

RAGNAR GRANIT
INSTITUTE
TAMPERE UNIVERSITY OF TECHNOLOGY

BIOELECTRO- MAGNETISM

Bioelectromagnetism



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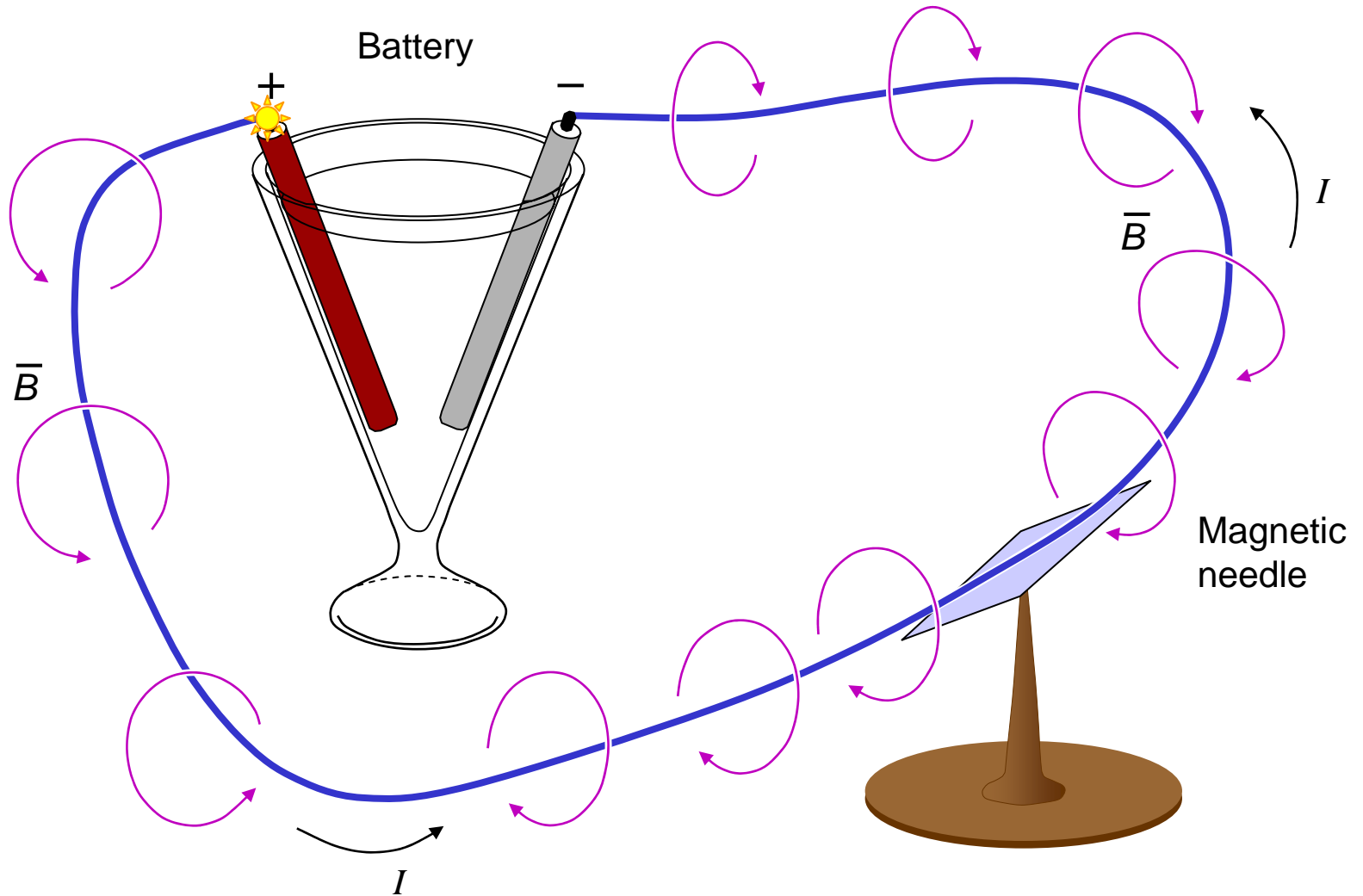
*The original PowerPoint
slides have also animations.*



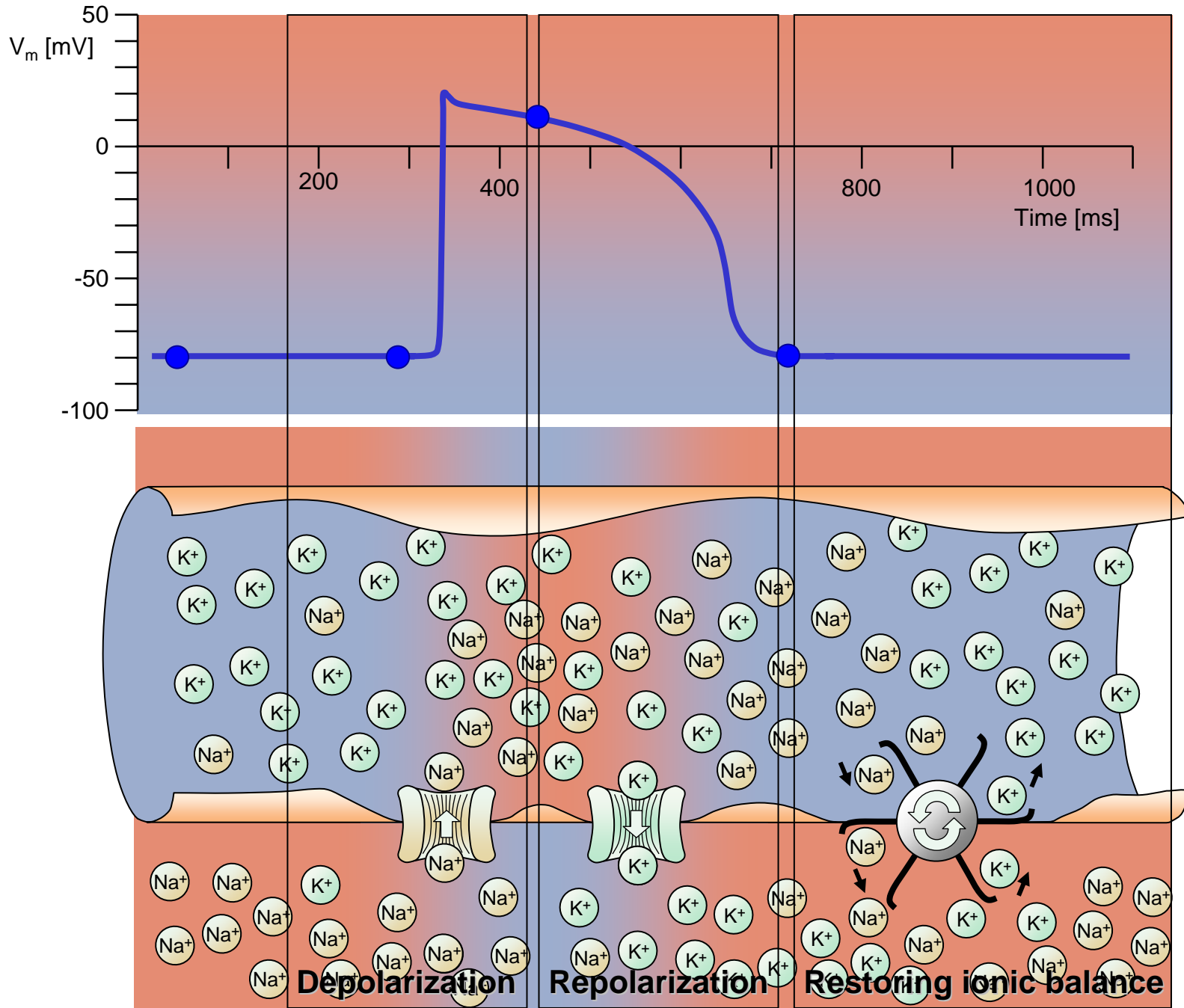
ηλεκτρον = amber



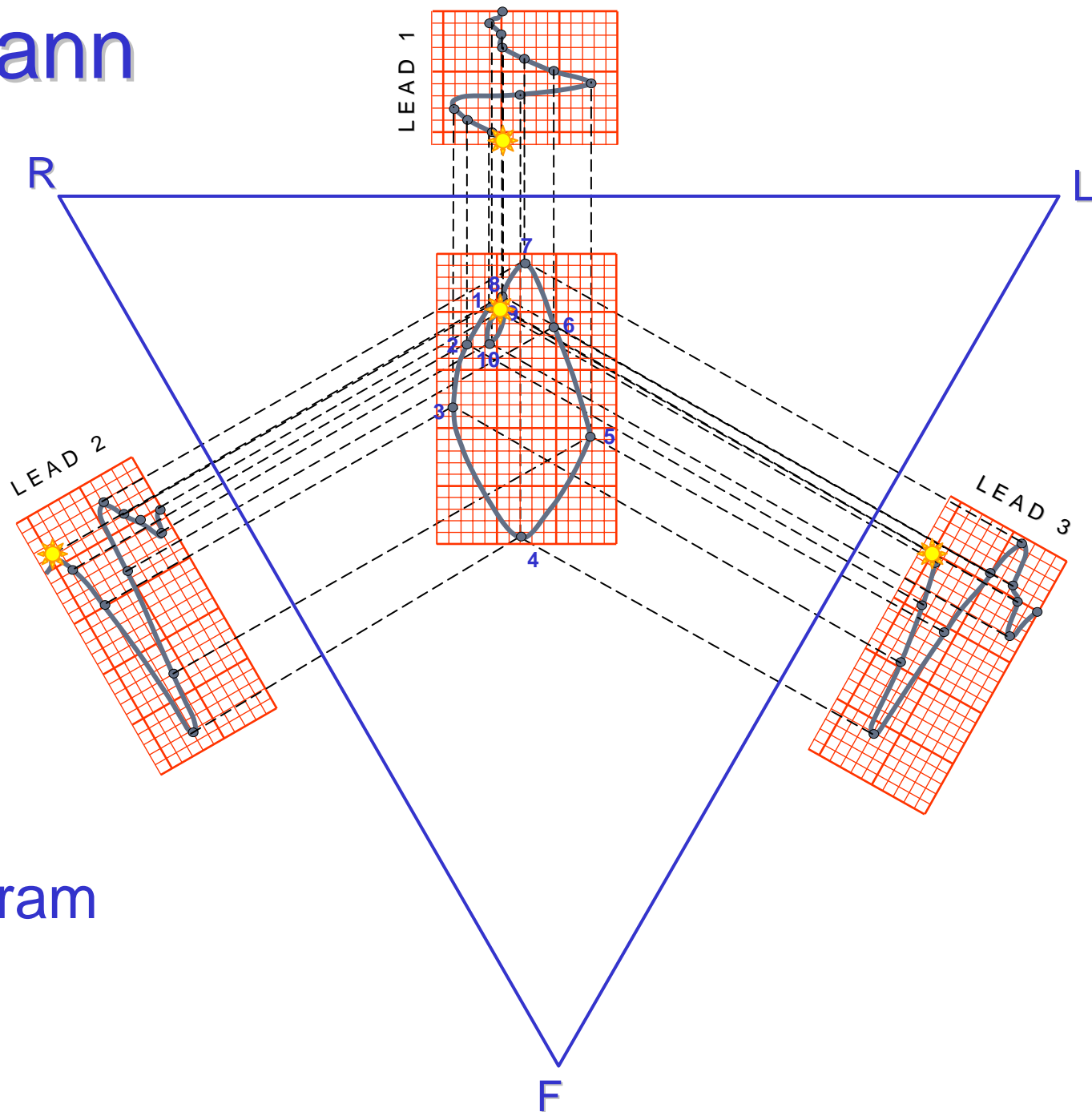
Hans Christian Ørsted 1819



Generation of bioelectric signal

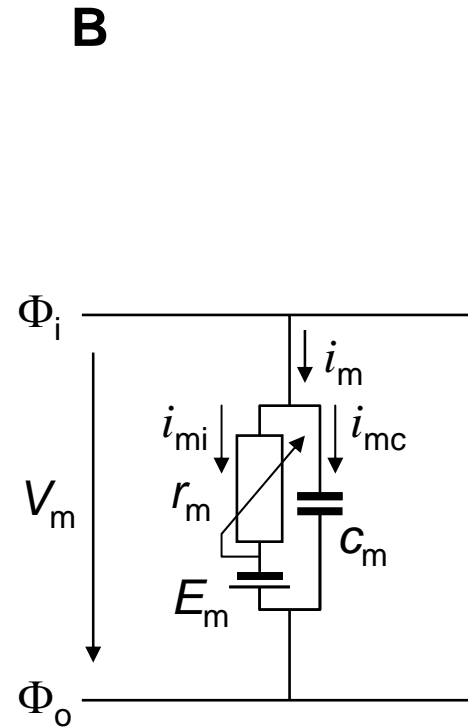
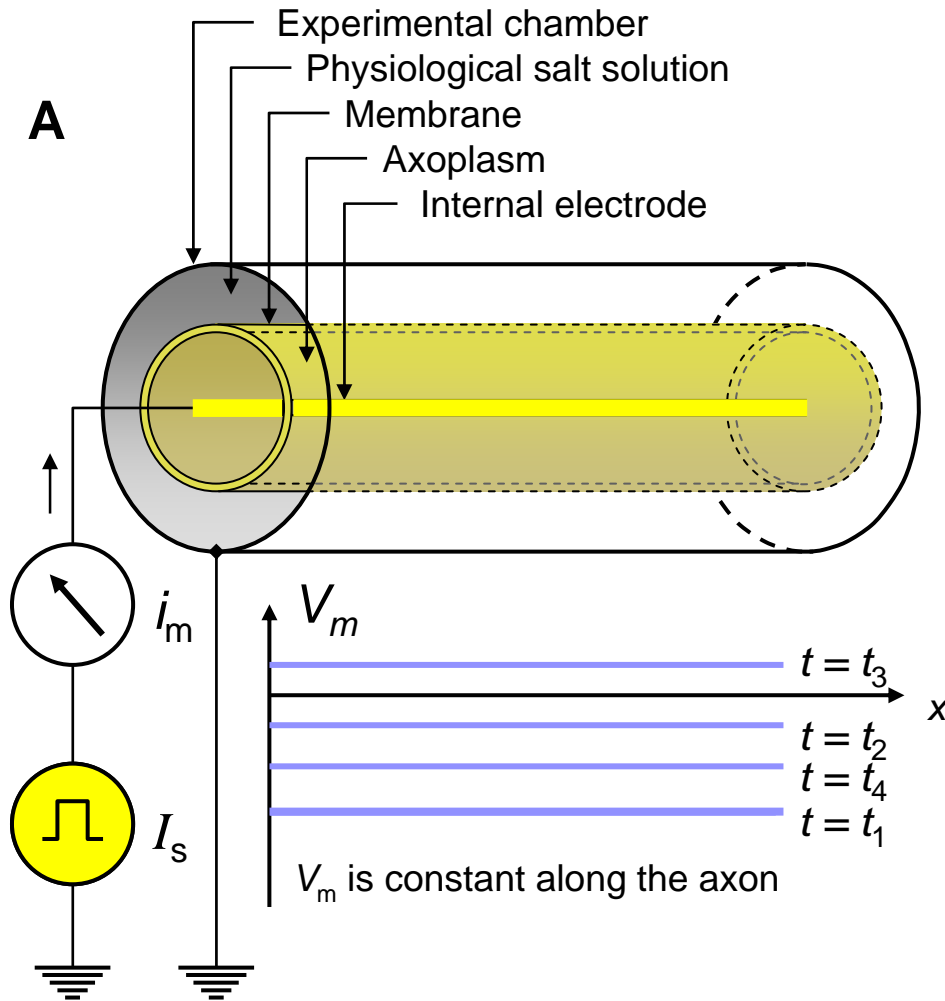


Hubert Mann



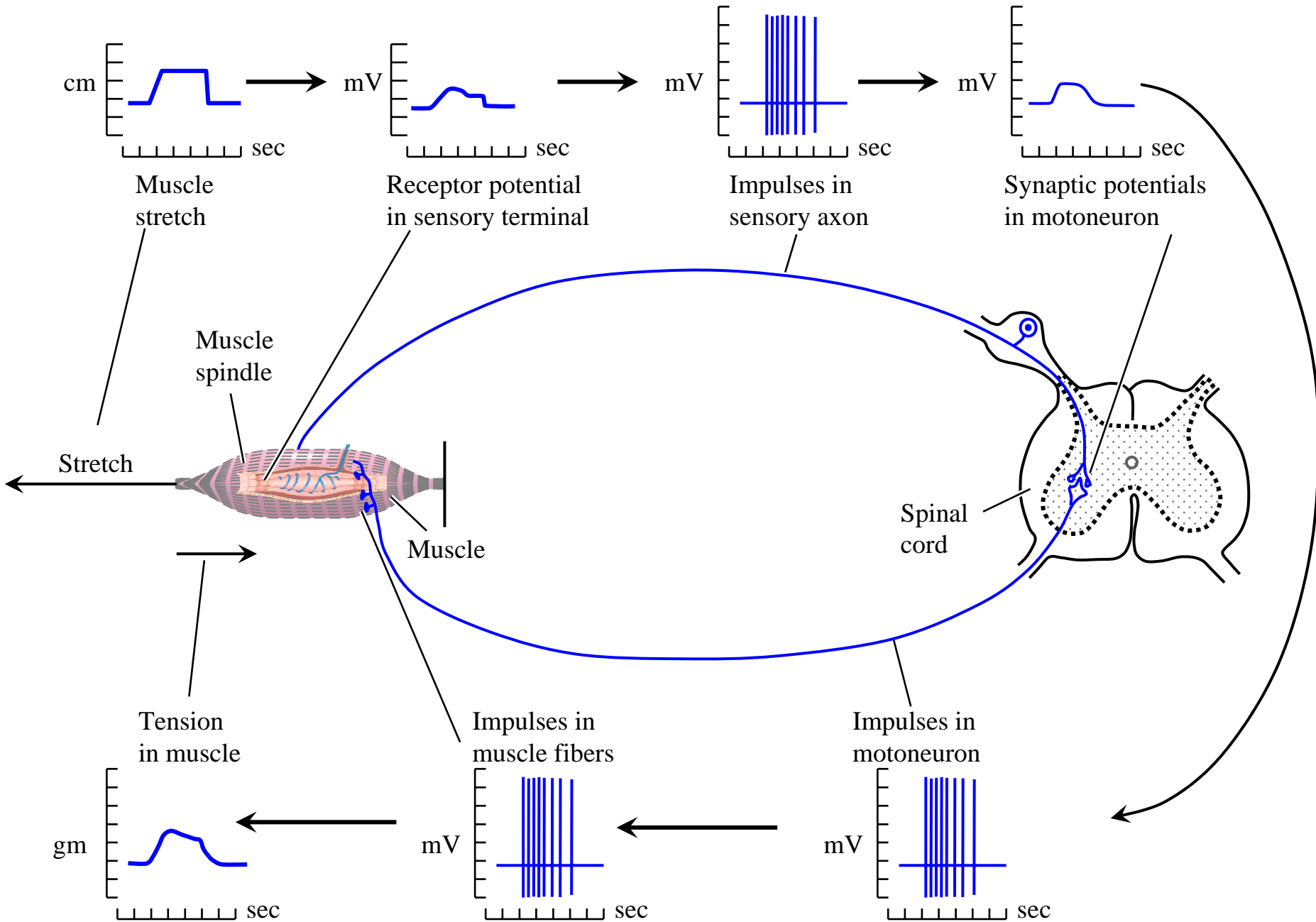
Monocardiogram
1916

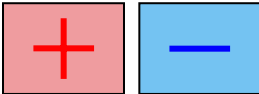
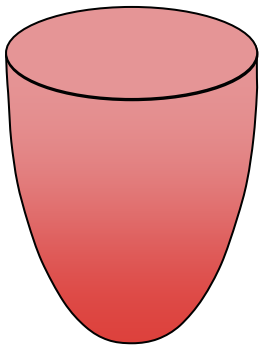
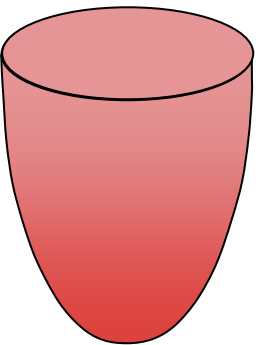
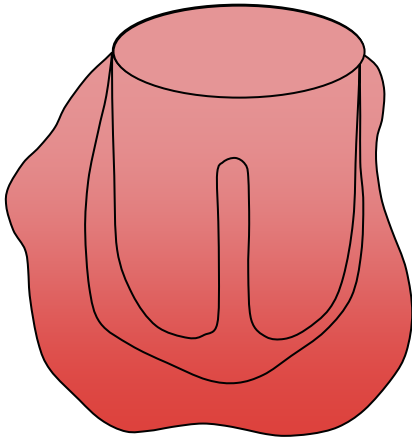
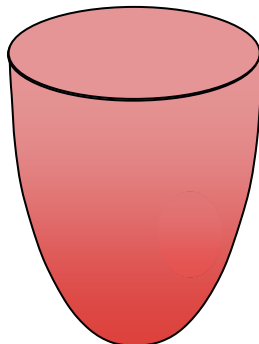


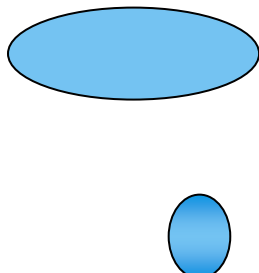


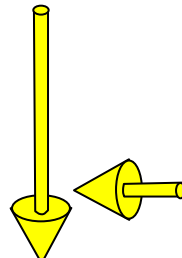
Space clamp

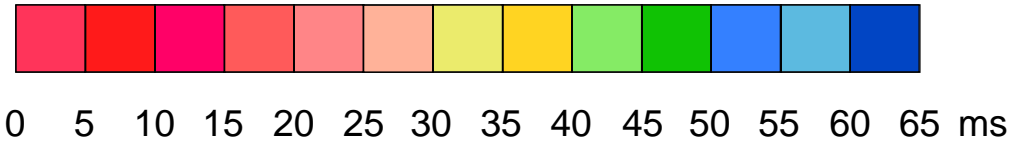
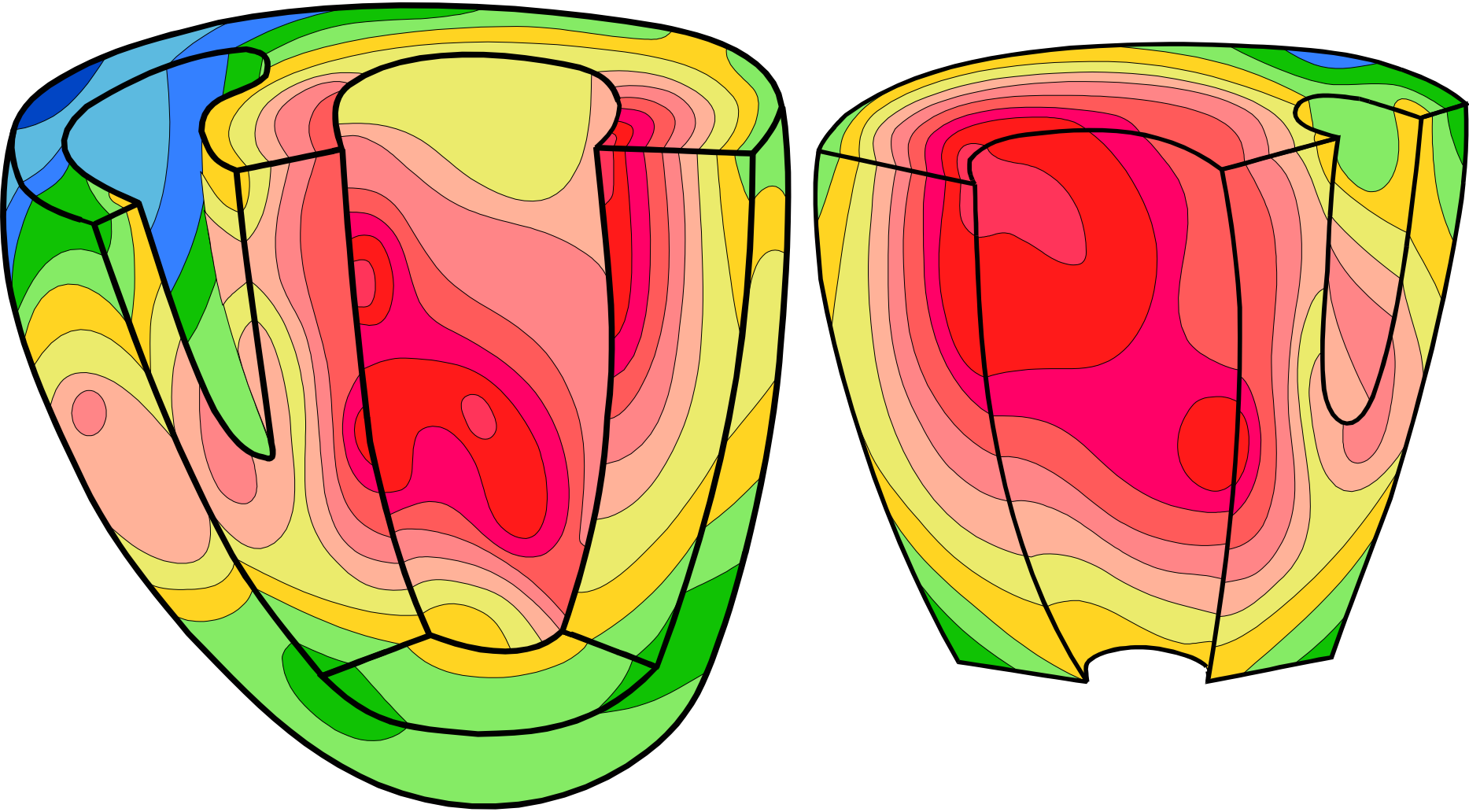


$$i_m = i_{mI} + c_m \frac{\partial V_m}{\partial t}$$

Reflex Arch



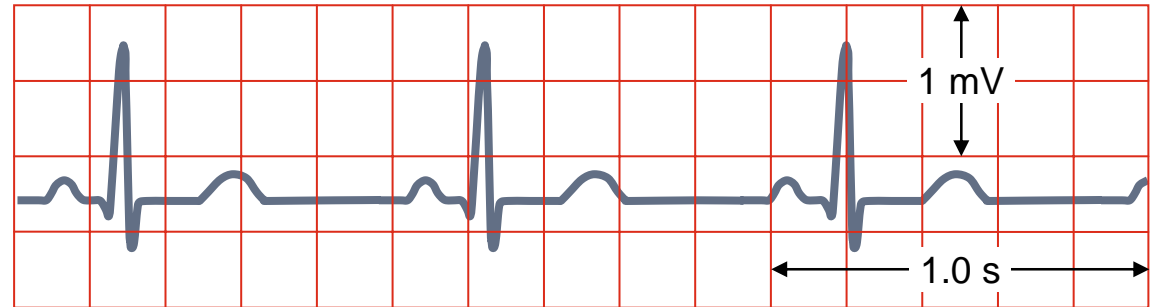
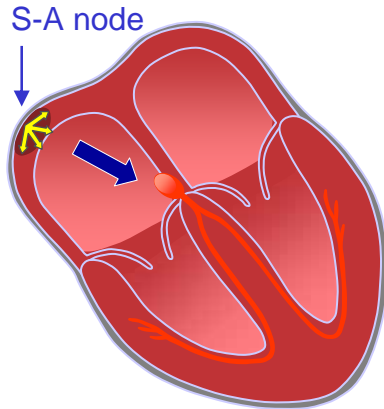
EQUIVALENT SOURCES	TYPE OF DOUBLE LAYER SOURCES			
	Closed double layer	Open double layer	Various double layers with the same opening	Open double layer with two openings
Double layer source 				
Equivalent double layer source	(Zero field)			
Equivalent dipole	(Null)			



2 Heart rate 1/2

NORMAL SINUS RHYTHM

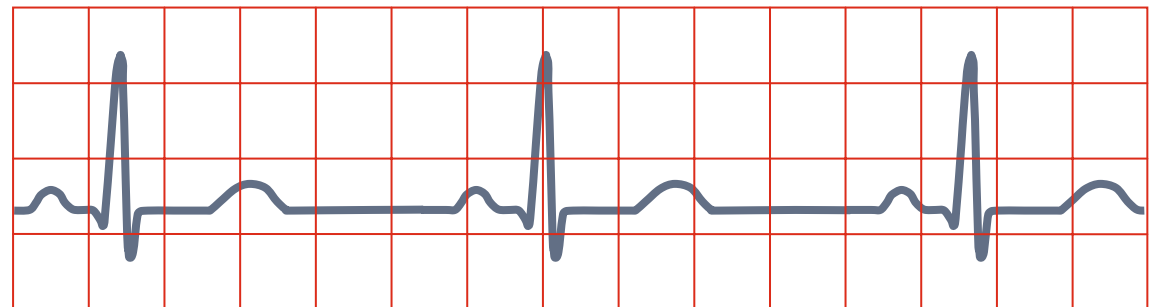
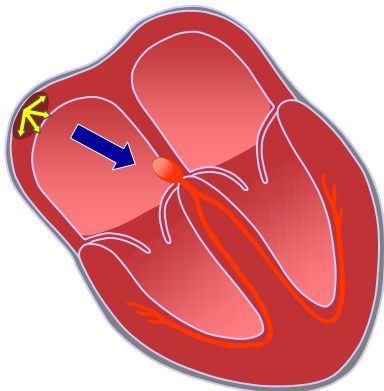
Impulses originate at S-A node at normal rate



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



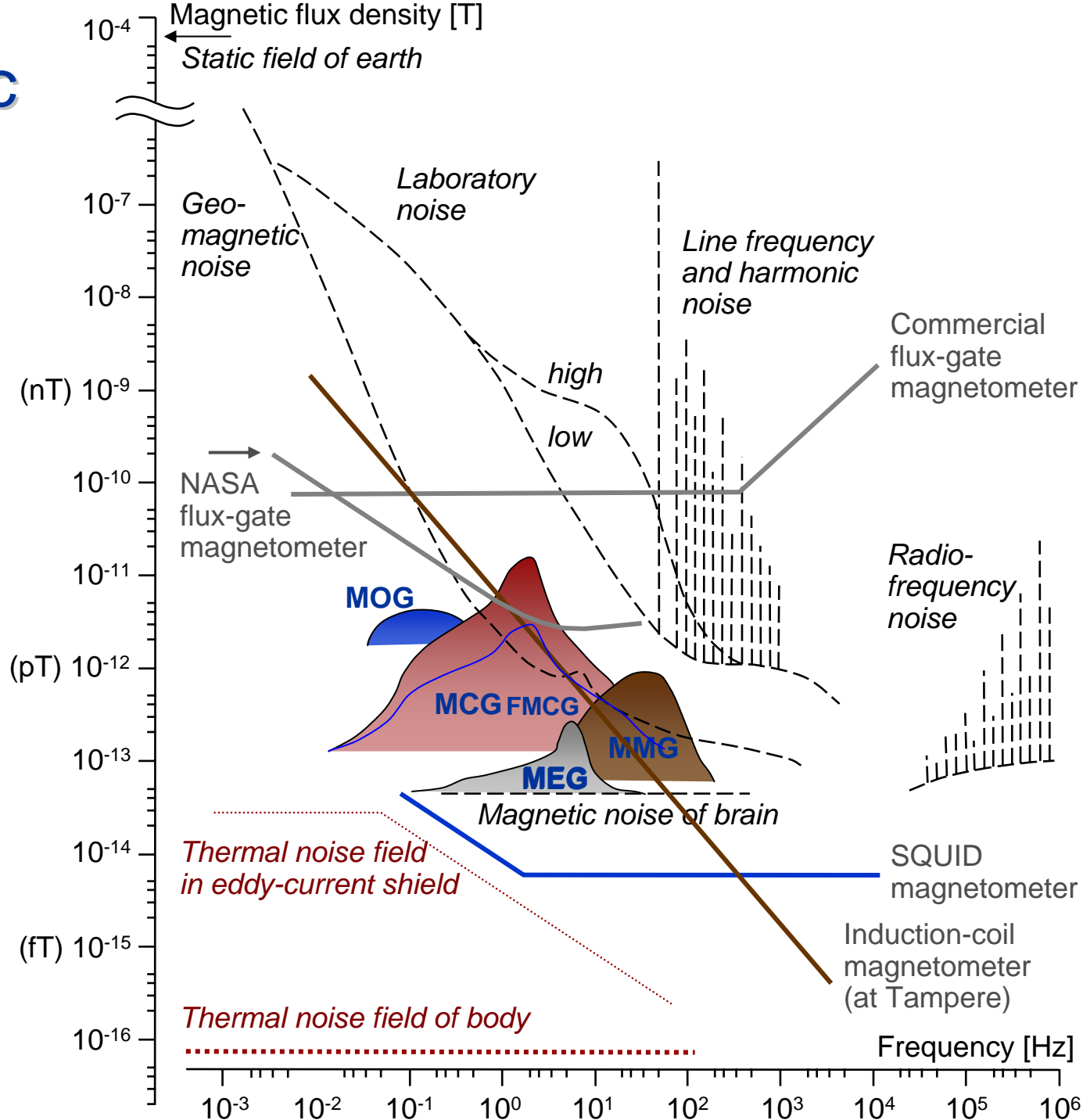
Noise fields



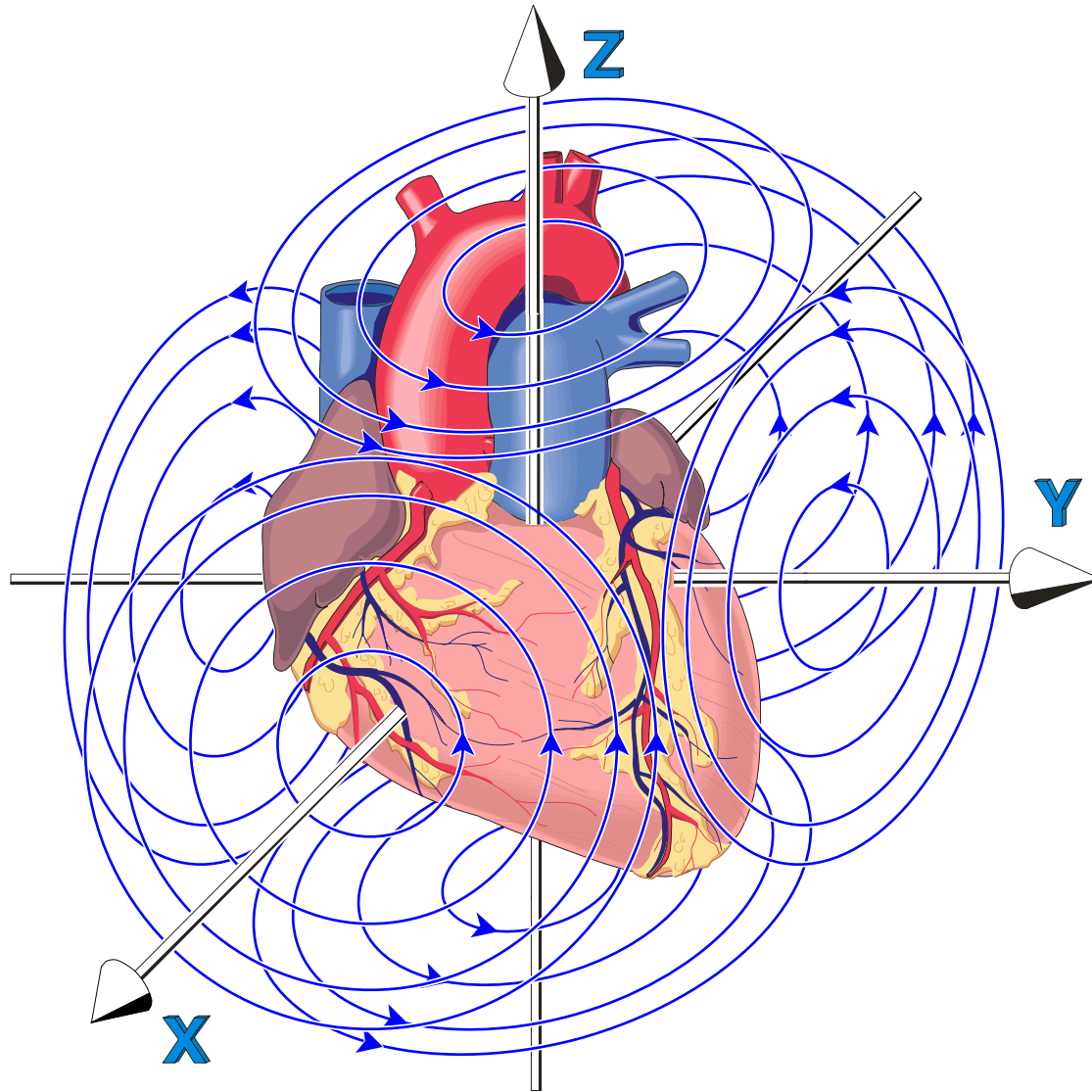
Equivalent input noise



Thermal noise fields



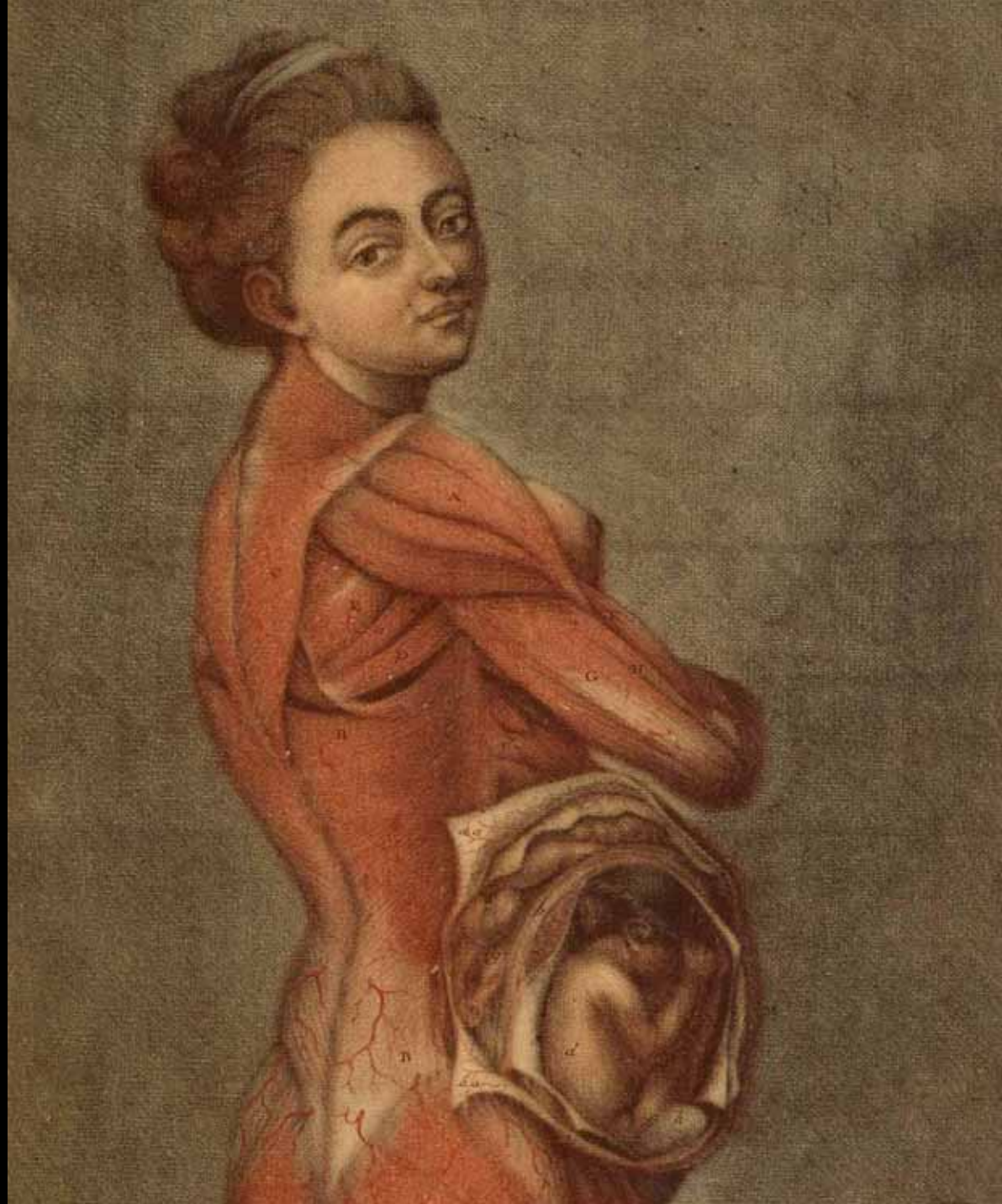
Lead field detecting the magnetic dipole moment



The Fetus

Jacques Fabien Gautier D'Agoty:
“*Anatomie des parties de la
génération 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.

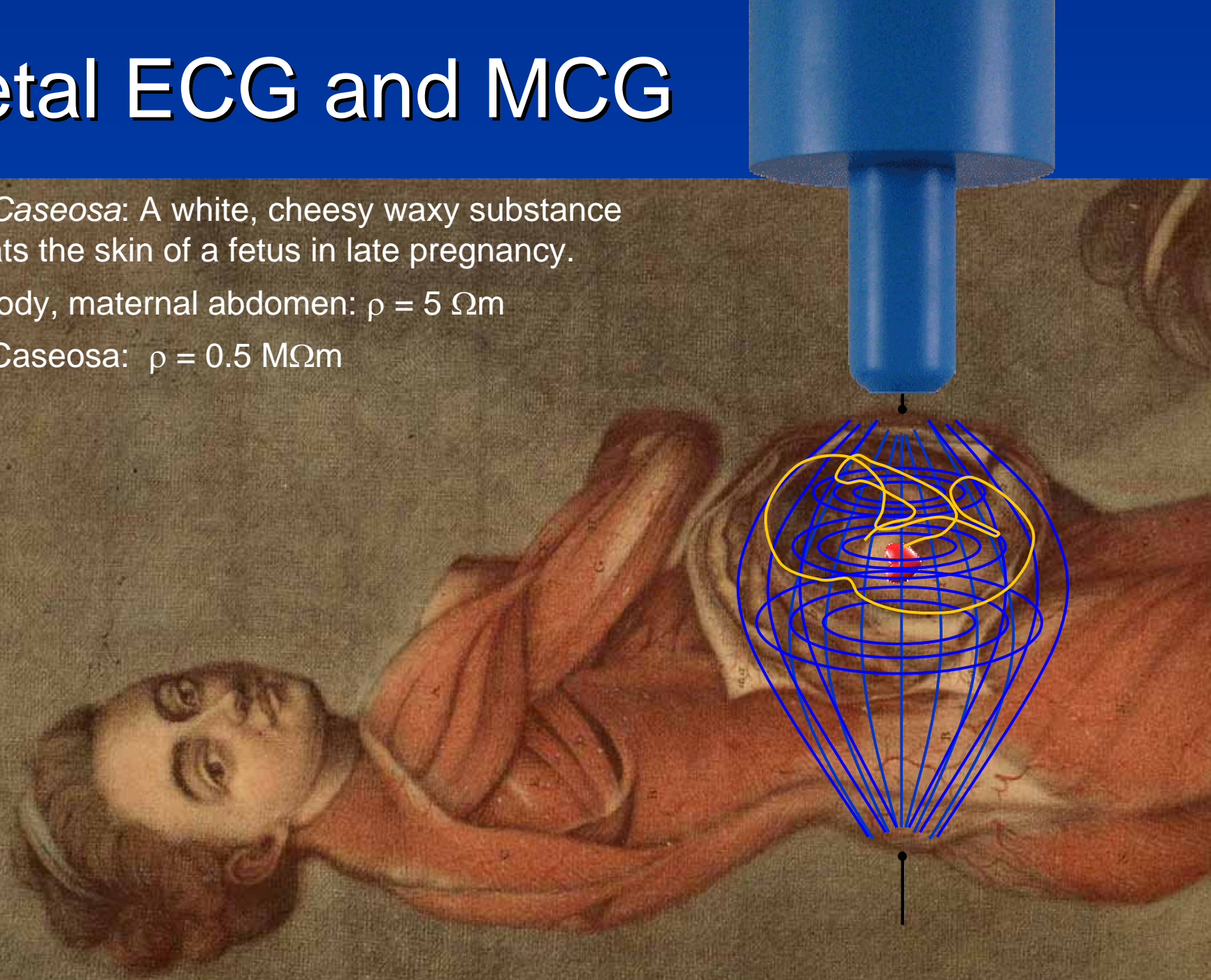


Fetal ECG and MCG

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

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

Vernix Caseosa: $\rho = 0.5 \text{ M}\Omega\text{m}$

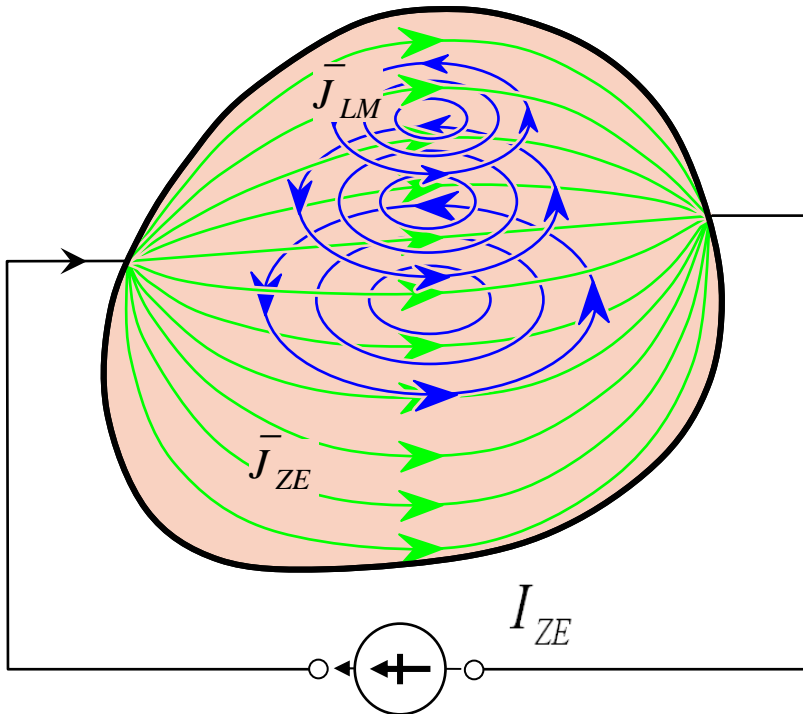
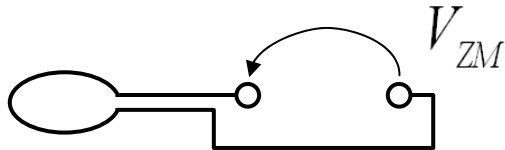


Electromagnetic Method W.R. Purvis, R.C. Tozer, I.L. Freeston, 1990

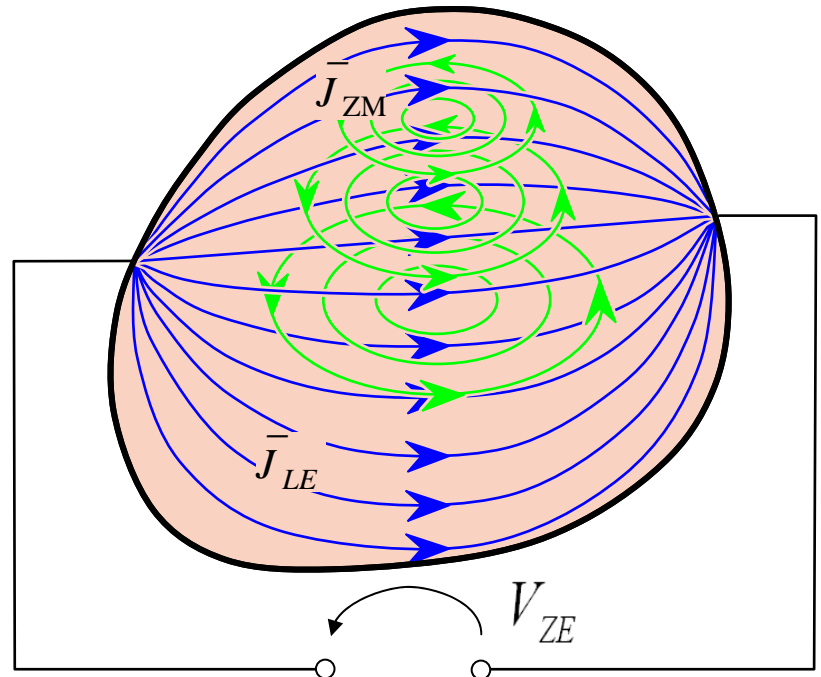
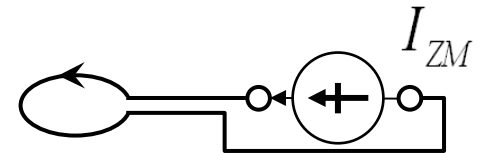
The current I_{ZE} is fed through electrodes and the voltage V_{ZM} from the magnetic field detector is measured. The sensitivity is proportional to the dot product of the lead fields.

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

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



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



Electroretinogram

