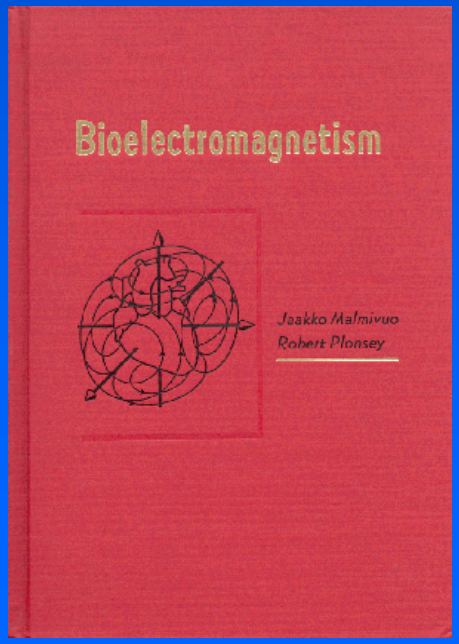
BIOELECTRO-MAGNETISM

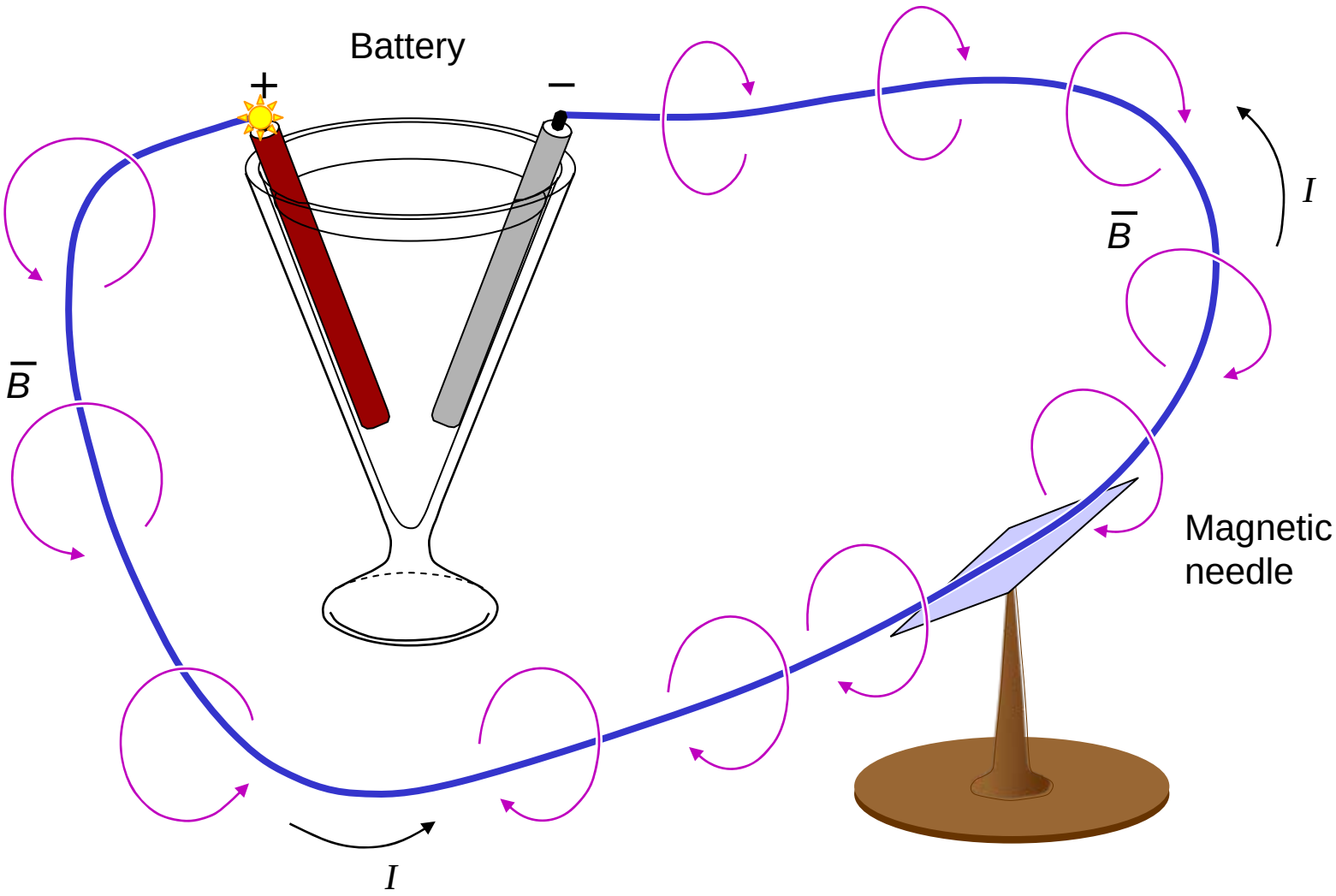
Jaakko Malmivuo

Demonstration slides

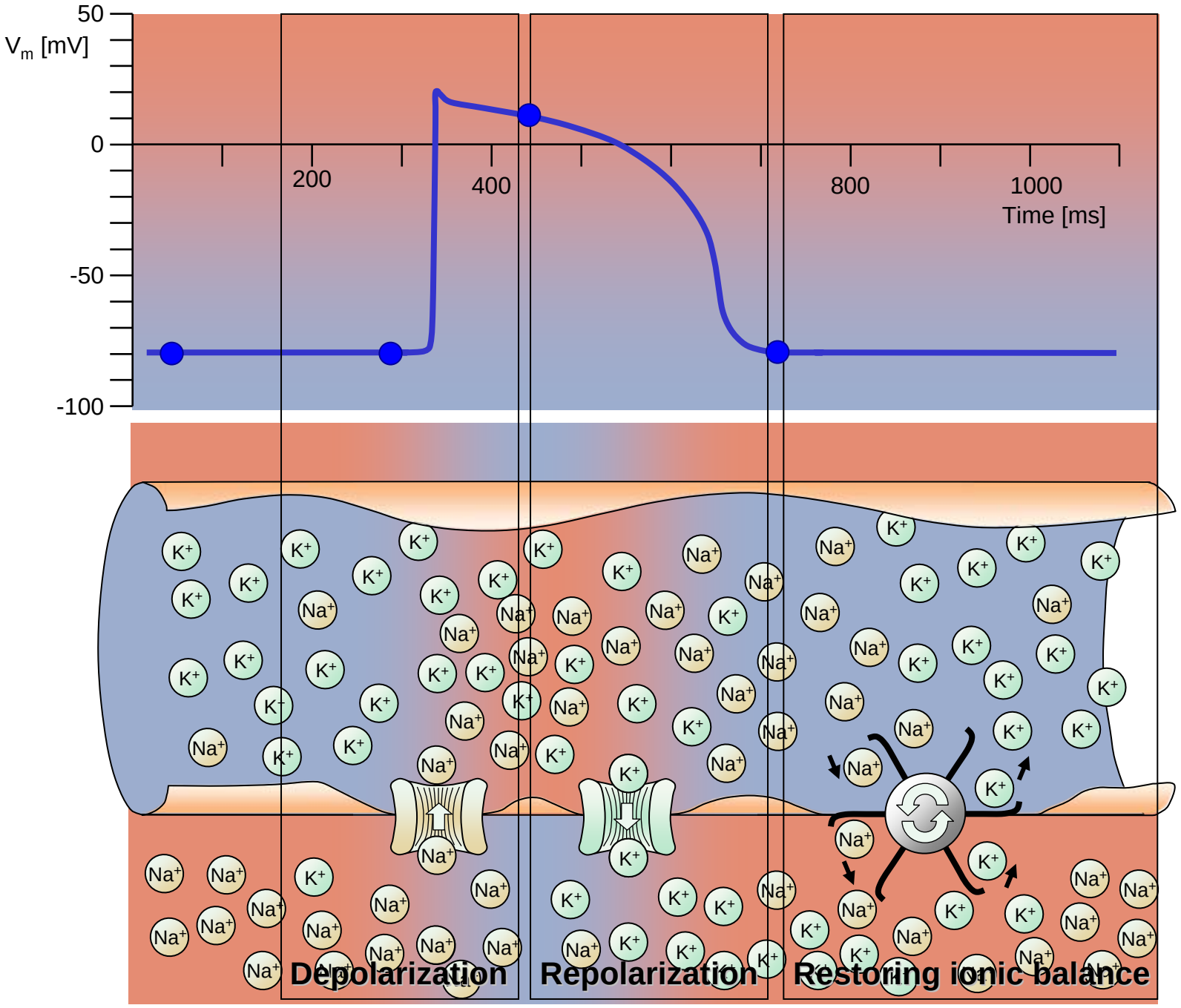


$\eta\lambda\varepsilon\kappa\tau\rho o\nu$ = amber

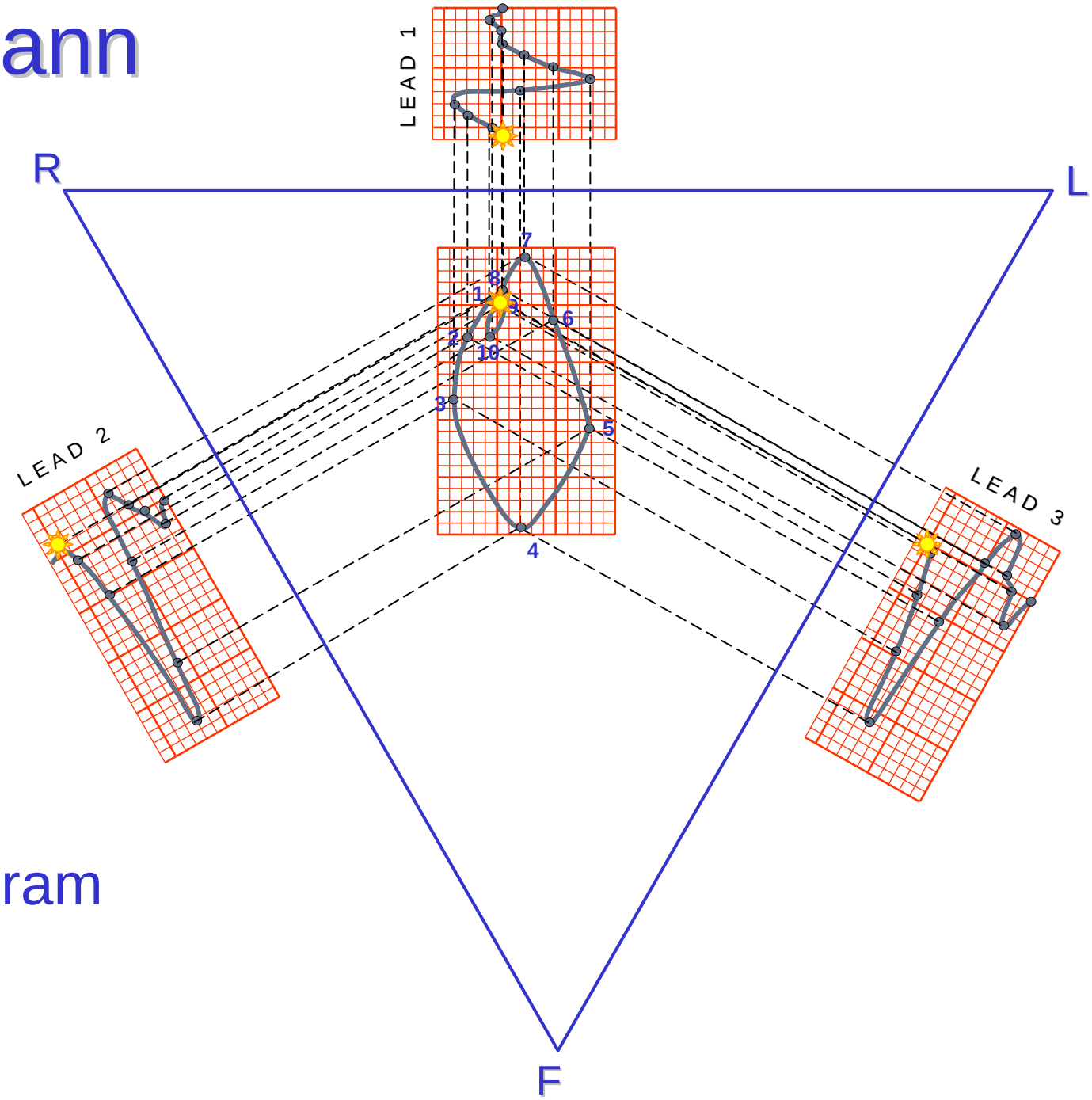
Hans Christian Örsted 1819



Generation of bioelectric signal

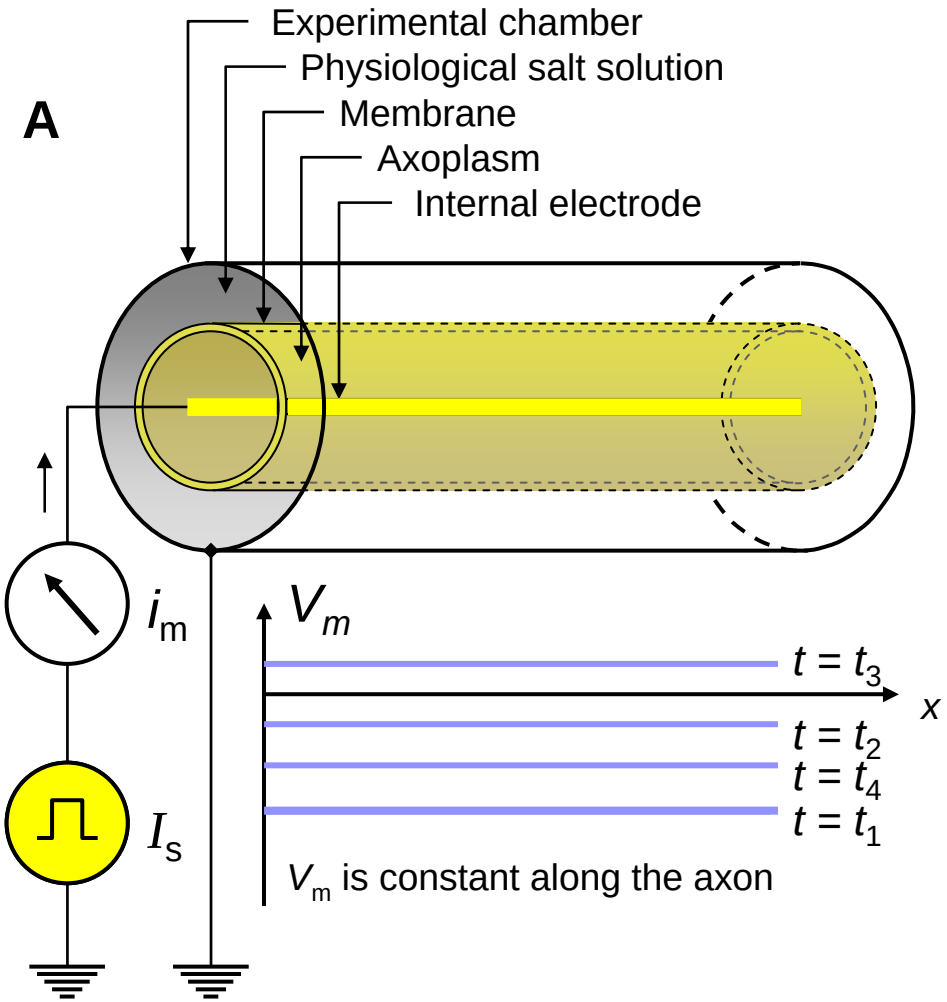


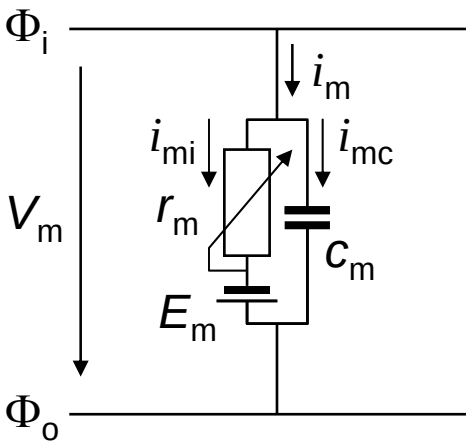
Hubert Mann



Monocardiogram
1916

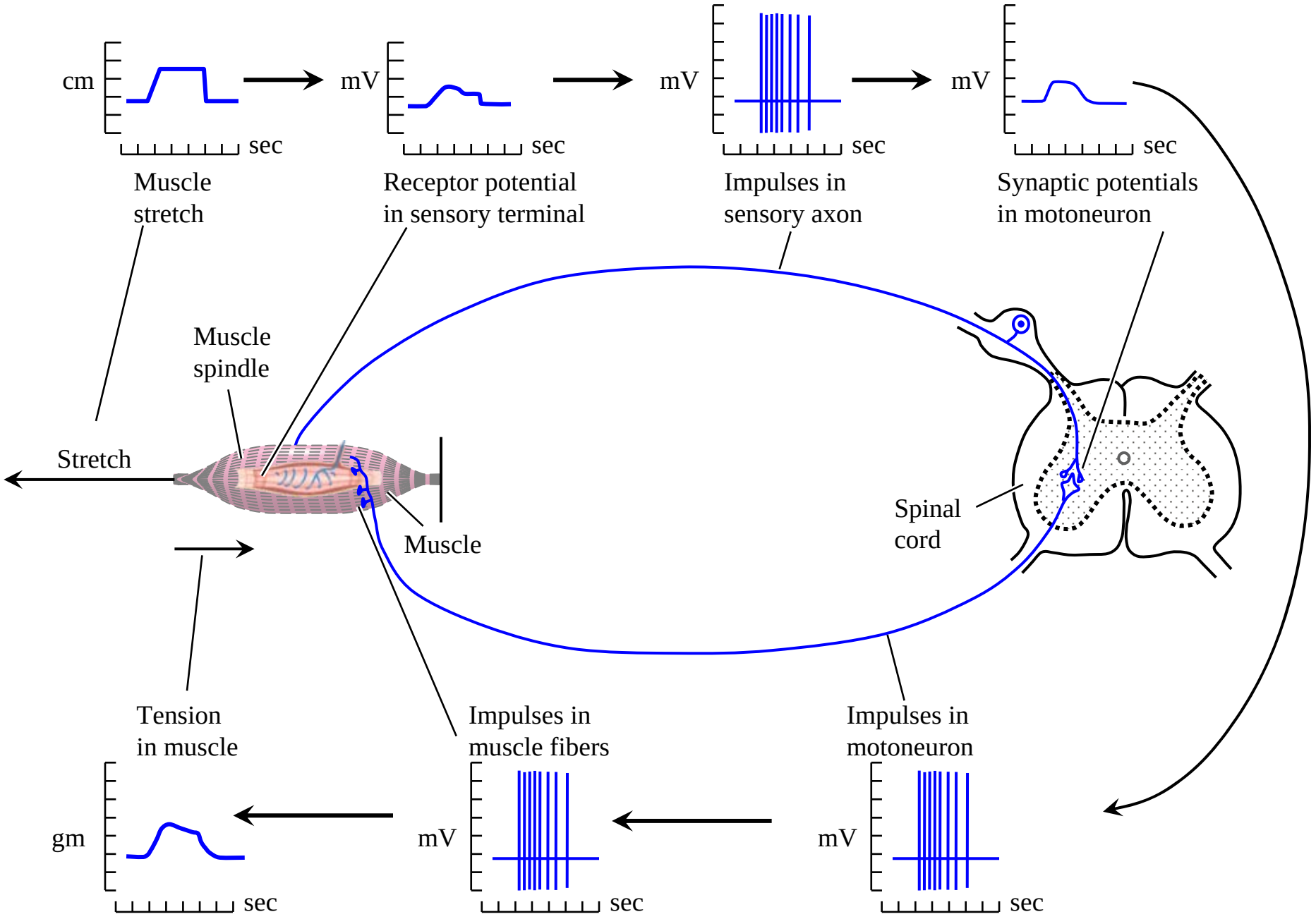
Space clamp

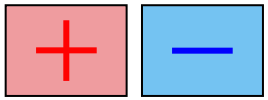
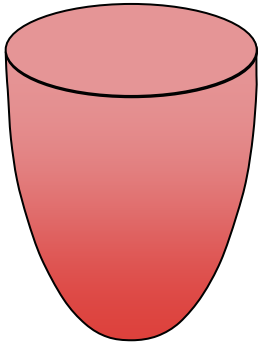
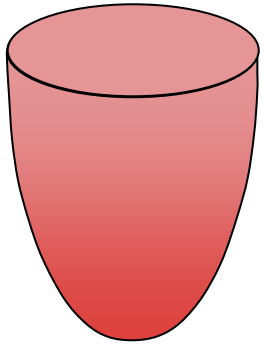
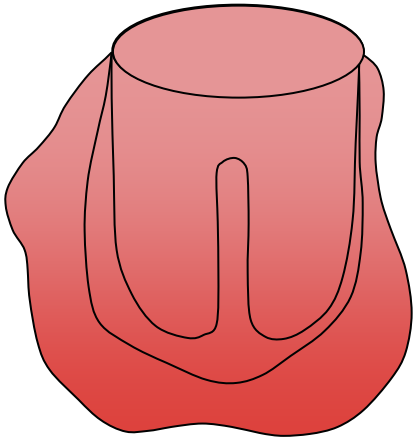
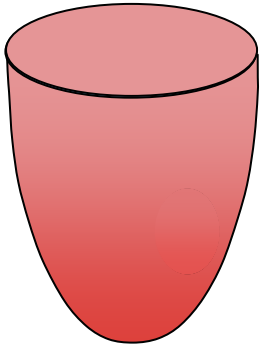
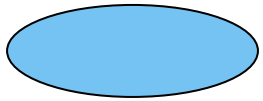
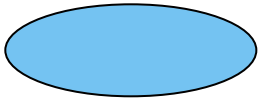
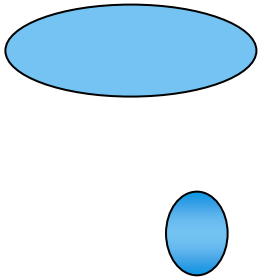
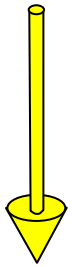
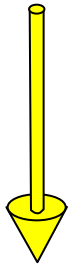
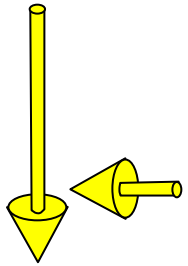


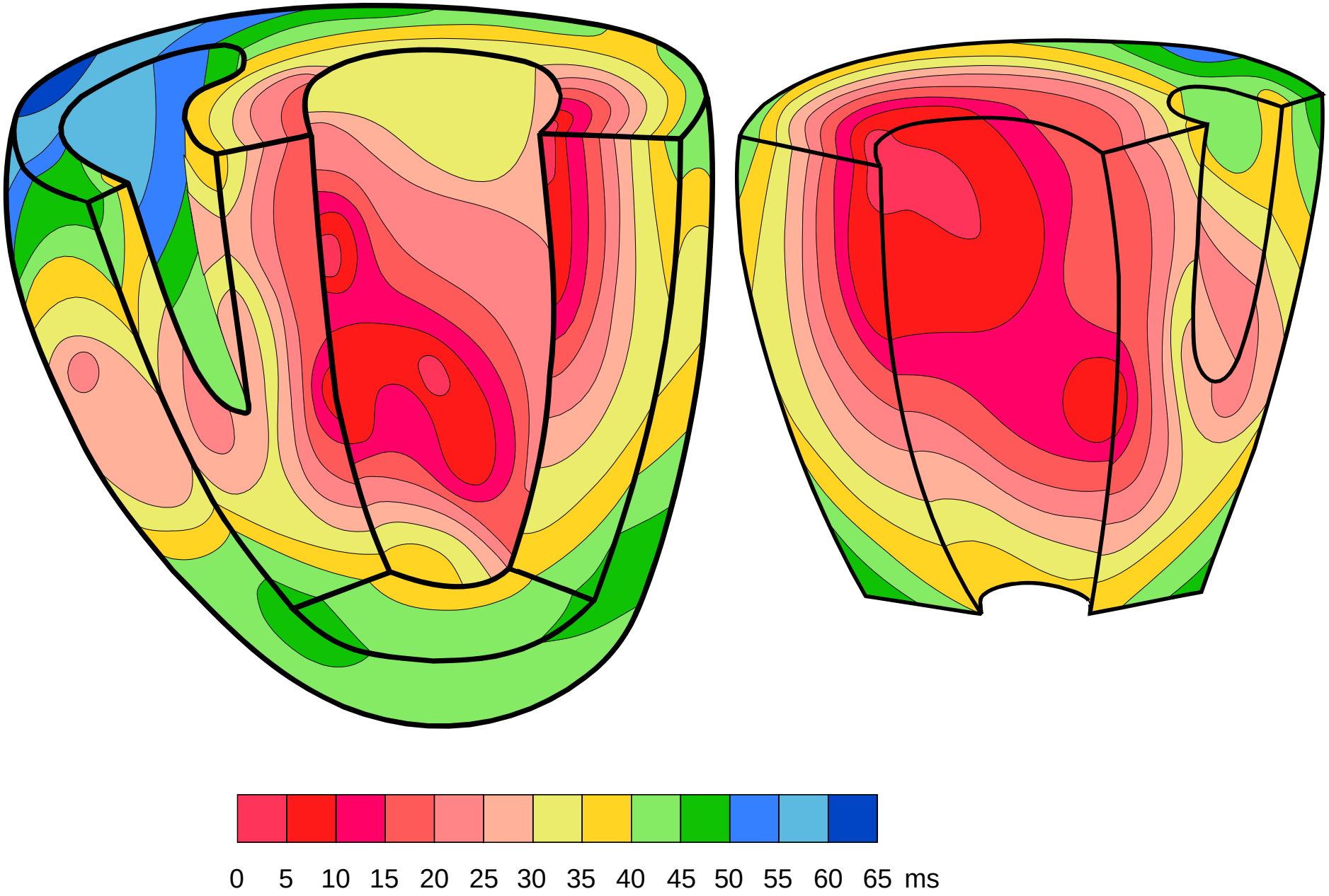


$$i_m = i_{mI} + c_m \frac{\partial V_m}{\partial t}$$

Reflex Arch


cm
sec
Muscle stretch
mV
sec
Receptor potential in sensory terminal
mV
sec
Impulses in sensory axon
mV
sec
Synaptic potentials in motoneuron
Muscle spindle
Stretch
Muscle
Spinal cord
Tension in muscle
Impulses in muscle fibers
Impulses in motoneuron
gm
sec
mV
sec
mV
sec

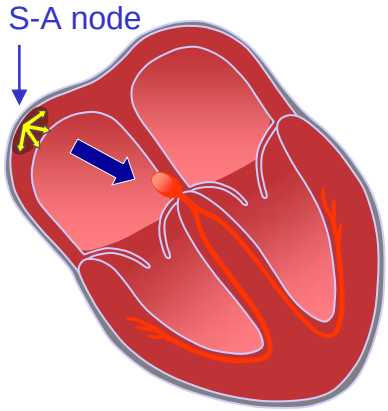
EQUIVALENT SOURCES	TYPE OF DOUBLE LAYER SOURCES			
	Closed double layer	Open double layer	Various double layers with the same opening	Open double layer with two openings
Double layer source 				
Equivalent double layer source	(Zero field)			
Equivalent dipole	(Null)			

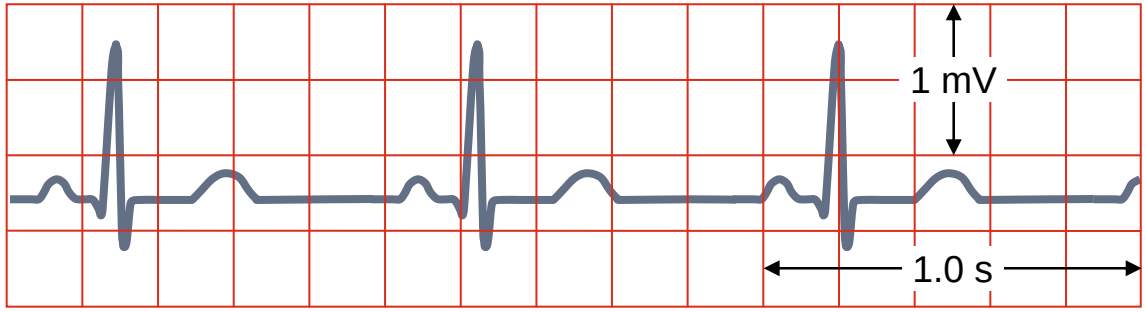

0 5 10 15 20 25 30 35 40 45 50 55 60 65 ms

2 Heart rate 1/2

NORMAL SINUS RHYTHM

Impulses originate at S-A node at normal rate

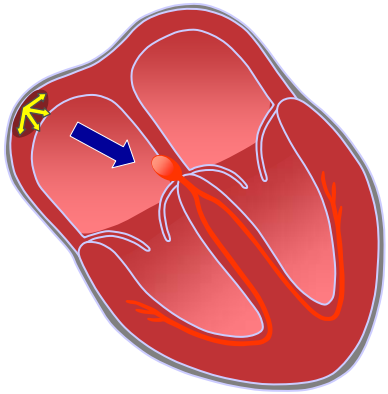


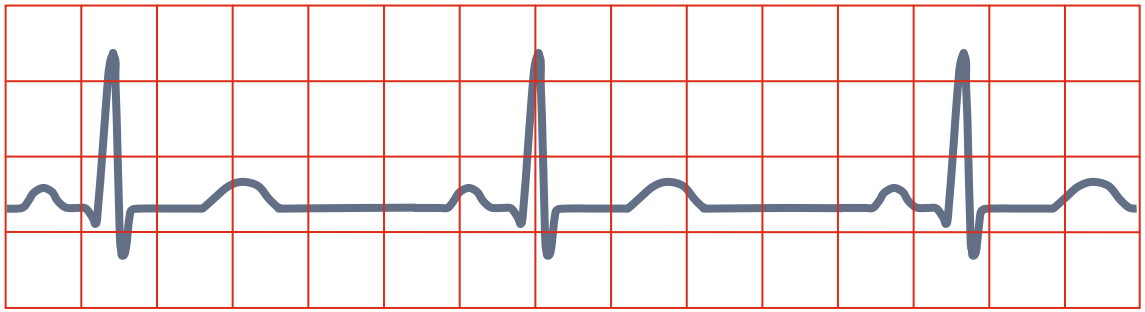


All complexes normal, evenly spaced. Rate 60 – 100/min.

SINUS BRADYCARDIA

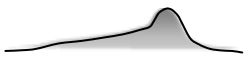
Impulses originate at S-A node at slow rate





All complexes normal, evenly spaced. Rate < 60/min.

Biomagnetic signals and magnetic noise

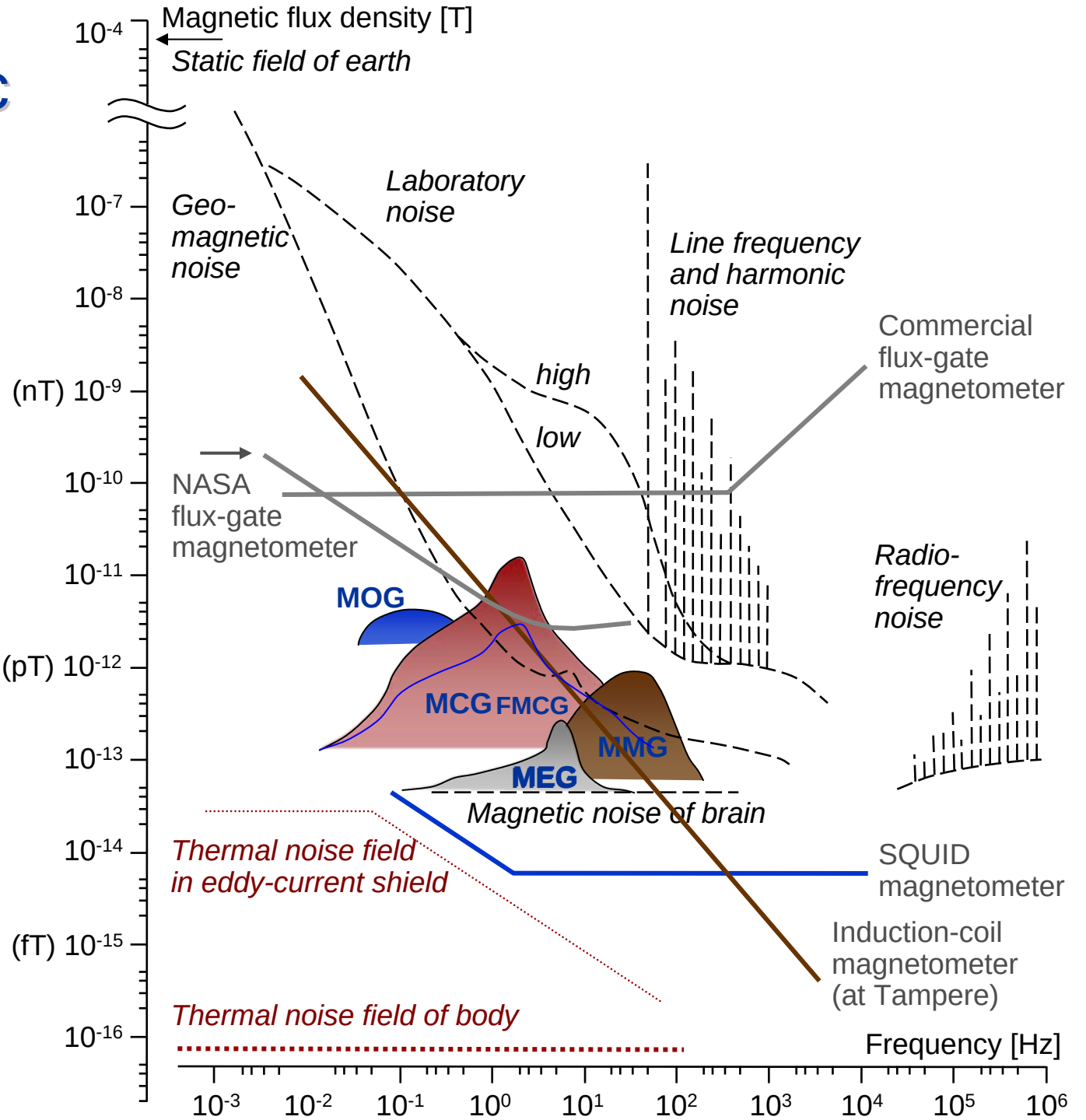


Biomagnetic signals

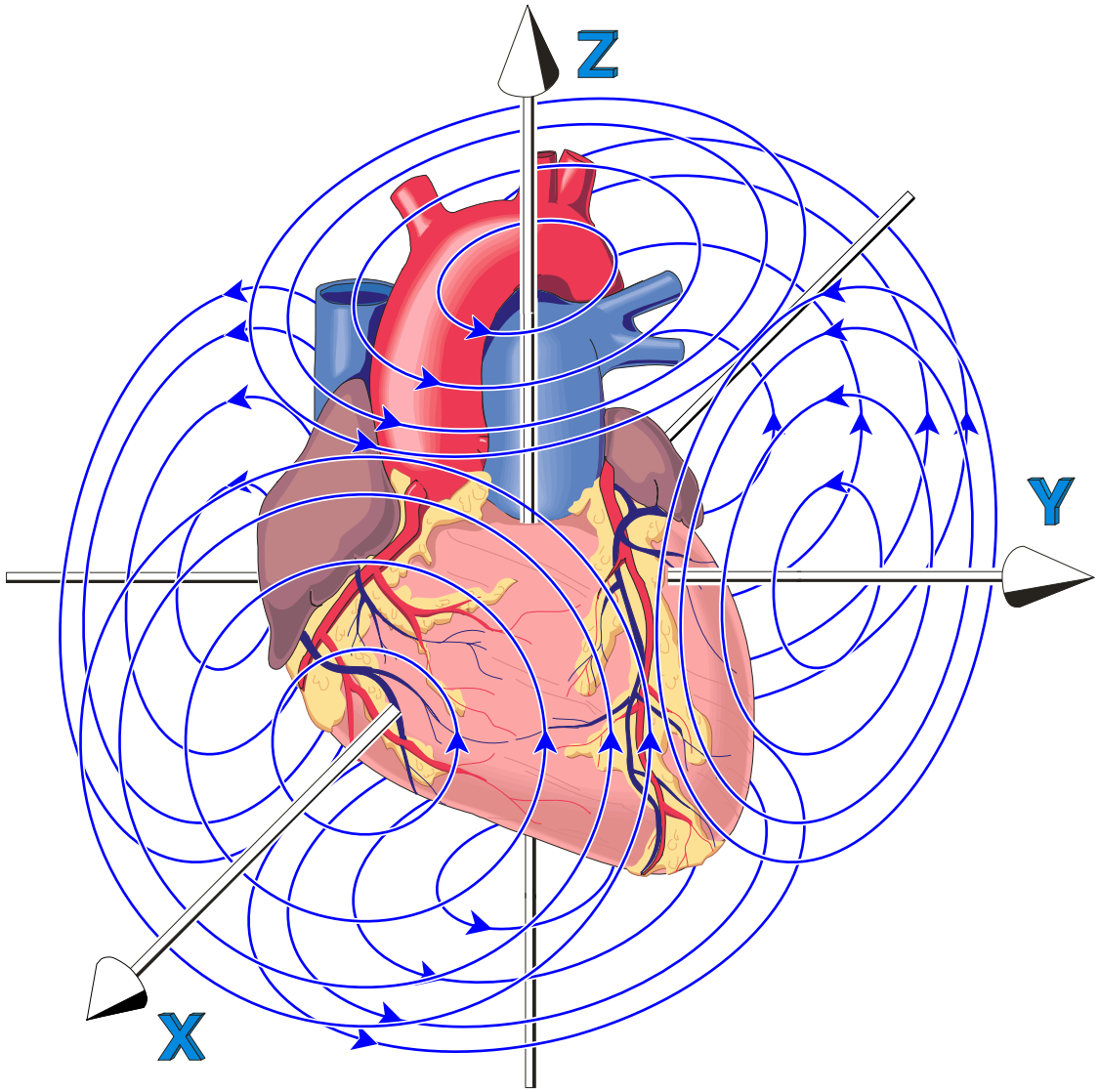
Noise fields

Equivalent input noise

Thermal noise fields



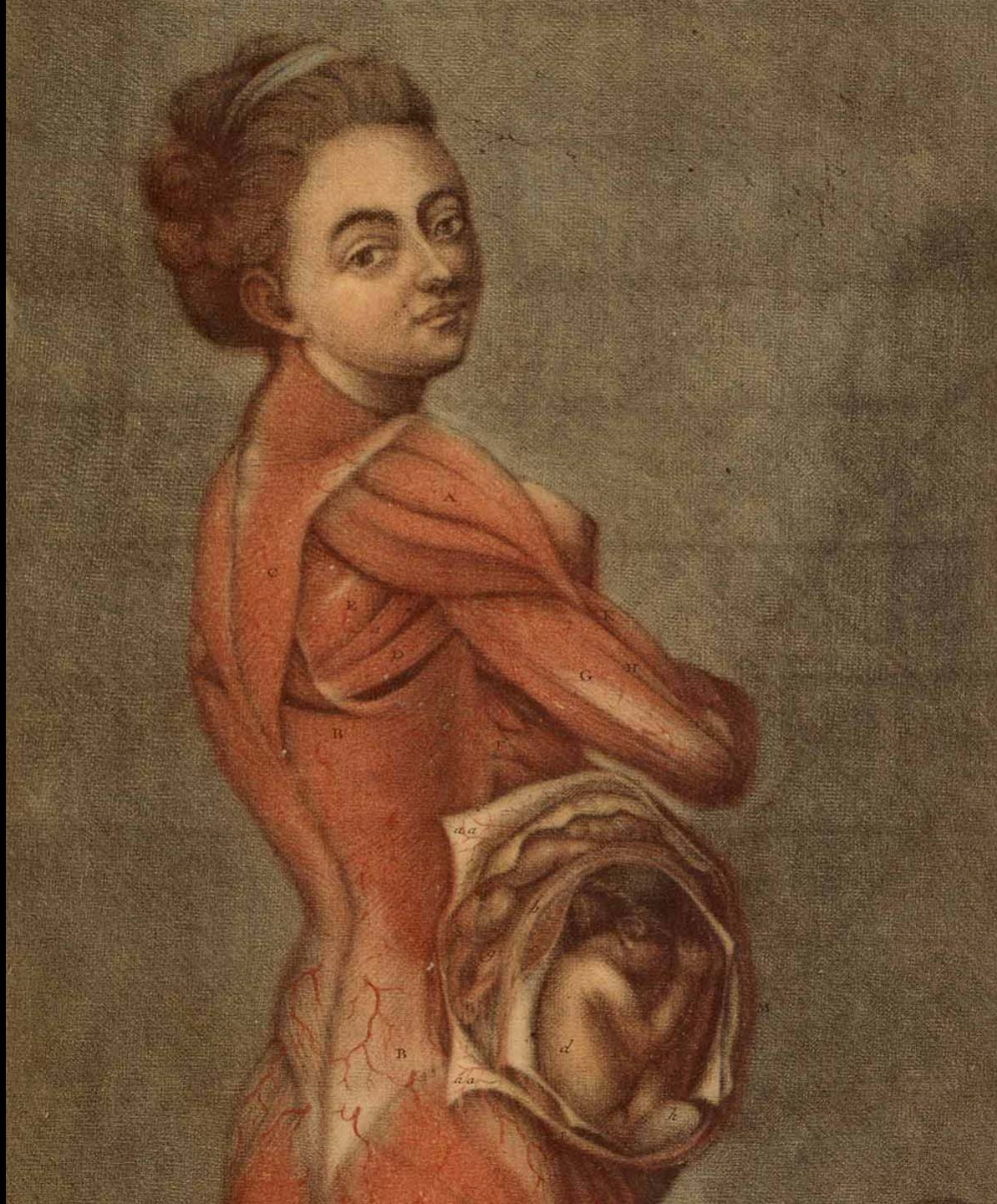
Lead field detecting the magnetic dipole moment



The Fetus

Jacques Fabien Gautier D'Agoty: "*Anatomie des parties de la génértion de l'homme et de la femme*". Paris, 1773. Colored mezzotint. National Library of Medicine

Gautier D'Agoty's colored mezzotints have a painterly quality. This pregnant woman calmly looks back at the viewer, a characteristic pose of 18th-century French portraiture.

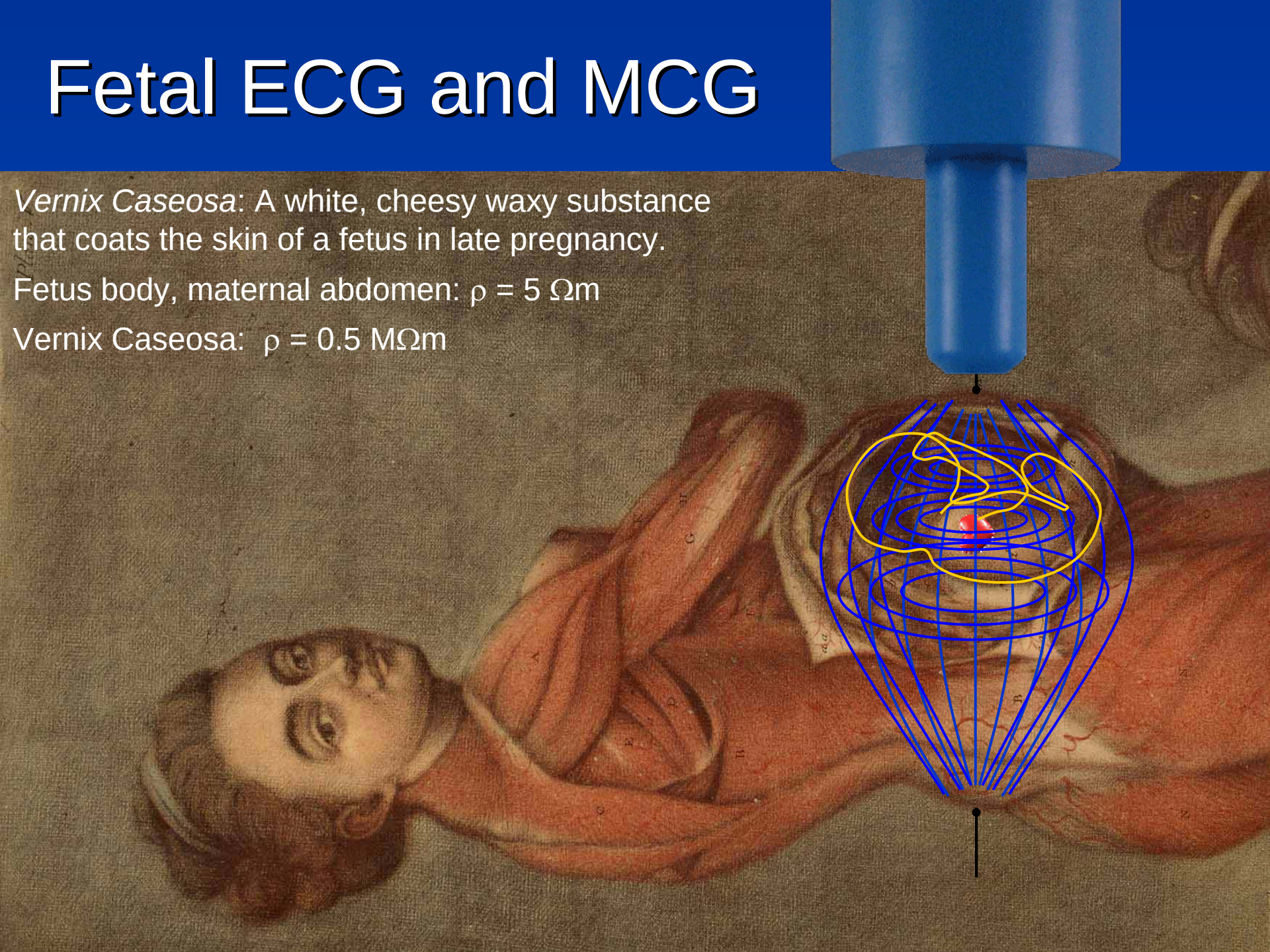


Fetal ECG and MCG

Vernix Caseosa: A white, cheesy waxy substance that coats the skin of a fetus in late pregnancy.

Fetus body, maternal abdomen: $\rho = 5\ \Omega m$

Vernix Caseosa: $\rho = 0.5\ M\Omega m$

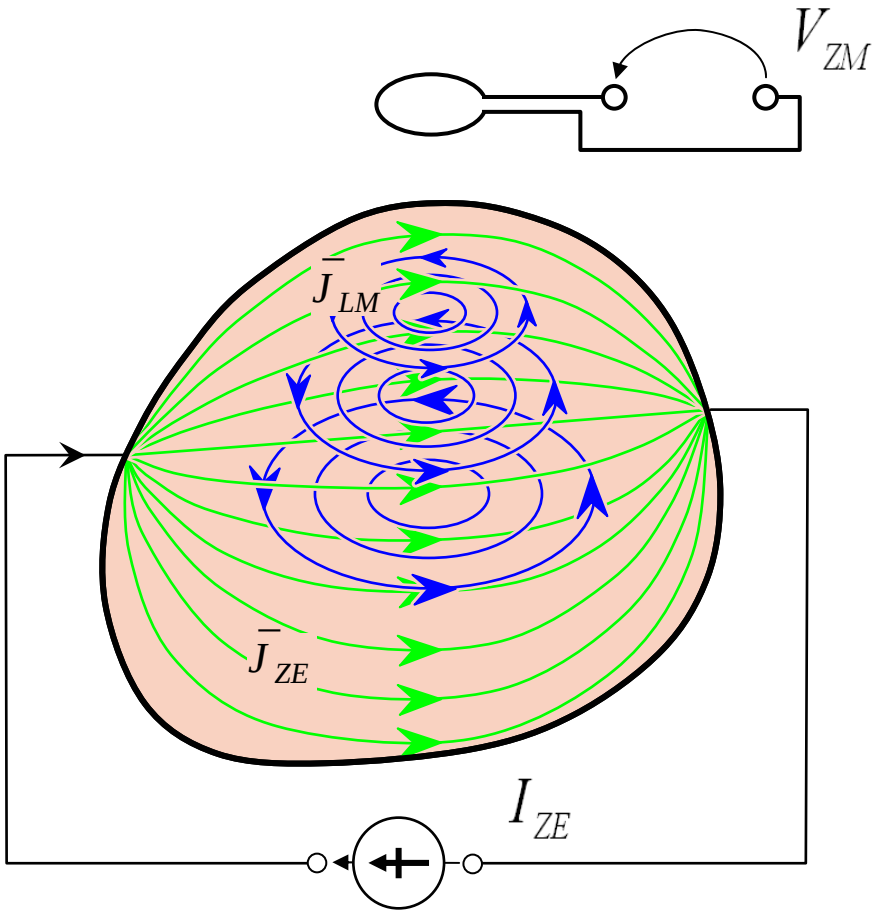


Electromagnetic Method W.R. Purvis, R.C. Tozer, I.L. Freeston, 1990

The current I_{ZE} is fed through electrodes and
the voltage V_{ZM} from the magnetic field detector is measured.
The sensitivity is proportional to
the dot product of the lead fields.

A

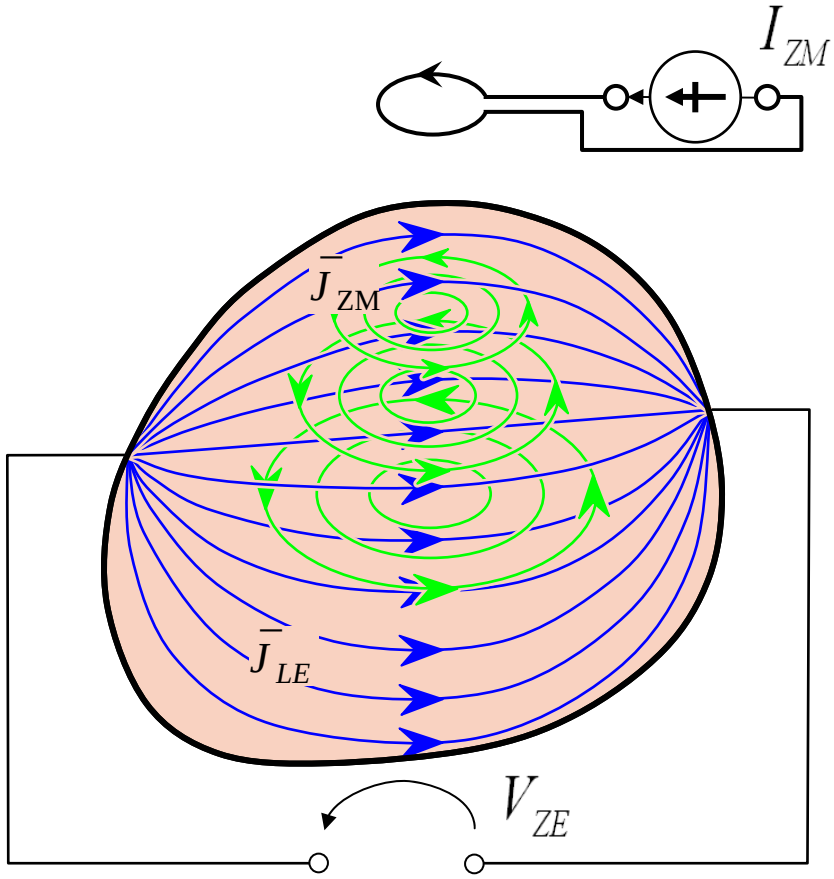
$$V_{ZM} \propto \bar{J}_{ZE} \bullet \bar{J}_{LM} \sigma$$



Feeding the current I_{ZM} to the coil and
measuring the voltage V_{ZE} with the electrodes
gives the same sensitivity distribution.

B

$$V_{ZE} \propto \bar{J}_{LE} \bullet \bar{J}_{ZM} \sigma$$



Electro-retino-gram