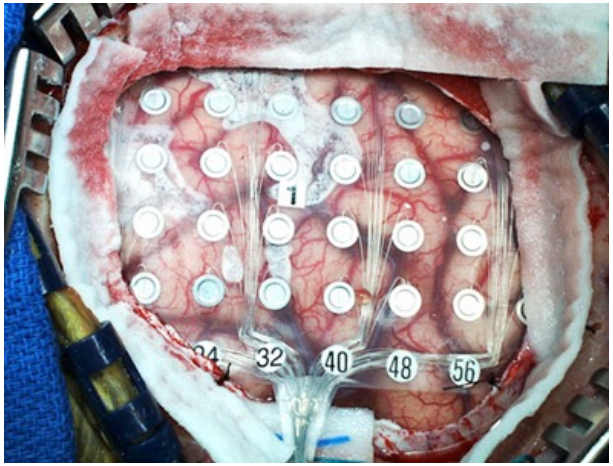
https://www.youtube.com/watch?v=44B0ms3XPKU

Typical EEG electrodes



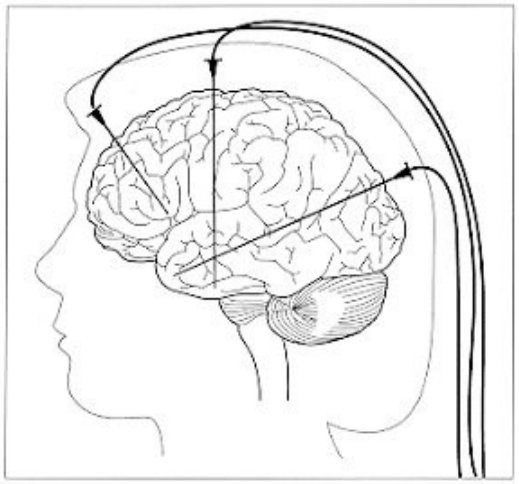
Scalp

http://www.geisinger.kramesonline.com/HealthSheets/168050.img



Cortical

http://www.downstate.edu/epilepsy/images/brain-electrodes.jpg



Depth

http://www.uwhealth.org/images/ewebeditpro2/upload/5334_Figure_2.jpg

EEG
electrodes

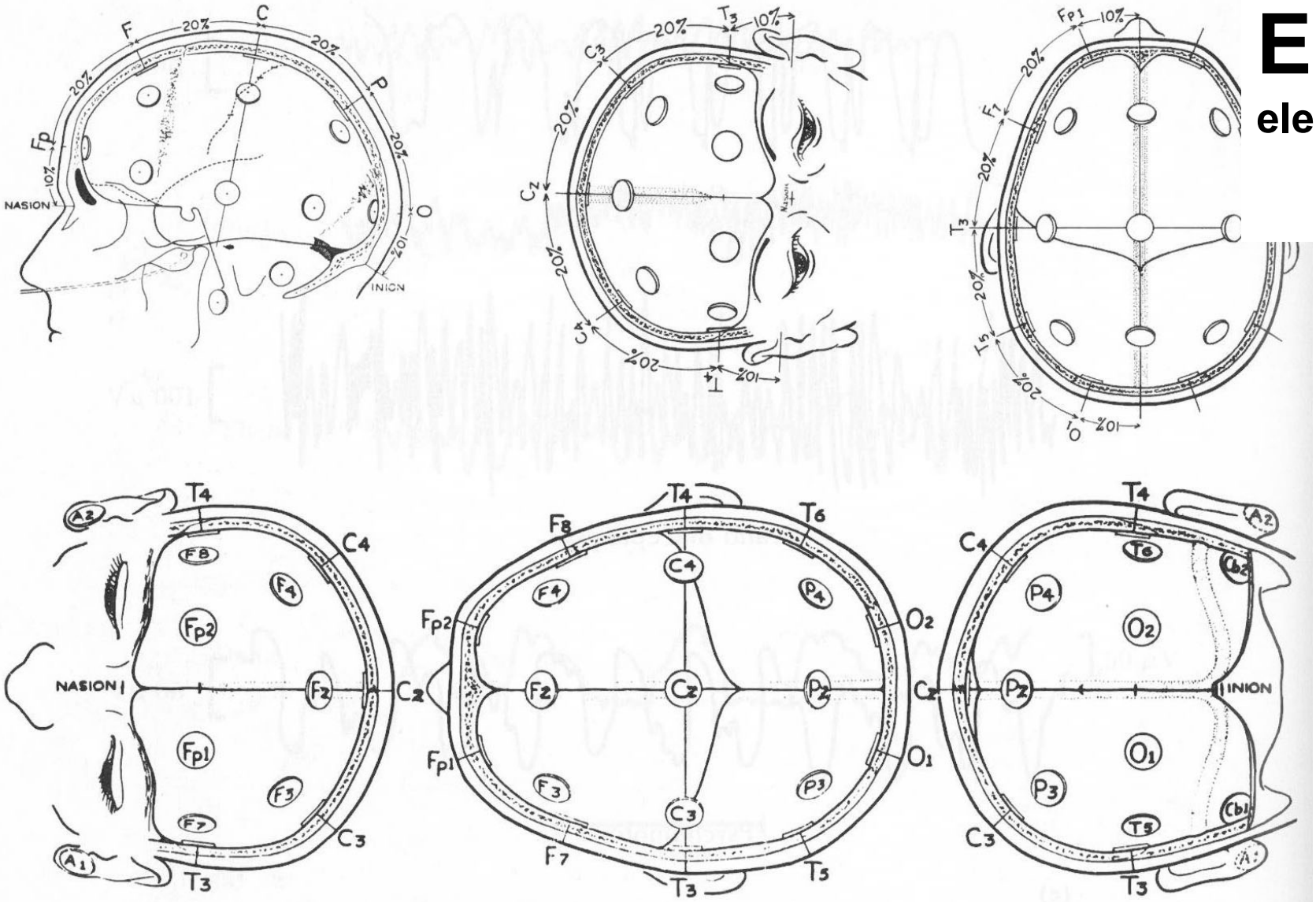
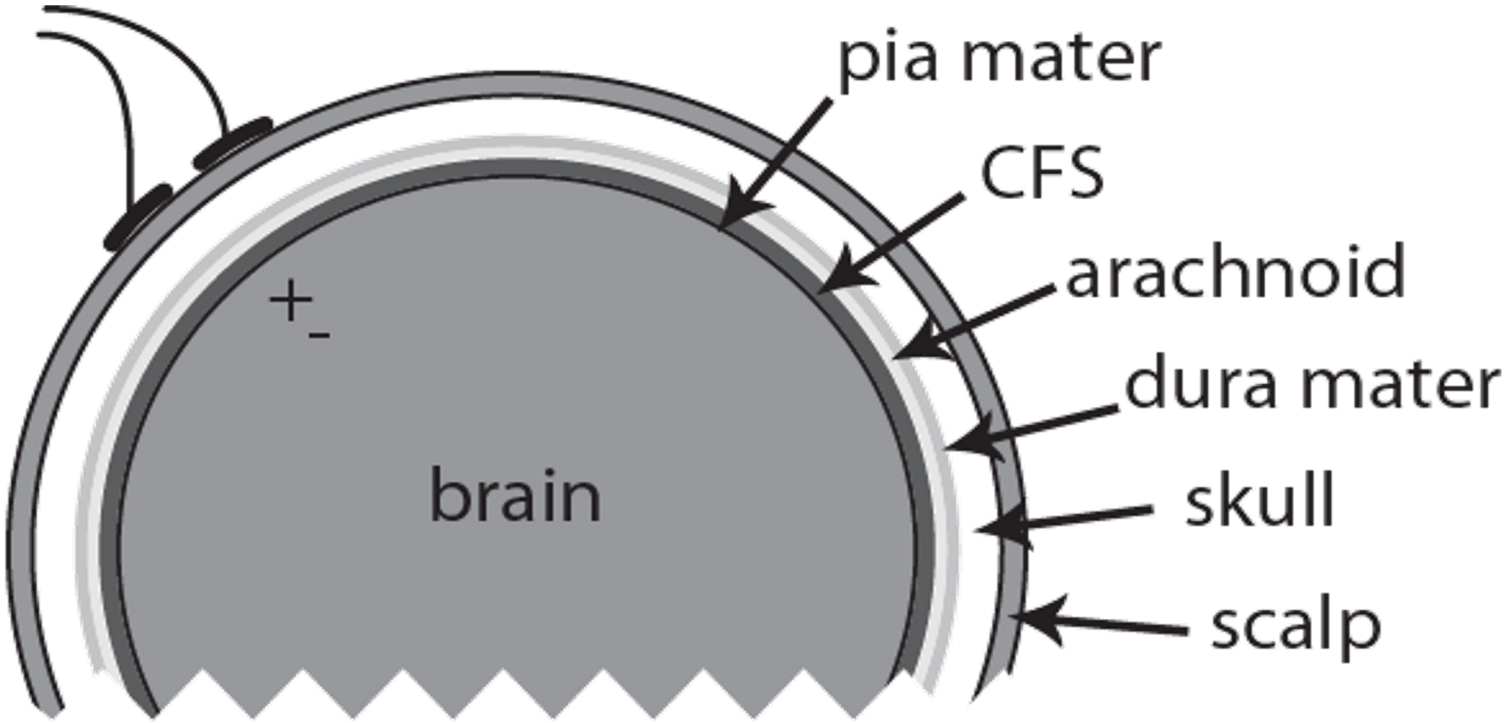


Figure 4.32 The 10-20 electrode system This system is recommended by the International Federation of EEG Societies. (From H. H. Jasper, "The Ten-Twenty Electrode System of the International Federation in Electroencephalography and Clinical Neurophysiology," *EEG Journal*, 1958, **10** (Appendix), 371–375.)

Transmisjon through the scull



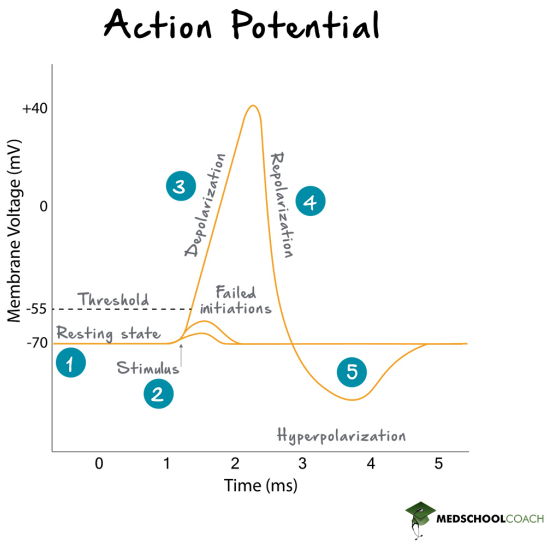
Source: Bioimpedance Bioelectricity Basics

EEG and MEG measure neural activity

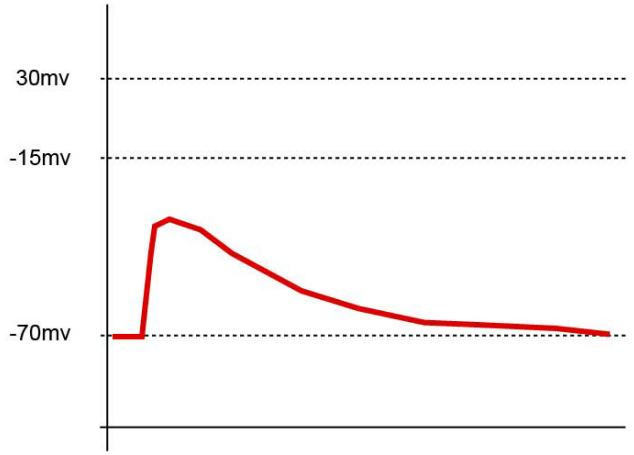
Not all neural activity is measured, e.g. are inhibitory inter-neurons not symmetrically oriented

Action potentials are biphasic – The potentials are normally cancelled

Postsynaptic potentials are monophasic and slow – Excellent for summation



https://www.medschoolcoach.com/action-potentials-refractory-period-and-summation-mcat-biology/



Wikipedia

EEG measurement

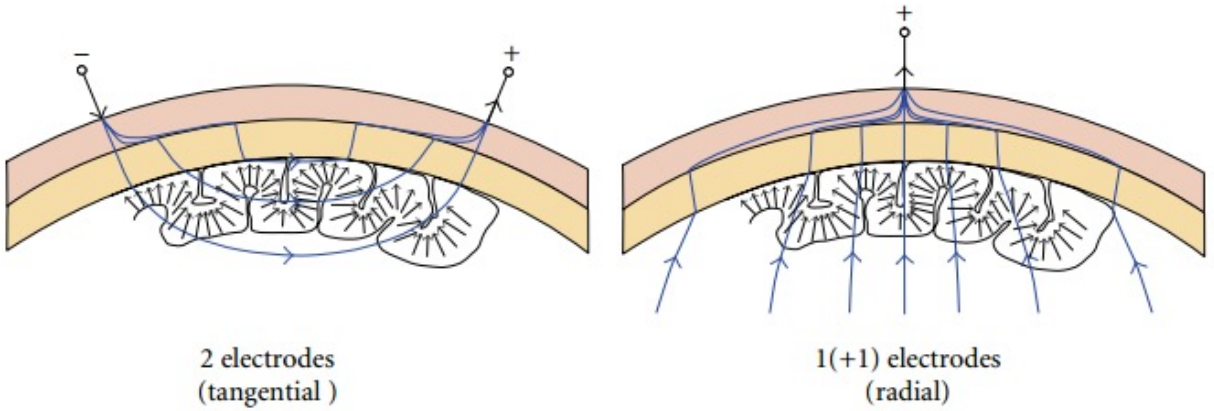


FIGURE 2: The Sensitivity Distributions of EEG. (Left) An EEG setup measuring the tangential components of neuroelectrical activity, where each bipolar lead is located relatively close to each other. (Right) An EEG setup measuring the radial components of neuroelectric activity, where the measuring electrode is located far from the reference electrode. The arrows in both figures represent macrocolumns of cellular architecture not dipolar sources.

The direction of the current is depending on the positioning of the electrodes, and the direction of the current decides the influence of the volume conductor with surrounding tissue

50 000 cells will generate a 10 nAm current (dipole source)

1. Katrina Wendel, Outi Väisänen, Jaakko Malmivuo, et al., “EEG/MEG Source Imaging: Methods, Challenges, and Open Issues,” Computational Intelligence and Neuroscience, vol. 2009, Article ID 656092, 12 pages, 2009. doi:10.1155/2009/656092

Source: Christian Tronstad

EEG-curves

Alpha 8-13 Hz, awake, quiet relaxed 20-200 uV. Disappear during sleep
Beta 14-30 Hz up to 50 Hz if intense mental activity. Beta 1 and beta 2. Affected by mental activity Beta 2 appear during intense activation of the CNS and during tension
Theta 4-7 Hz children, and emotional stress among some adults (disappointment and frustration)
Delta below 3.5 Hz, sometimes only every 2 or 3 second, deep sleep, infancy and serious organic brain diseases

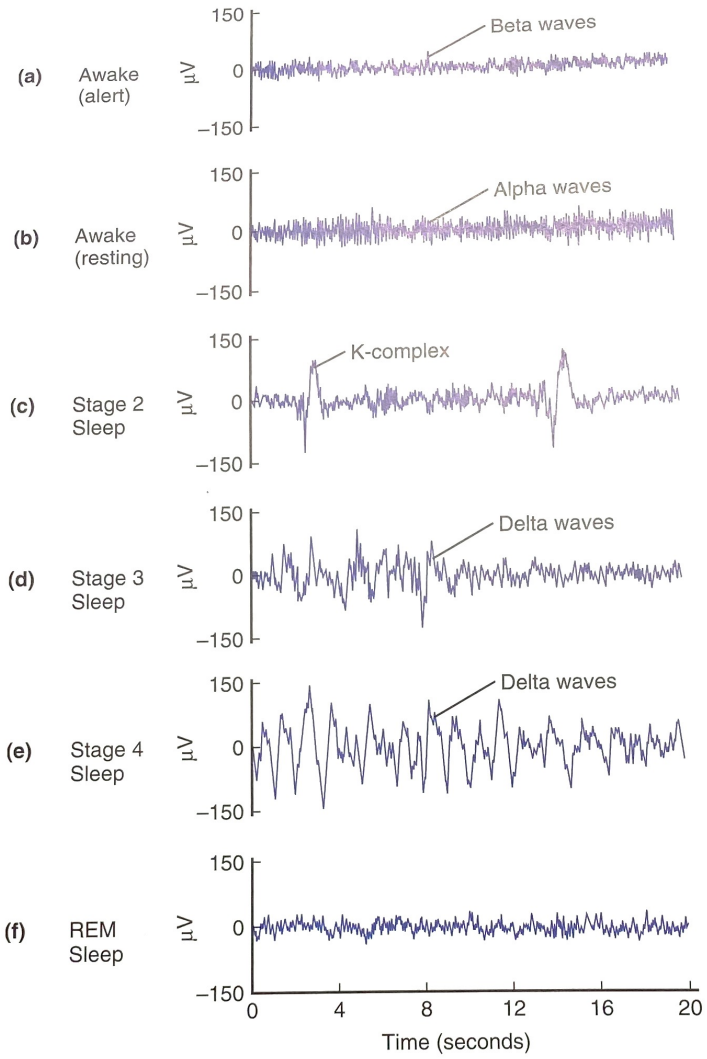
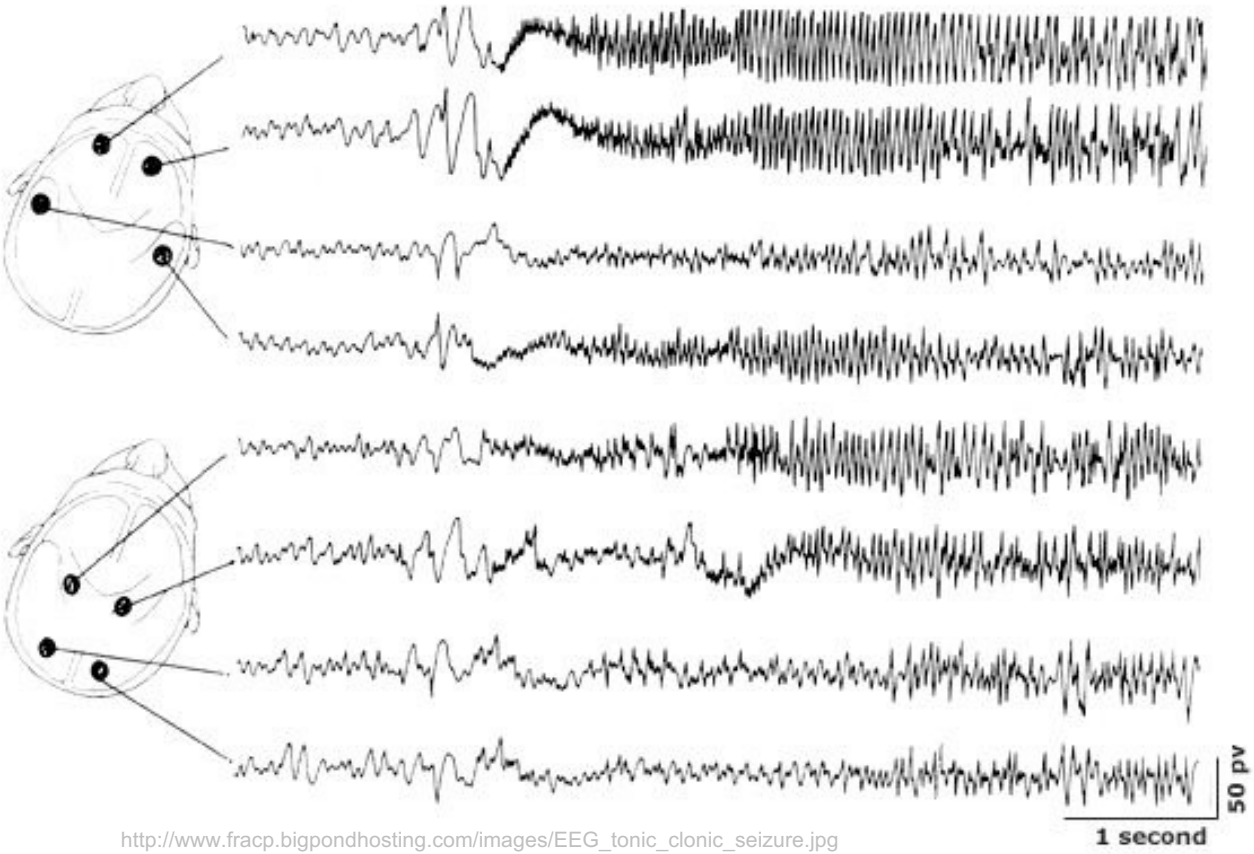


Figure 10.25 EEG recordings during wakefulness and sleep. These graphs are 20-second EEG samples recorded from a 21-year-old female subject. Amplitudes of EEG recordings are given in microvolts (μV), and frequencies are given in Hertz (Hz). (a) Waking EEG is characterized by high-frequency, low-amplitude waves. (b) During relaxed waking, alpha waves of 8–12 Hz are present in the EEG. (c) The EEG during stage 2 sleep is characterized by high-amplitude K-complexes (seen here at 3 and 14 seconds) and sleep spindles (12- to 15-Hz waves seen here at 6, 10, and 12 seconds). (d, e) High-amplitude delta (0.3–3 Hz) waves are present in stage 3 sleep and occupy the entire 20-second period in the sample of stage 4 sleep. (f) EEG amplitude decreases and frequency increases in REM sleep. (Data provided courtesy of I. G. Campbell, University of California, Davis.)

During which phase of sleep is electrical activity of the brain most synchronized?

EEG-signals



http://www.fracp.bigpondhosting.com/images/EEG_tonic_clonic_seizure.jpg

Exercise

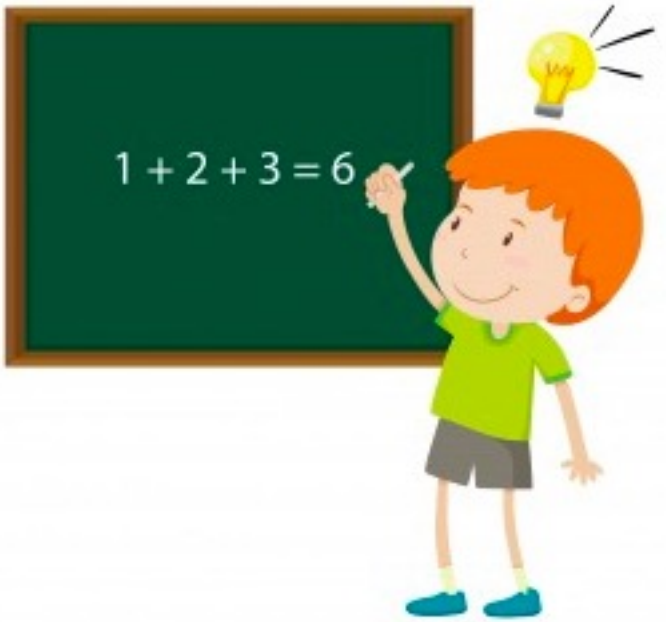
Form groups of 2 or 3 students, and discuss:

a. What considerations are important to think of when designing an EEG amplifier system?



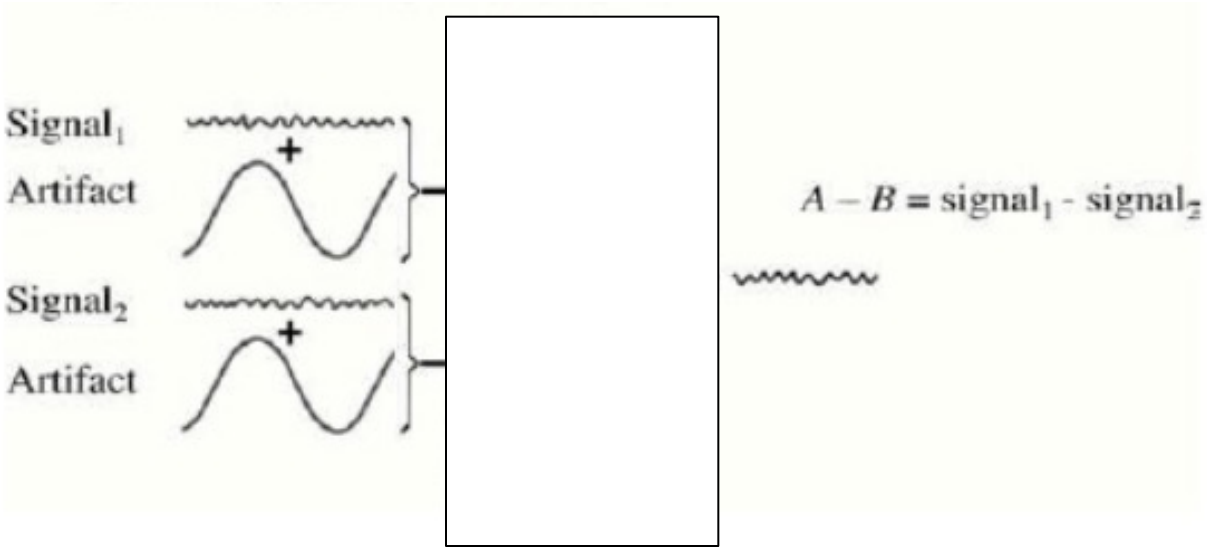
http://integrativeosteopathy.com.au/wp-content/uploads/2015/08/Exercise.jpg

Answers



a. The frequency range of interest (for filtering)
b. The signal amplitude (for amplification)
c. The wanted spatial or radial resolution (electrodes)
d. Sources of electromagnetic interference (for noise cancelling)
e. Filter properties, cut-off frequency, passband ripple, stopband attenuation, roll off sharpness
f. Polarisable or non-polarisable electrodes
g. Electrical protection of the body
h. Number of channels (= electrodes) and sampling rate
+++

EEG-amplifier



Biopotentail amplifiers

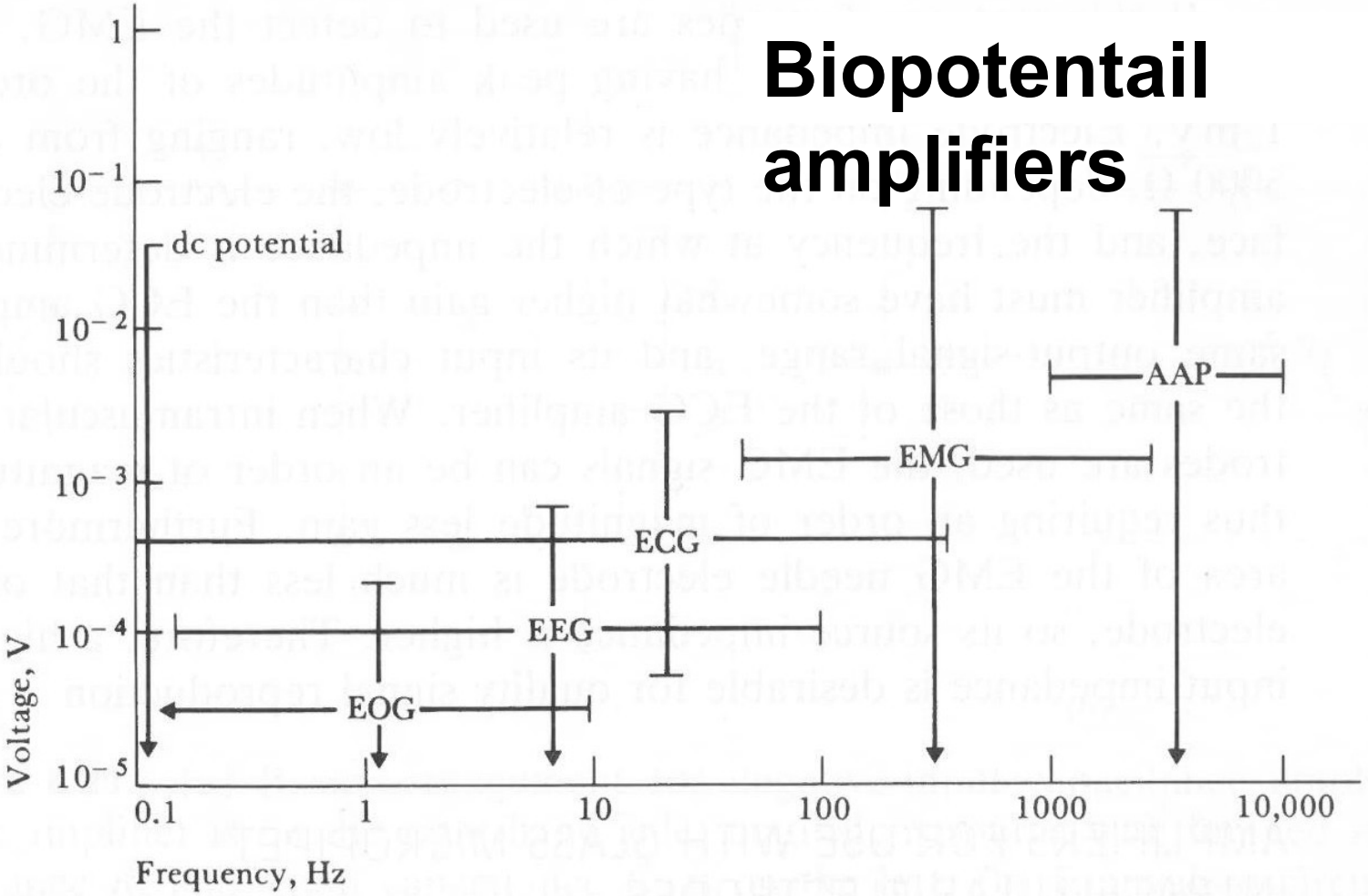
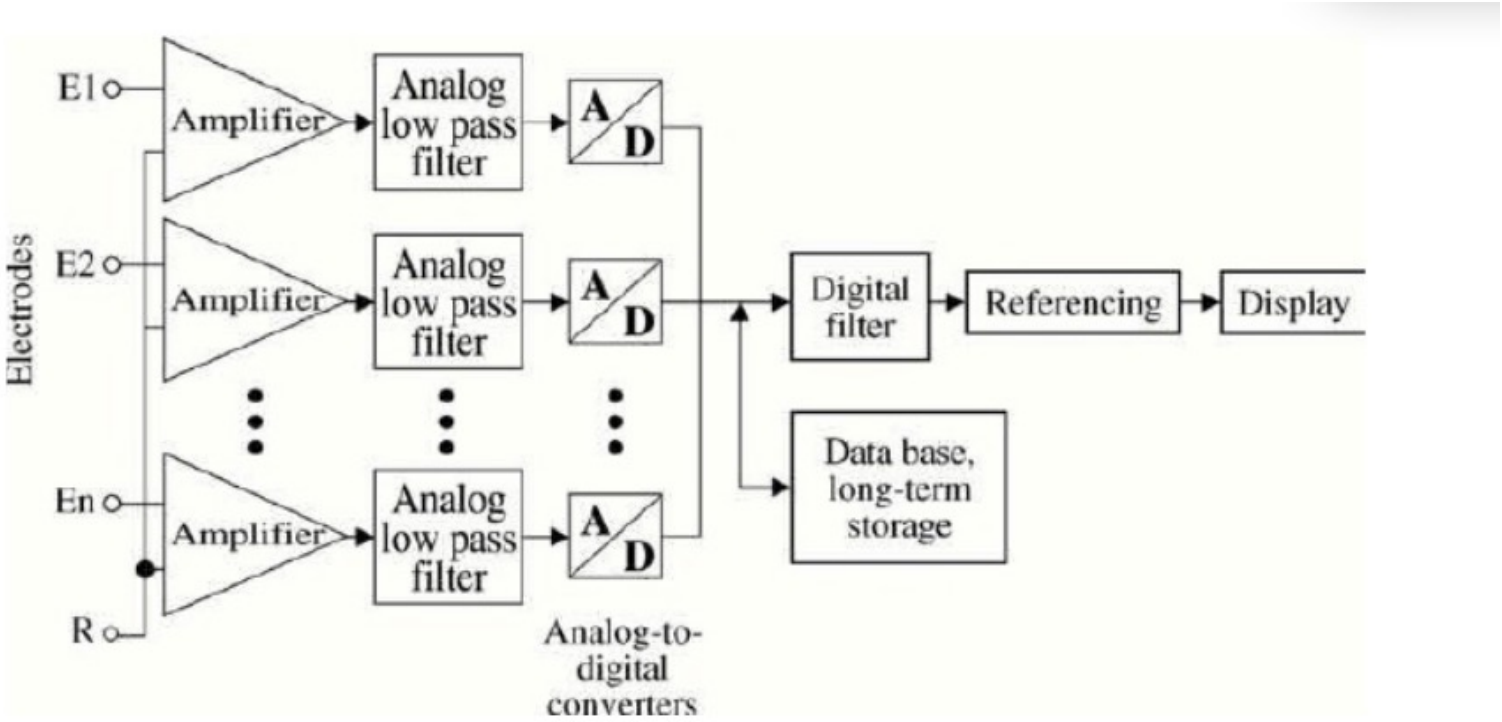
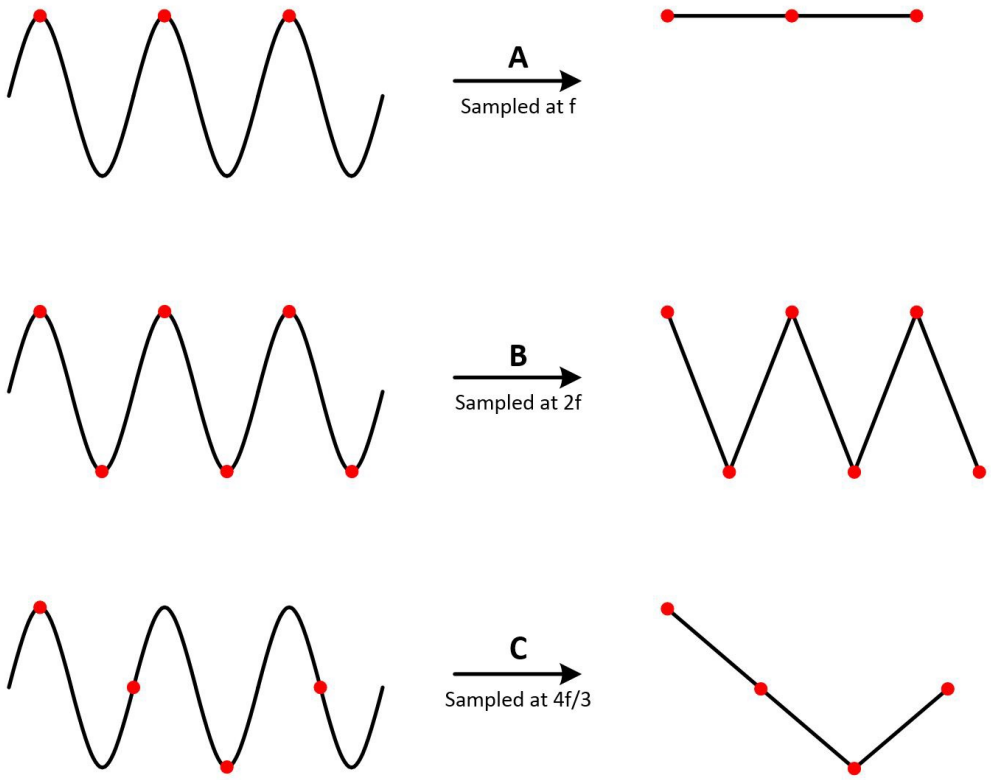


Figure 6.20 Voltage and frequency ranges of some common biopotential signals; dc potentials include intracellular voltages as well as voltages measured from several points on the body. EOG is the electrooculogram, EEG is the electroencephalogram, ECG is the electrocardiogram, EMG is the electromyogram, and AAP is the axon action potential. (From J.M.R. Delgado, "Electrodes for Extracellular Recording and Stimulation," in *Physical Techniques in Biological Research*, edited by W.L. Nastuk, New York: Academic Press, 1964.

A/D-conversion

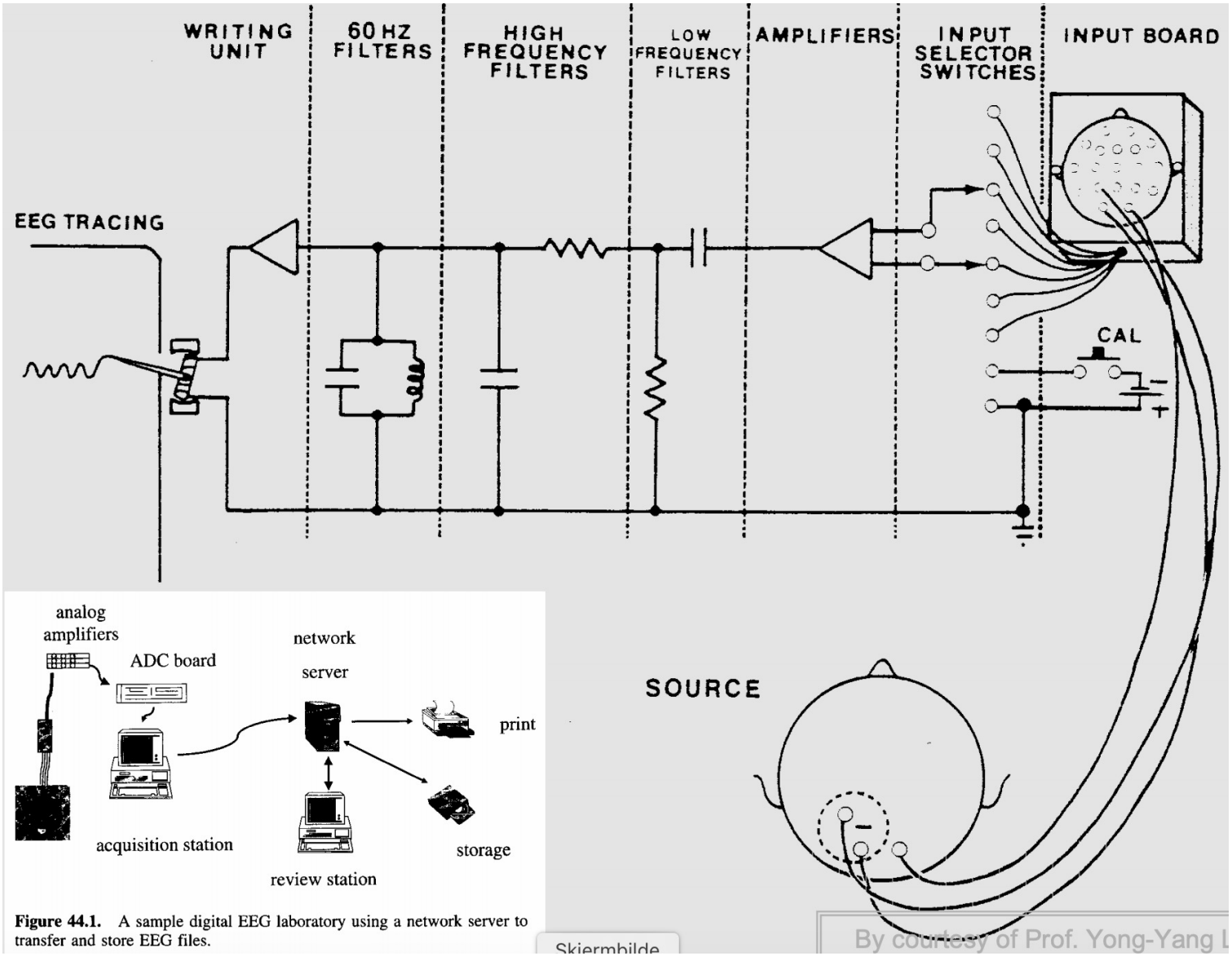


Nyquist theorem



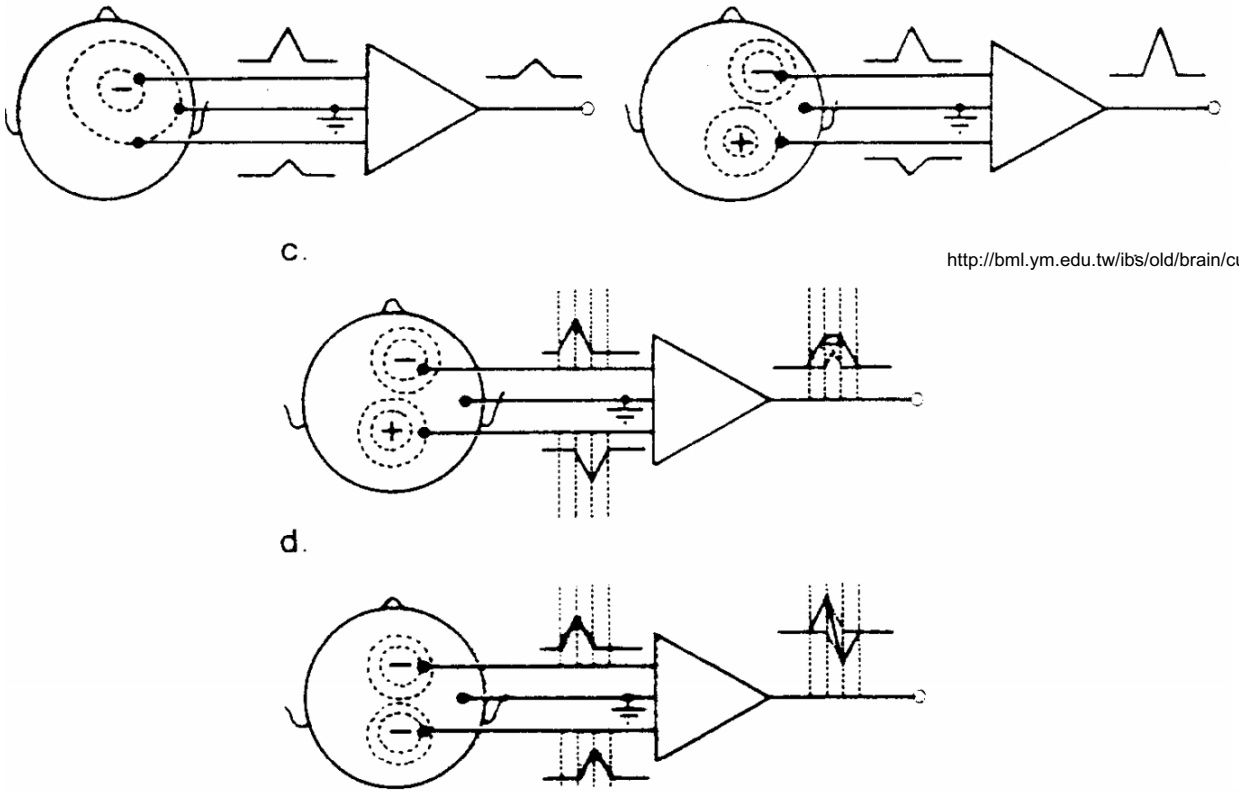
Sample rate = Minimum 2f (in practical life more)

EEG-amplification



http://bml.ym.edu.tw/ibs/old/brain/curricurium/952curricurium/file/MEG_EEG_Clinical%20applications.pdf

Differential amplification of signals



http://bml.ym.edu.tw/ibs/old/brain/curricurium/952curricurium/file/MEG_EEG_Clinical%20applications.pdf

Fig. 3.1. Differential amplification of simple signals, applied to input 1 (top input at the triangular amplifier symbol) and input 2 (bottom input) with respect to an electrical zero level at the ground connection (middle input). Electrical changes at scalp electrodes are indicated by fields on the head diagram; a change towards negative in an electrode is indicated by an upward deflection of the signal above or below the electrode lead; a change towards positive is indicated by a downward deflection. The same polarity convention is used for the signals at the amplifier output which represent pen deflections. – a. A negative signal at input 1 causes an upgoing pen deflection; – b. A positive signal at input 2 is inverted at the ground level and also causes an upgoing pen deflection; – c. Two signals of equal size but opposite polarity appearing simultaneously at both inputs are added to each other and cause a pen deflection twice the size of that caused by each potential alone; – d. Two signals of equal size and the same polarity applied simultaneously to both inputs are subtracted from each other and cause no pen deflection.

Case 12



After controlling the tonic-clonic seizure, the doctors wonders what might be the source of the epileptic activity. Additional EEG's after the seizures are all negative, and no abnormalities can be found CT scan, nor are there any findings from the MRI-scan.

In order to explore possible neurological diseases, they decide to measure the neural velocity

EMG

Cross sectional view of the spinal cord. A method for distinguishing between myopathic and neurogenic muscle weakness and wasting

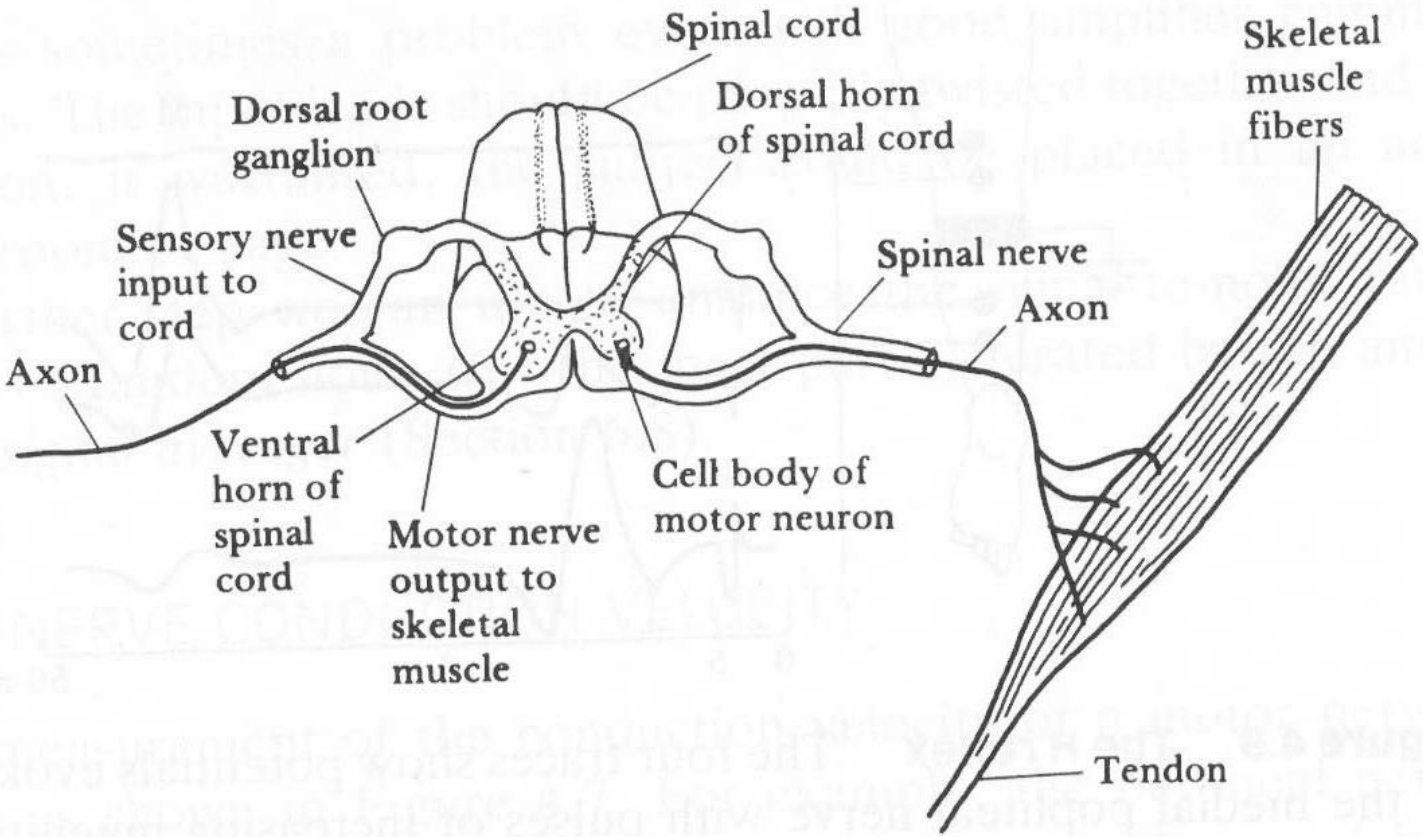
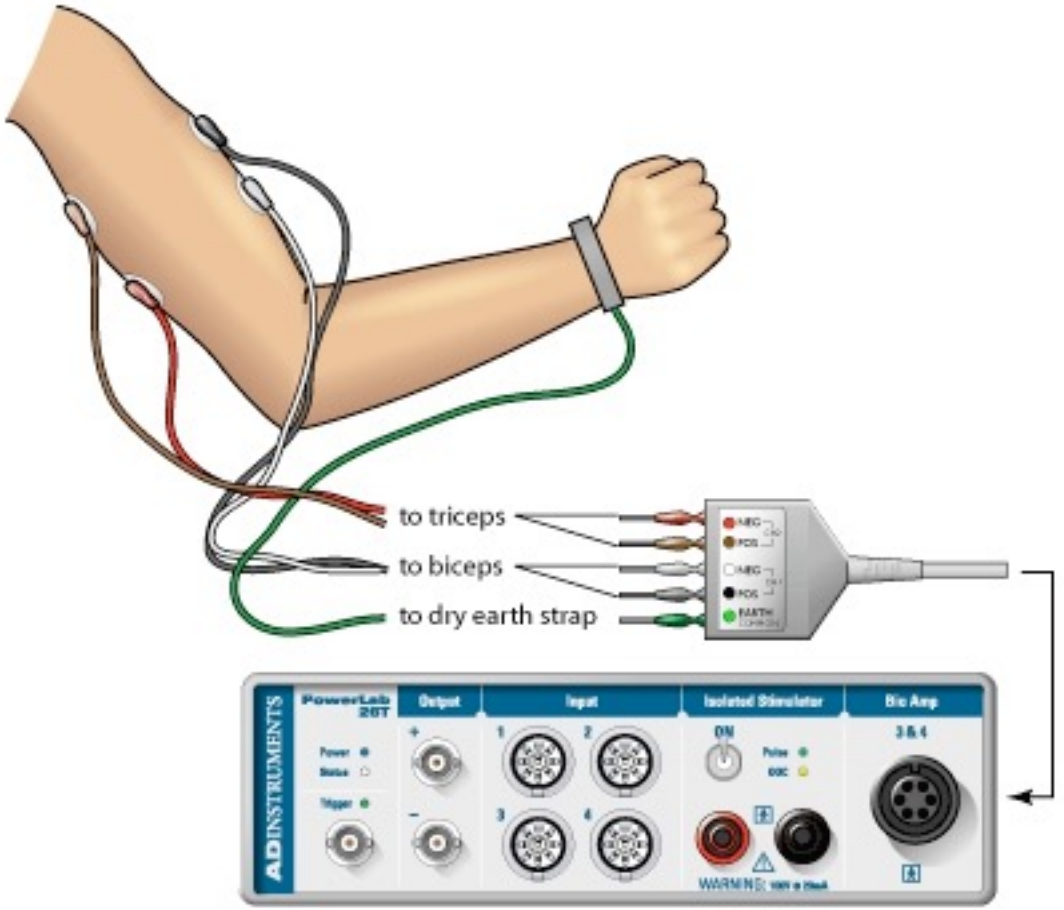


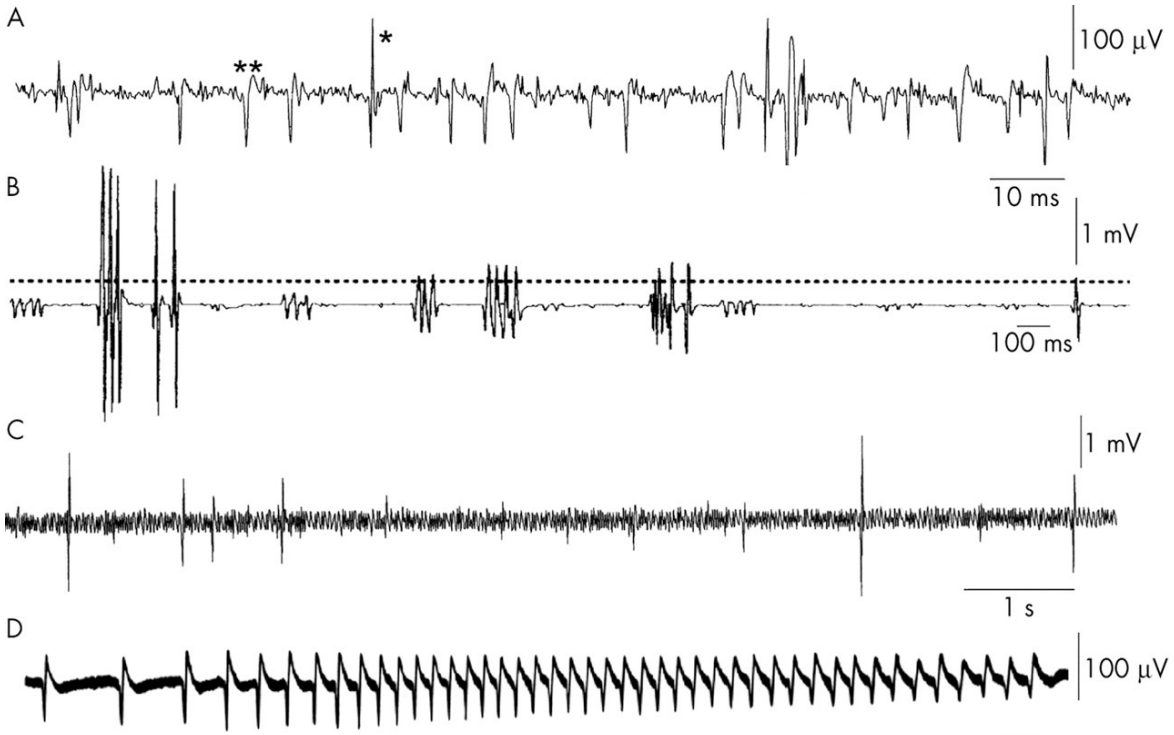
Figure 4.10 Diagram of a single motor unit (SMU), which consists of a single motoneuron and the group of skeletal muscle fibers that it innervates.

EMG setup



http://www.adinstruments.com/sites/default/files/images/rcexp_SEMG-example.jpg

EMG



http://jnnp.bmj.com/content/76/suppl_2/ii32/F1.large.jpg

Abnormal spontaneous activity. (A) Fibrillations (*) and positive sharp waves (**) in an acutely denervated hand muscle. (B) Single, doublet, triplet, and multiplet motor unit neuromyotonic discharges. Bursts of discharge are irregular in frequency and the intra-burst frequency of discharge is up to 200 Hz. (C) Fasciculations in the tongue in a patient with amyotrophic lateral sclerosis. The single discharges are irregular and occur on a background of ongoing EMG activity caused by poor relaxation. (D) Myotonic discharges in a patient with dystrophia myotonica. There is a characteristic waxing and waning in frequency

Exercise

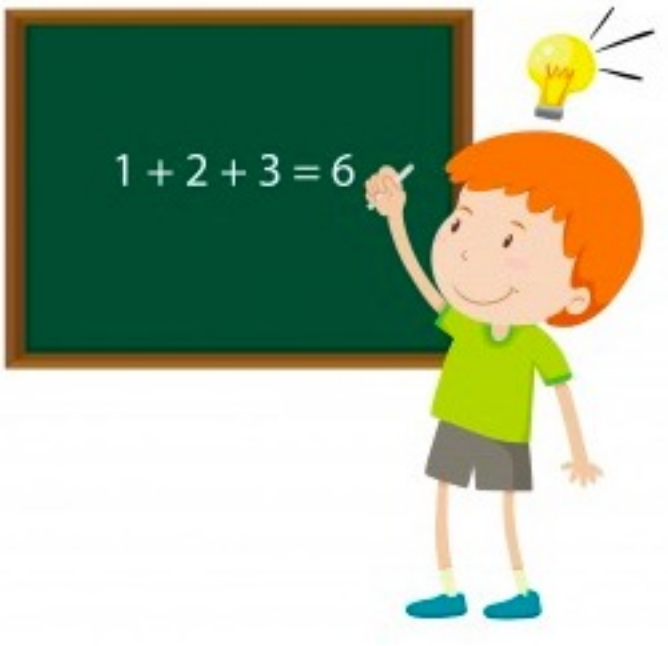
Form groups of 2 or 3 students, and discuss:

a. What are the main disadvantages of recording EMG by using surface electrodes?



http://integrativeosteopathy.com.au/wp-content/uploads/2015/08/Exercise.jpg

Answers



a. The main disadvantages are:

- Can measure superficial muscles only
- Are sensitive to electrical activity from other tissues
- Prone to common mode noise
- Need to use the right type of electrodes (low resistance, non-polarizable)

Magnetoencefalography (MEG)



http://conic.ntu.edu.sg/Facilities/Magnetoencephalography_MEG/PublishingImages/10.png

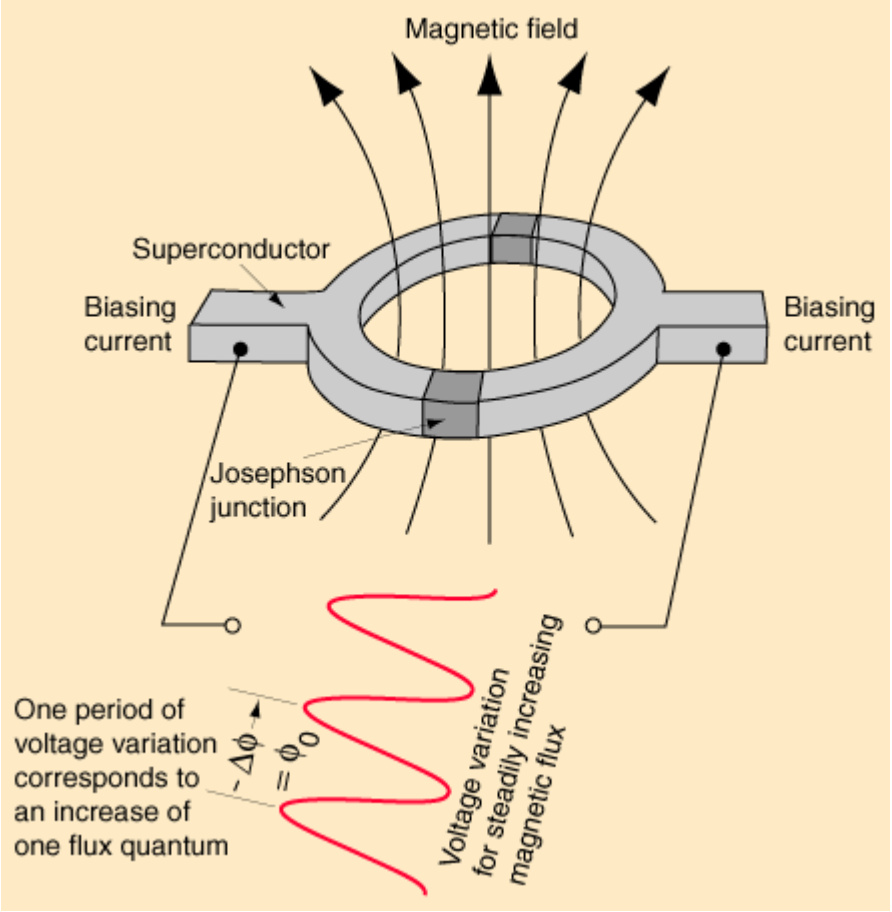
SQUID- Superconducting Quantum Interference Device

We need a supersensitive detector in order to measure the small changes in magnetic flux = SQUID

A superconductor measuring field changes (V) in the order of 10^{-15} Tesla.

Using Helium for superconducting, just as the MRI-scanner

Flux transformers =M coils



SourceL J Clarke, Scientific American 1994

Magnetometers and gradiometers

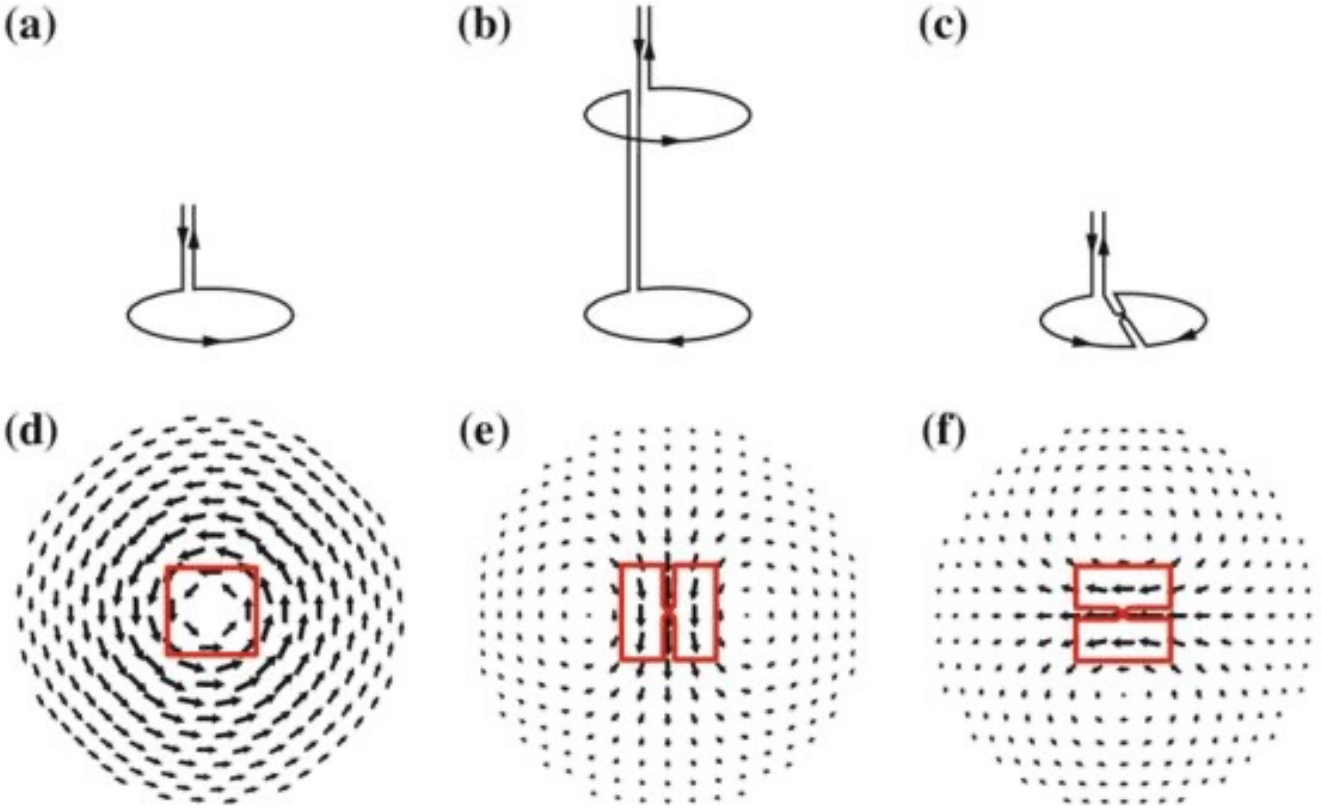
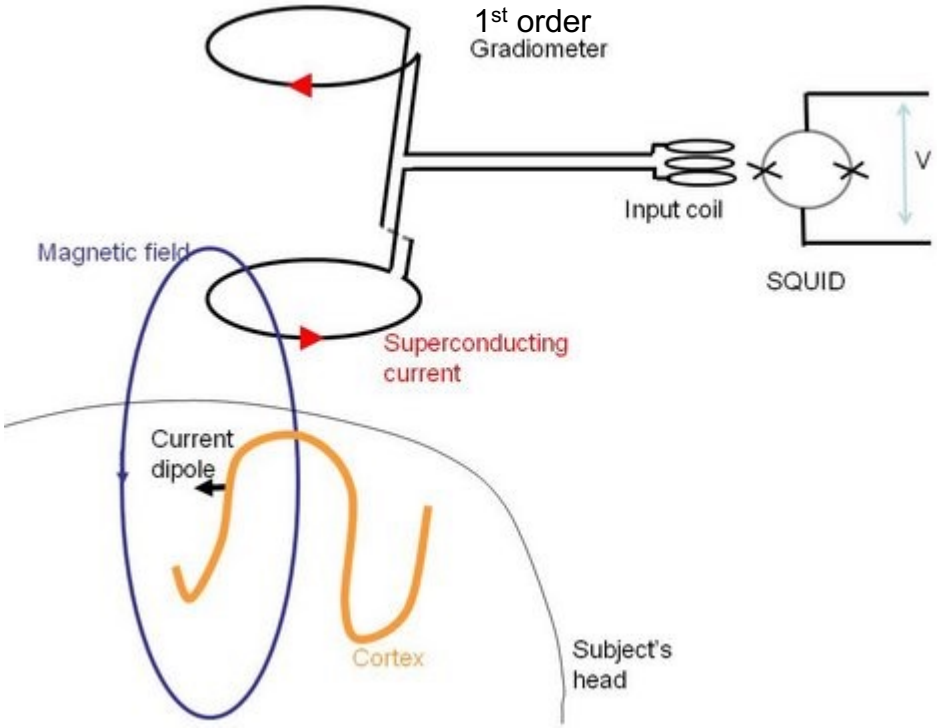


Fig. 4 Some pick-up coil geometries: a magnetometer, b co-axial first-order gradiometer, and c planar first-order gradiometer. The leadfield, or sensitivity, patterns of d magnetometer and axial gradiometer measuring B z , e planar gradiometer measuring dB z =dx, and f planar gradiometer measuring dB z =dy

https://www.researchgate.net/publication/287121844_Novel_Noise_Reduction_Methods/figures?lo=1

Flux transformers and SQUIDS

1. Neural population becomes active, current and magnetic field is created.
2. Changes in magnetic flux → current flow in superconducting sensor coil
3. Change in superconducting current is transferred through input coil to SQUID
4. This induces magnetic flux across SQUID which also induces a change in voltage.

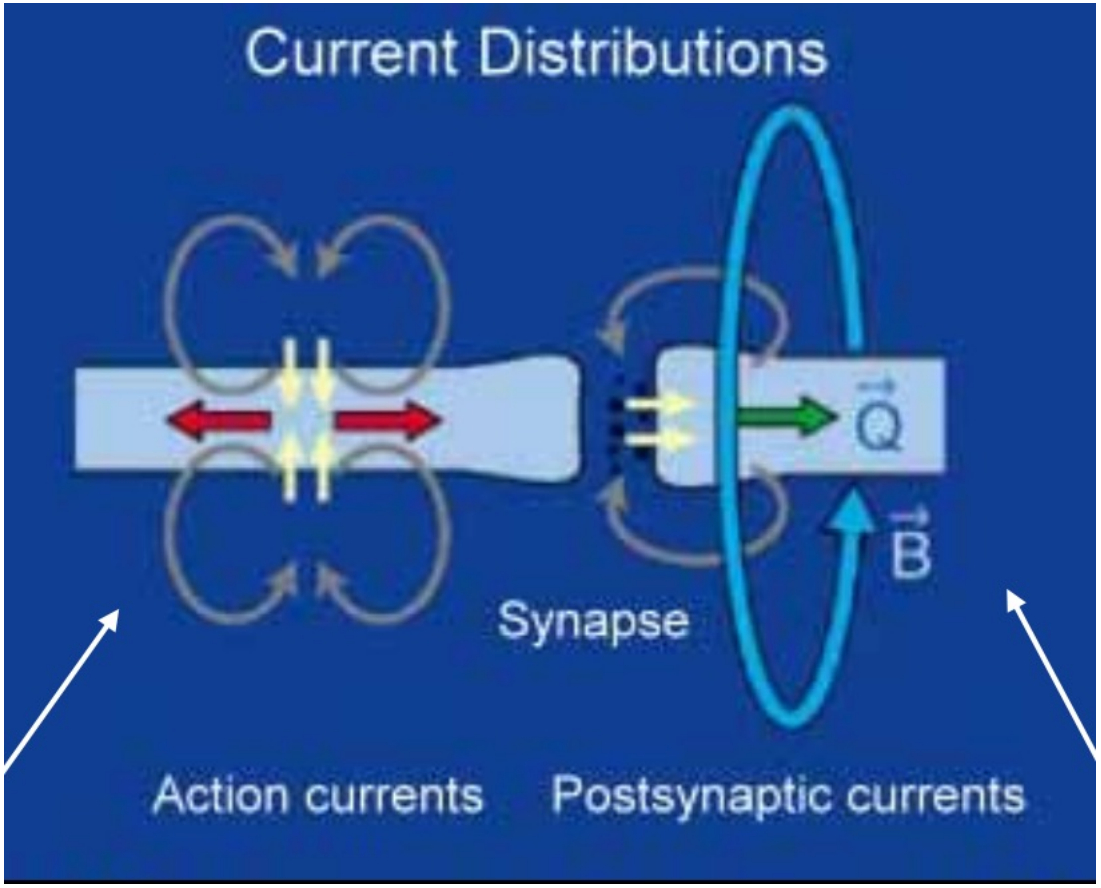


The flux transformer here has two coils. Good for minimizing noise because the magnetic field decreases very sharply with distance.

Source: James Bonaiuto Institut des Sciences Cognitives, CNRS, Lyon, France

Origin of the MEG-signal

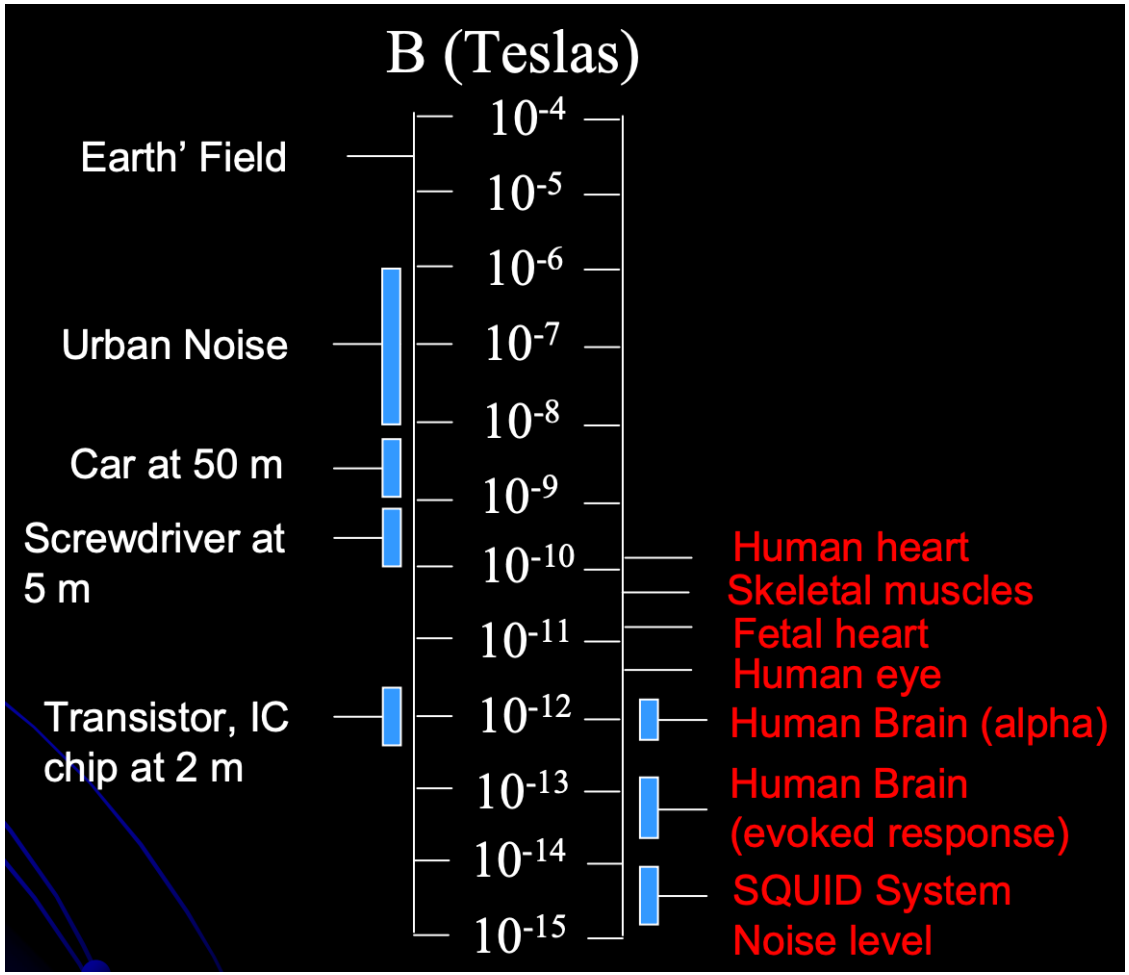
Because he current is bidirectional in the axon, the two dipoles will cancel each other



Because he current is unidirectional in the postsynapse, there will be a magnetic field

http://bml.ym.edu.tw/ibs/old/brain/curricurium/952curricurium/file/MEG_EEG_Clinical%20applications.pdf

Magnetic fields

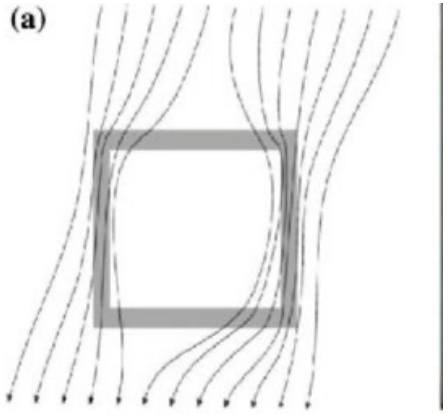


The signal is extremely weak, magnetically shielded rooms necessary

Magnetic fields – shielded room

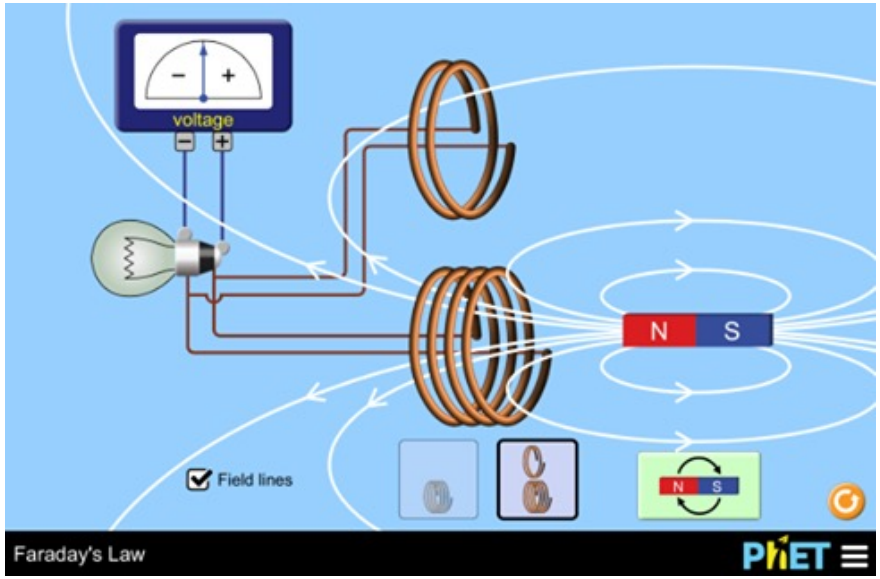


https://www.researchgate.net/publication/273518073_Meg_for_Kids_Listening_to_Your_Brain_with_Super-Cool_SQUIDs/figures?lo=1



https://www.researchgate.net/publication/287121844_Novel_Noise_Reduction_Methods/figures?lo=1

Faradays law of induction



Source: Electronicslovers.com

Faraday's Law of Induction

The magnitude of the emf induced in a conducting loop is equal to the rate at which the magnetic flux through that loop changes with time.

$$\mathcal{E} = -\frac{d\Phi_B}{dt} \text{ (Faraday's law)}$$

If we change the magnetic flux through a coil of N turns, an induced emf appears in every turn and the total emf induced in the coil is the sum of these individual induced emfs.

$$\mathcal{E} = -N\frac{d\Phi_B}{dt} \quad (\text{coil of } N \text{ turns}) .$$

https://i.stack.imgur.com/ZCMN1.jpg

Magnetoencefalography (MEG)

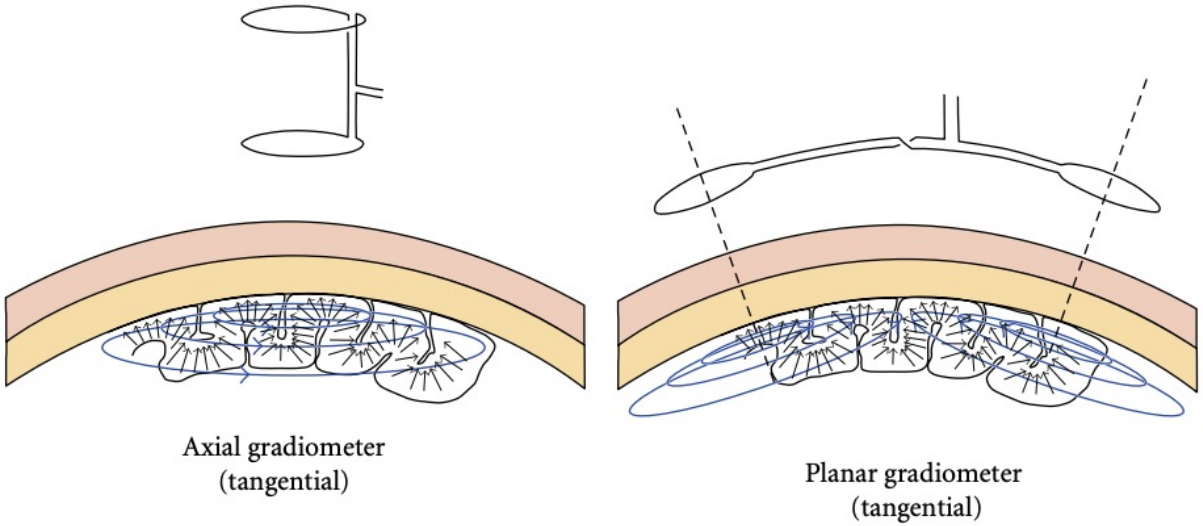


FIGURE 3: The Sensitivity Distributions of MEG. (Left) An MEG setup measuring the tangential components of neuroelectrical activity, using an axial gradiometer. (Right) An MEG setup measuring the tangential components of neuroelectric activity, using a planar gradiometer. The arrows in both figures represent macrocolumns of cellular architecture not dipolar sources.

What is one major limitation in MEG? Answer: Depth

Wendel: EEG/MEG Source Imaging: Methods, Challenges, and Open Issues

Advantages of MEG compared to fMRI and EEG

- MEG alone provides both timing as well as spatial information of the brain activity
- fMRI reflects brain activity (by measuring oxygenation of blood near the neuronss), while MEG measures directly neural activity
- MEG can be used on sleeping subjects
- No movement artefacts
- Sub-millisecond presicion, fMRI provides poor temporal information

http://ilabs.washington.edu/what-magnetoencephalography-meg

ERG

Electroretinogram

Eye 24 mm in diameter. Light transmitting parts -> cornea, anterior chamber, lens and vitreous chamber

A transparent fluid is found in the anterior chamber, vitreous chamber is filled with a transparent gel

Normal pressure 20 – 25 mmHg, necessary for a clear visual image

Glaucoma = high pressure condition, injure the retina. Caused by obstruction of flow between blood and fluid

5 types of nerve cells:

Photoreceptors, bipolar, horizontal, amacrine and ganglion cells (axons)

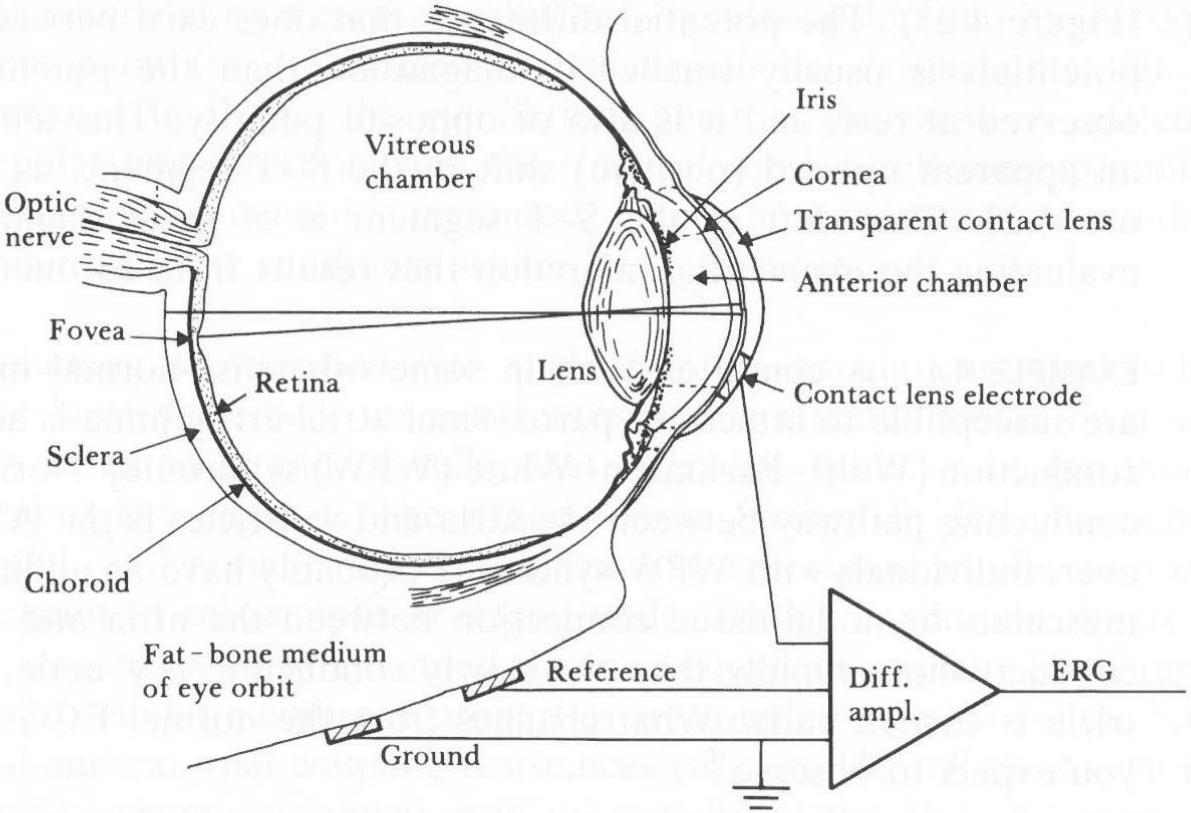


Figure 4.25 The transparent contact lens contains one electrode, shown here on horizontal section of the right eye. Reference electrode is placed on the right temple.

ERG

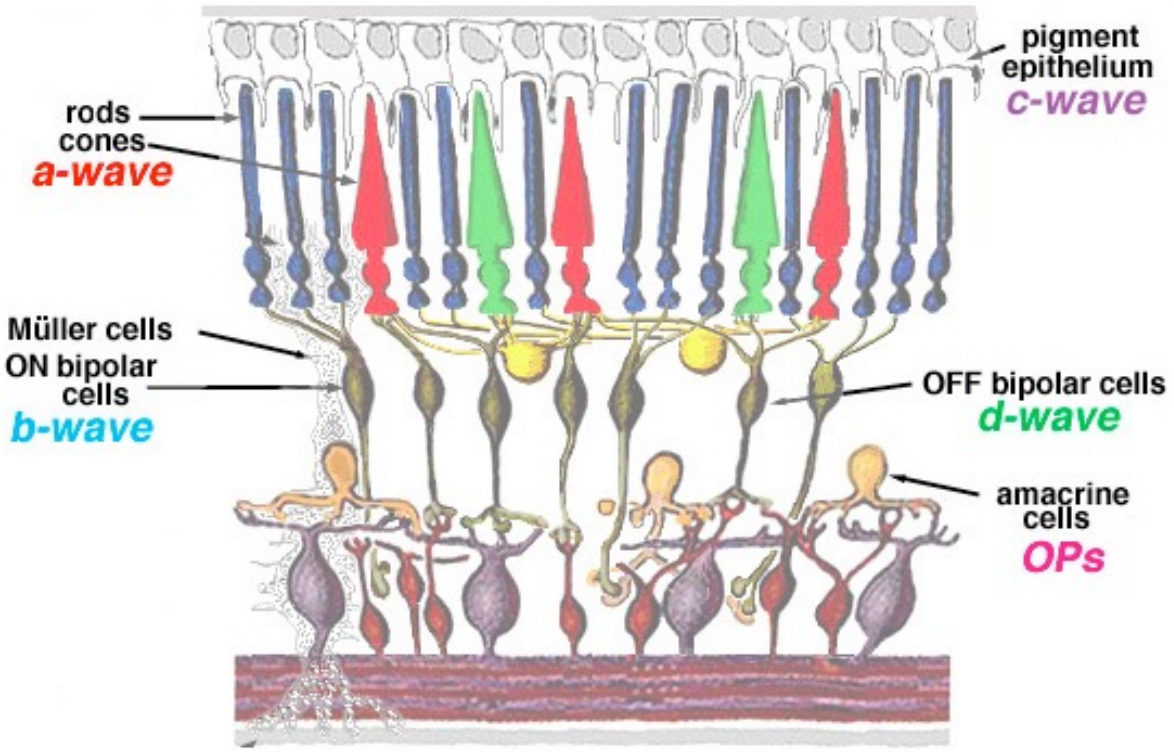


Fig.3 Cartoon of the retina to show where the major components of the ERG originate.

http://webvision.med.utah.edu/gifswv/DONFig3.gif

ERG

A - Early receptor potensial ERP + late receptor potensial LRP
B- Bipolare og ganglion cells in inner layer of retina
C – pigment epitel-celler
D- av-respond til retina
Early receptor potential (ERP) light-induced changes in photopigment molecules (first pa
Late receptor potential (LRP) output of the photoreceptors (second part)

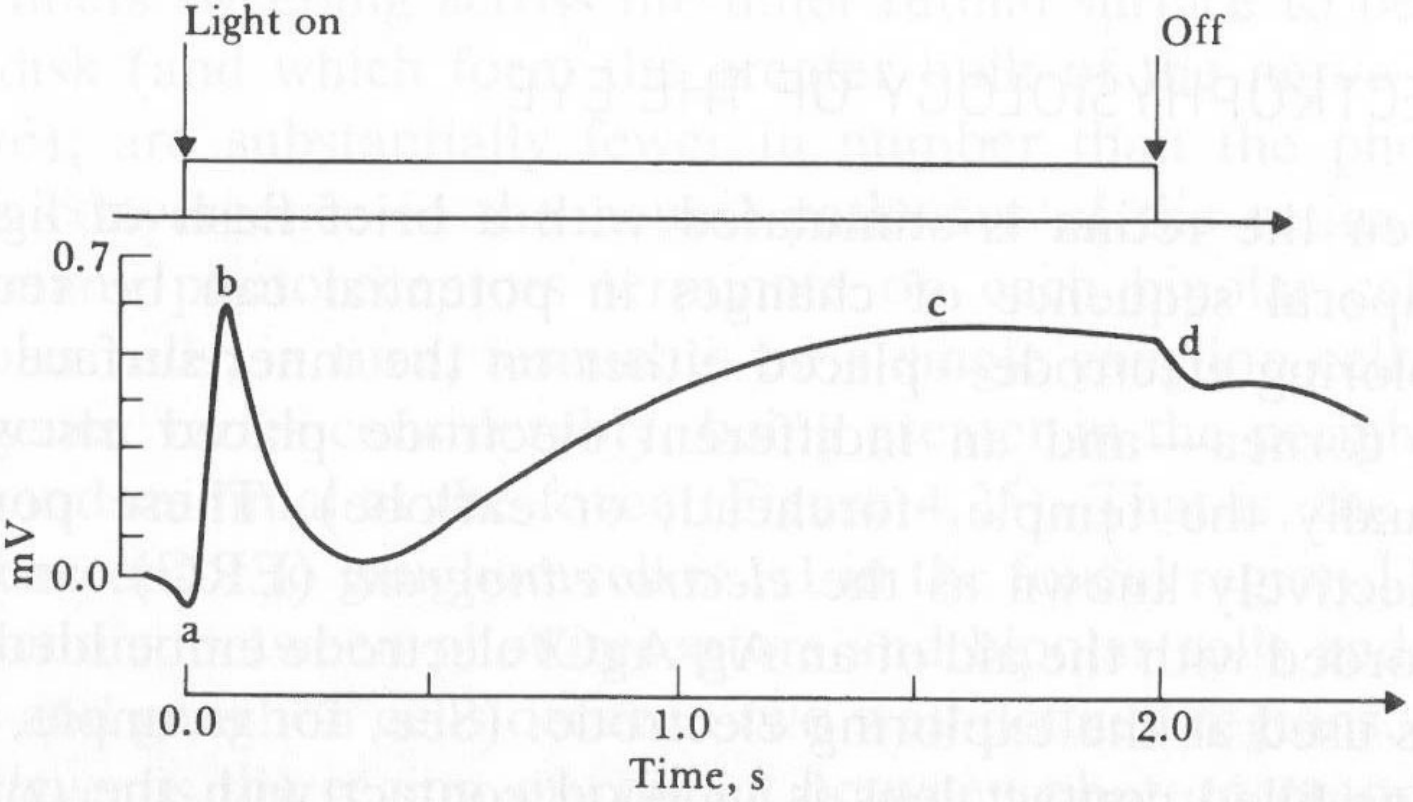


Figure 4.26 Vertebrate electroretinogram

ERG

Figure 1: Summary of classic electrophysiological findings in retinal dystrophies.

	Rod Specific	Maximum Scotopic Responses	Photopic 30 Hz Flicker	Transient Photopic
Normal	b-wave	b-wave, a-wave		b-wave
	Rod function	Mixed rod and cone function	Cone function	Cone function
Complete CSNB		electronegative b-wave, a-wave		b-wave
	Undetectable	Electronegative	Simplified waveform	Borderline normal
Rod Monochromatism	b-wave	b-wave, a-wave		blink artifact
	Normal	Moderate reduction	Undetectable	Undetectable
Cone Dystrophy	b-wave	b-wave, a-wave		b-wave
	Normal	Moderate reduction	Small and slow	Small and slow
RP		b-wave, a-wave		b-wave
	Extinguished	Small and slow	Small and slow	Small and slow

Scale: 50 µvolts, 50 ms | 100 µvolts, 50 ms | 50 µvolts, 50 ms | 20 µvolts, 50 ms

http://www.retinalphysician.com/content/archive/2007/April/jpg%5C9FF1.jpg

MEG and EEG

- Both measuring aggregated signals of postsynaptic currents from tens of thousands of pyramidal cells + some contribution from action potentials and other cell types generating electric signals
- EEG is more sensitive to deep signals, but is more influenced by changes in conductivity on the way through the brain, skull and scalp
- MEG is more sensitive to tangetial than to radial changes in magnetic flux, EEG is good at both
- The signals are extremely weak, high demands to amplifiers and measuring systems SNR.
- The higher the sensitivity, the more noise
- Excellent temporal resolution (1 ms or less), quite good spatial resolution
- Non-invasive methods

Case 12



All tests are perfectly normal, except for one thing: The Urine toxicology screen is positive for cocaine.

What is your conclusion?

Case 12



The patient was trying to smuggle cocaine into the country by swallowing one or more condoms filled with cocaine. One of the condoms cracks, not a big crack, but enough for allowing a significant amount of cocaine to flow into the intestines and into the blood. This led to a status epilepticus caused by the cocaine, and explains the hypertension as cocaine is highly vasoconstrictive, thus increasing the blood pressure dramatically when the body absorbs large amounts of the drug.