

Účinky elektrického proudu na organismus a působení organismů na elektrický proud



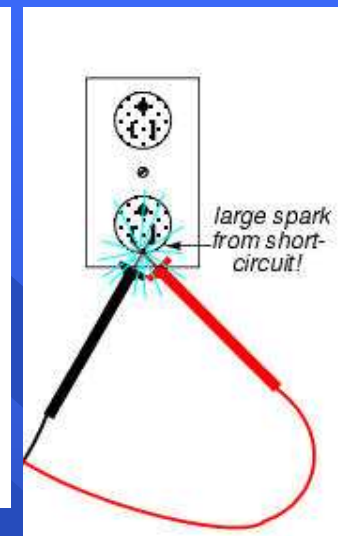
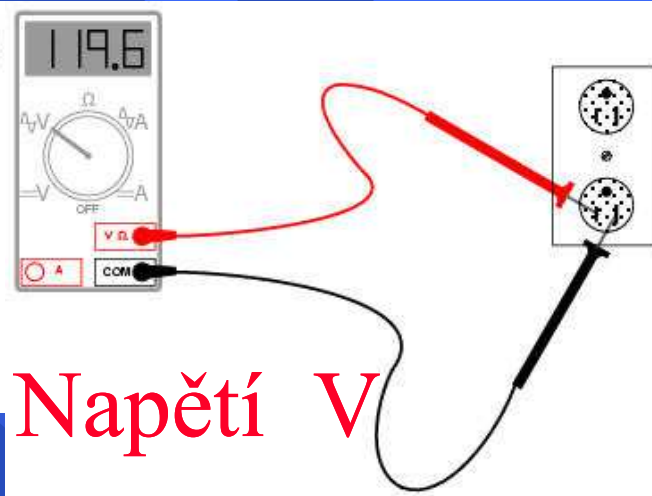
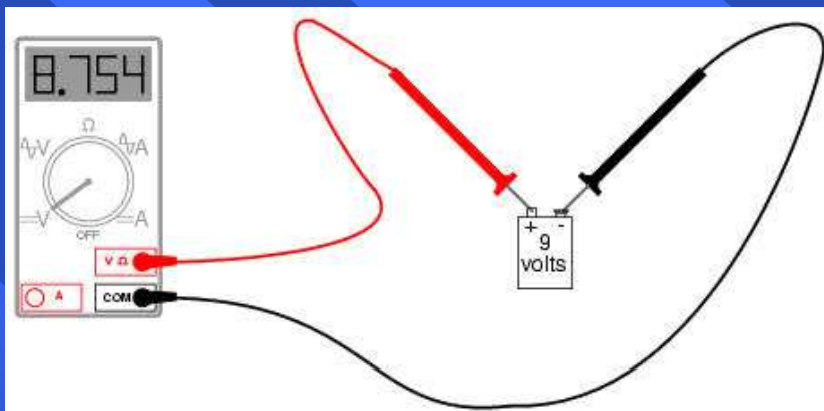
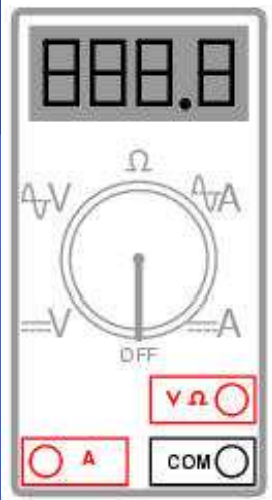
1. *Pojmy elektřiny*
2. *Vysoké napětí – ochrana, statická elektřina a blesky*
3. *Elektrické projevy organismu*
4. *JIP - Elektrostimulace Elektrikoagulace, kardioverze*
5. *Terapie diatermie*

Praha 2020

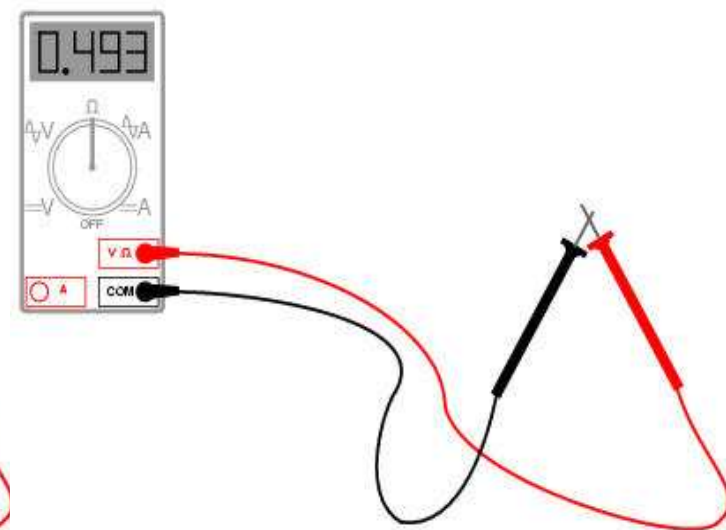
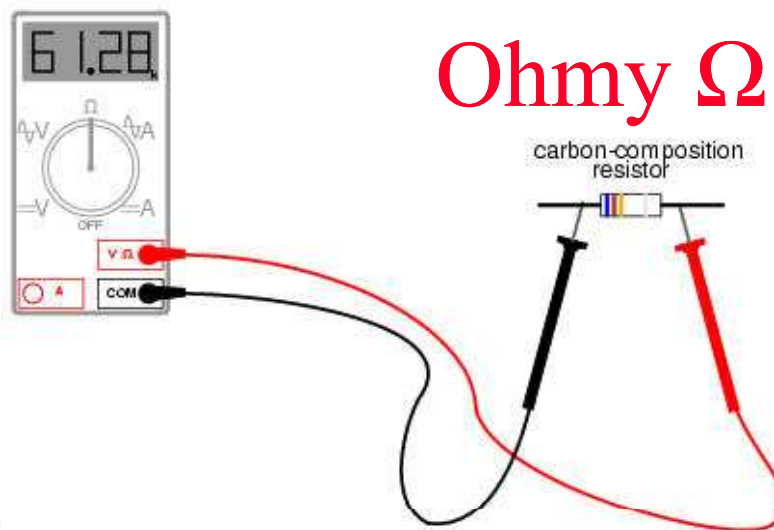
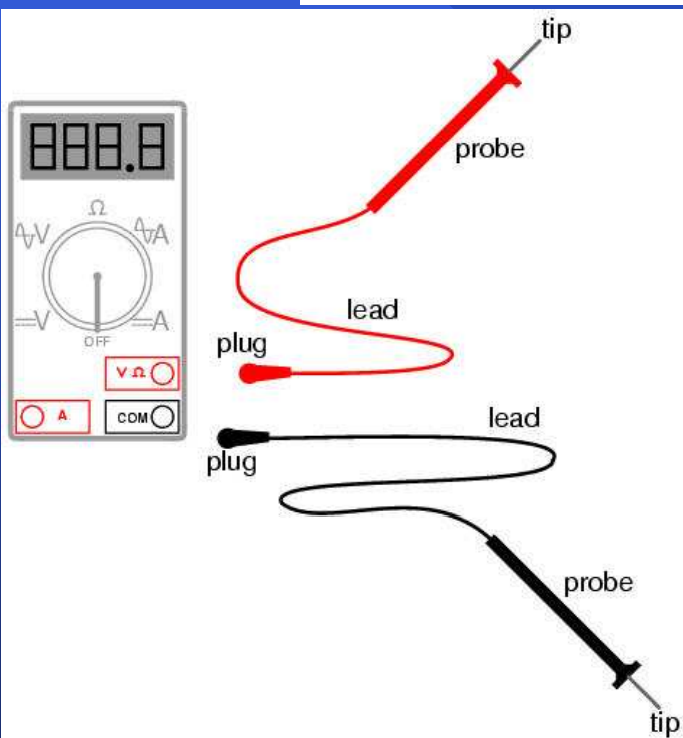
Beneš J



Měření elektrických parametrů v praxi



Napětí V



Ohmy Ω

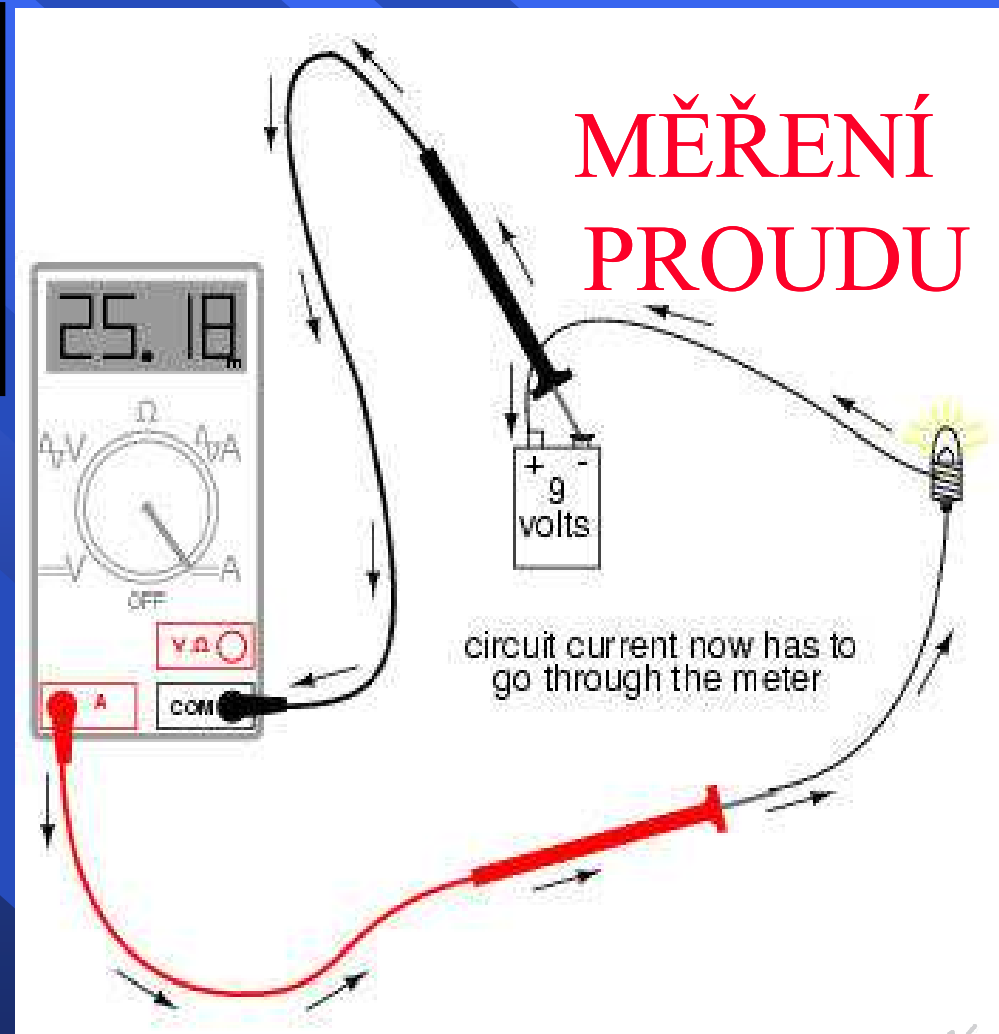
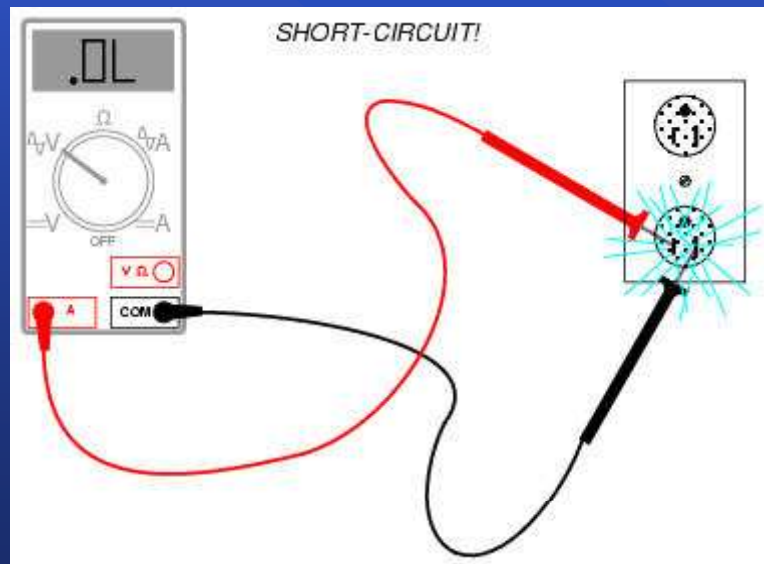


Měření elektrických parametrů v praxi 2

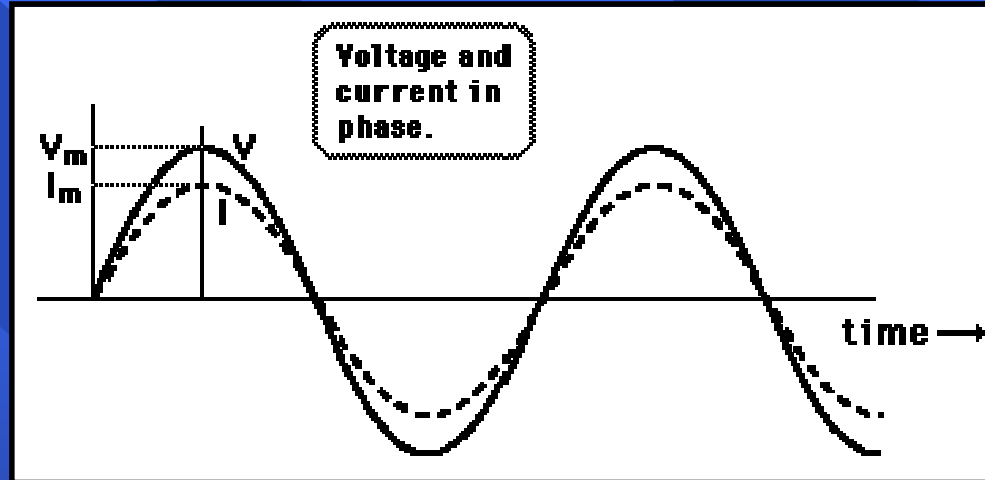
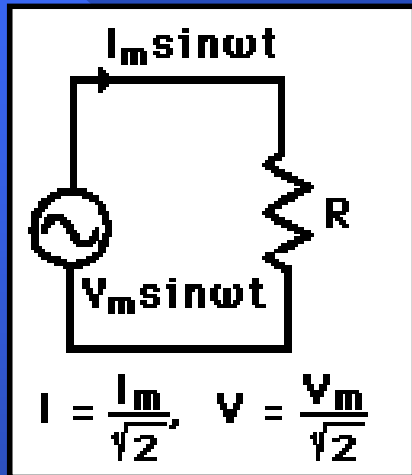
Ohm's Law

$$I = \frac{V}{R}$$

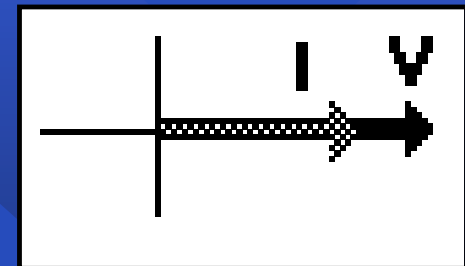
Electric current = Voltage / Resistance



Odpor v obvodu



$$I = \frac{V}{R}$$
$$Z = R$$



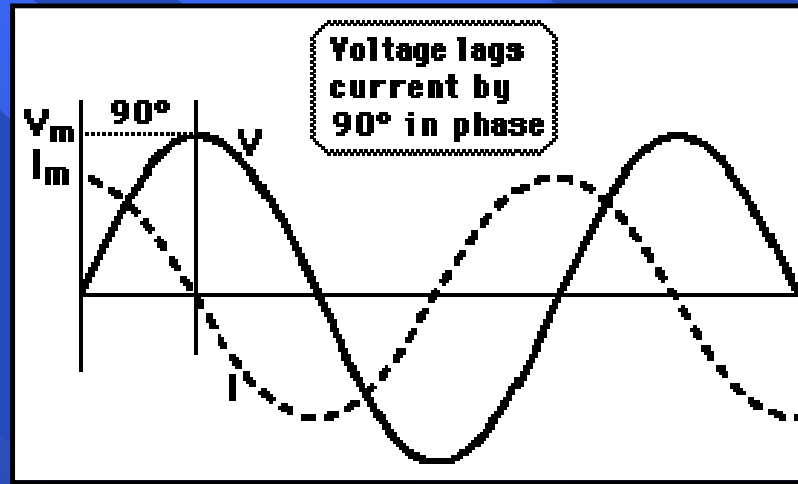
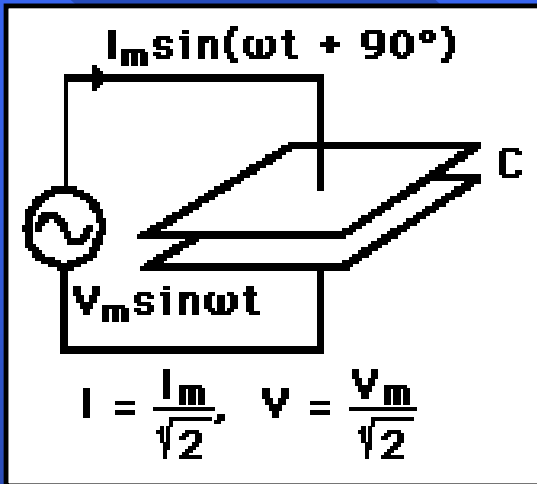
Rezistor

Odpor ohm

Energie v odporu = $\frac{1}{2} R I^2$



Kondenzátor v obvodu



$$I = \frac{V}{X_C}$$
$$X_C = \frac{1}{\omega C}$$

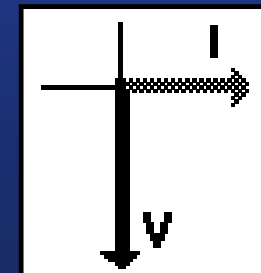
Impedance kondenzátoru, kapacitance

Kapacita Q – Farrad

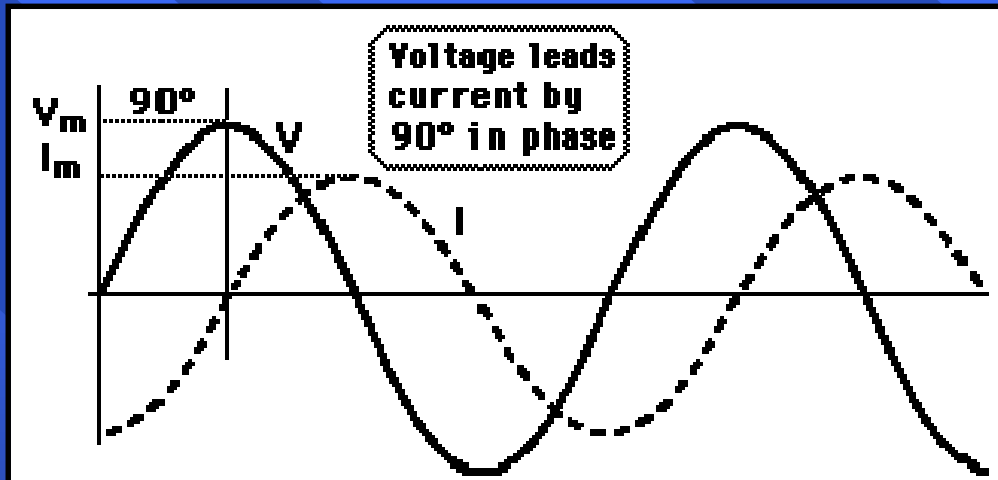
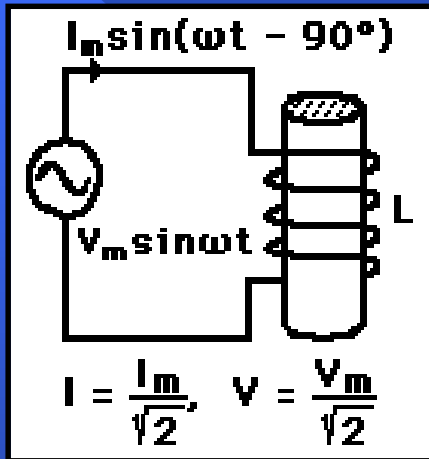
Kolik náboje nateče

Energie v kondenzátoru = $\frac{1}{2} C U^2$

$$\frac{-j}{\omega C}$$



Cívka v obvodu *(nejde o cívku na šití)*

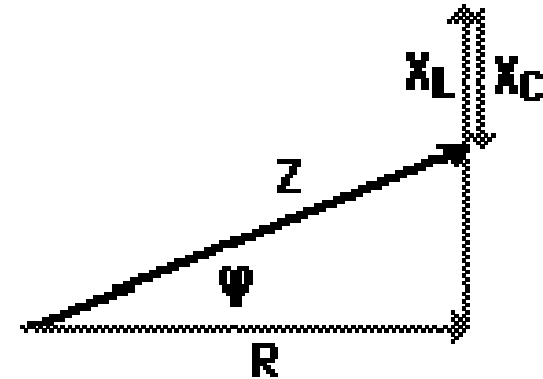
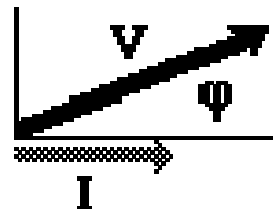
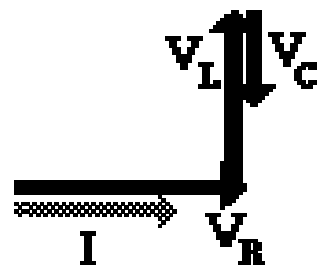
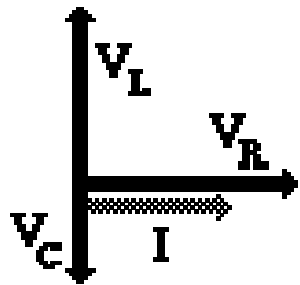


$$I = \frac{V}{X_L}$$
$$X_L = \omega L$$

- Impedance cívky indukčnosti
- Indukčnost L – Henry
- Jak velké magnetické pole je v cívce pole
- Energie = $\frac{1}{2} L I^2$



Impedance obvodu



$$V = \sqrt{V_R^2 + (V_L - V_C)^2}$$

$$\varphi = \tan^{-1} \frac{V_L - V_C}{V_R}$$

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

$$\varphi = \tan^{-1} \frac{X_L - X_C}{R}$$

$$Z = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$$



Zákony elektrických obvodů

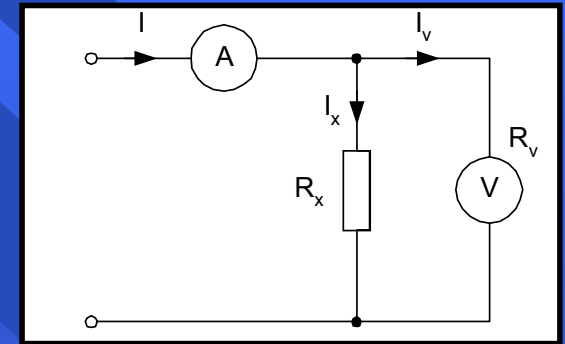
KIRCHOFFOVY ZÁKONY

- základ pro řešení elektrických sítí - obsahují smyčky a uzly

Algebraický součet proudů v uzlu je roven nule:

- n - počet větví v uzlu
- proud vstupující do uzlu +
- proud vystupující z uzlu -

$$\sum_{k=1}^n I_k = 0$$



Součet napětí na rezistorech ($R \cdot I$) je v uzavřené smyčce roven součtu elektromotorických napětí zdrojů.

$$\sum_{i=1}^n R_i \cdot I_i = \sum_{j=1}^m U_{ej}$$

$$U = \frac{W}{Q} \Rightarrow W = U \cdot Q = U \cdot I \cdot t$$

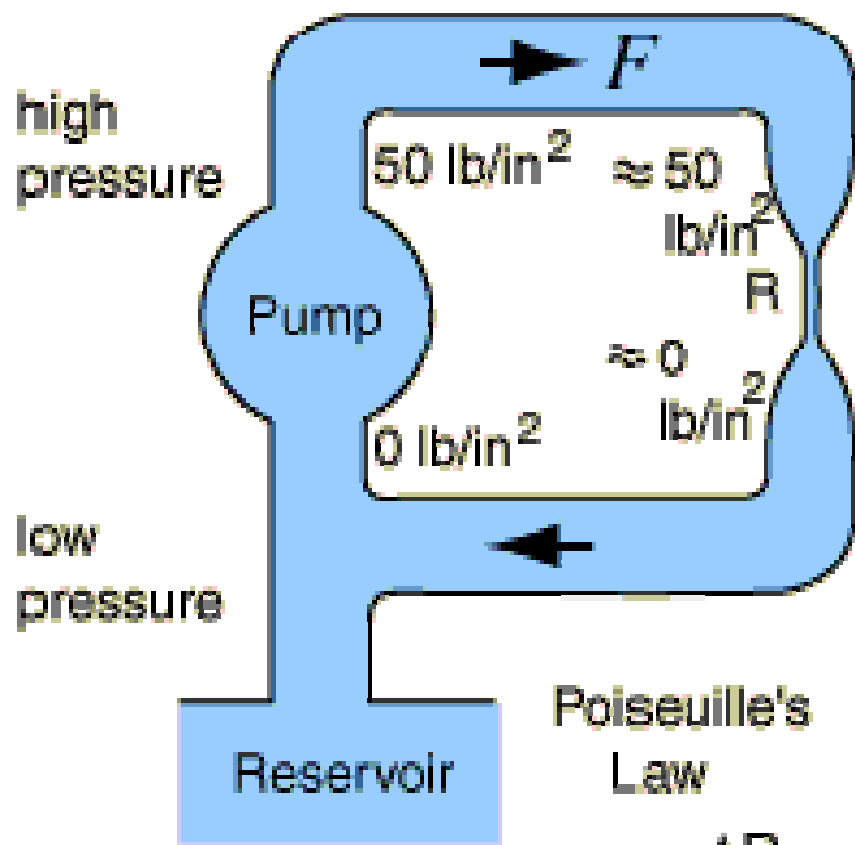
Práce je joule

$$P = \frac{W}{t} = U \cdot I$$

Výkon je ve wattech

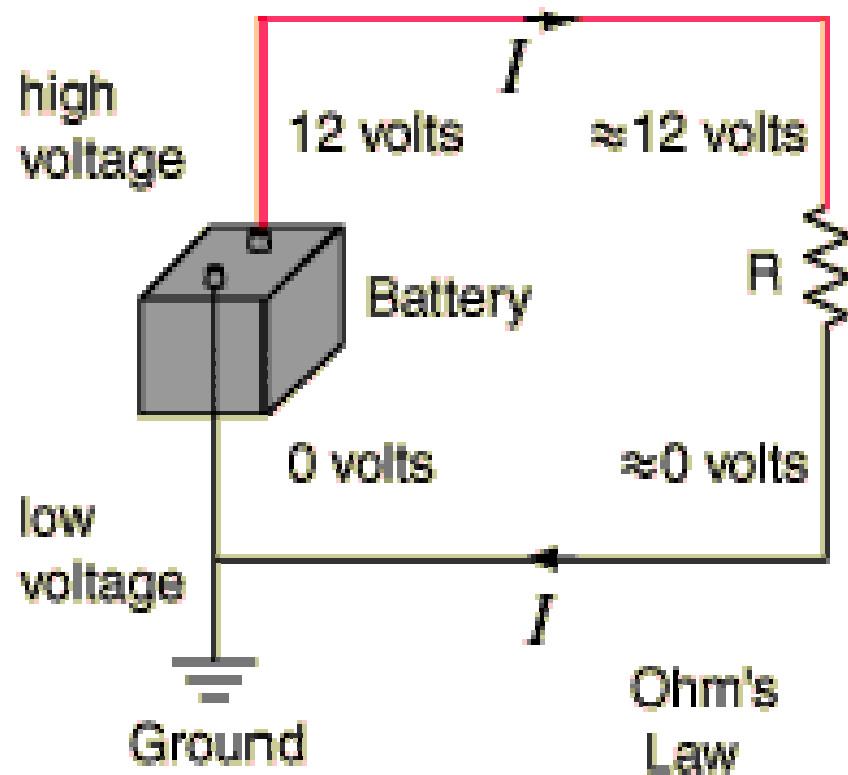


volume flowrate e.g., cm^3/sec



$$F = \frac{\Delta P}{R}$$

charge flowrate = current = $\frac{\text{coulombs}}{\text{second}} = \text{amperes}$



$$I = \frac{\Delta V}{R}$$





Blesk

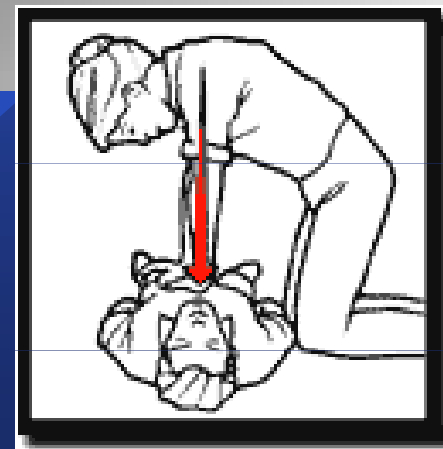
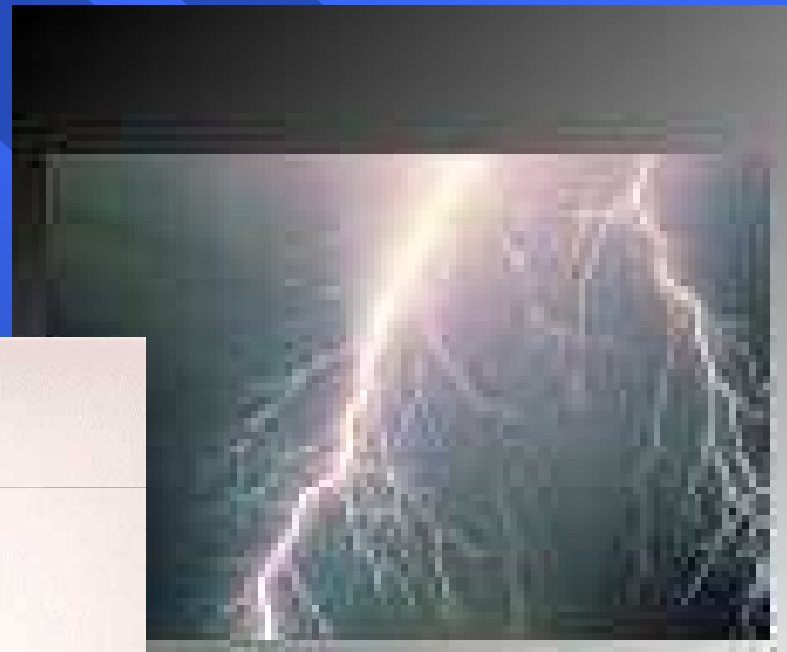
nejde o seriózní časopis



- Blesk má 100000 voltů – náboj – efekt proudu, ale i expendující přehřátý vzduch
- Krokové napětí nohy na různém potenciálu – až 30 m od místa úderu.
- Není vždy smrt – 40 %, vždy je různě dlouhé bezvědomí, fraaktury kostí sval kontrakcí zlomí



Smrt u vysokého napětí je popálením



Worker Deaths by Electrocution

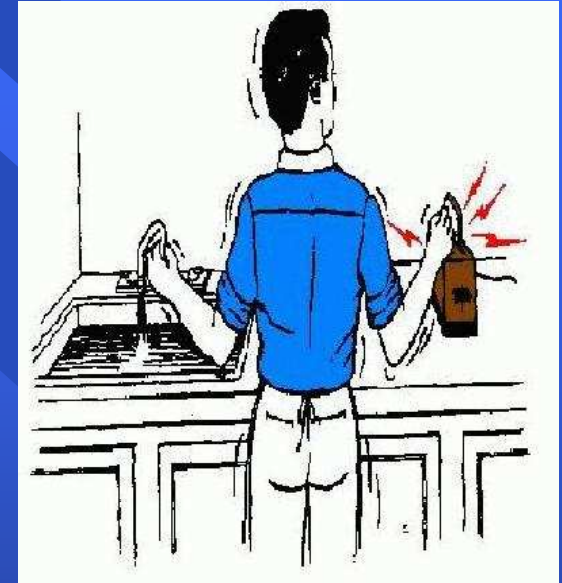
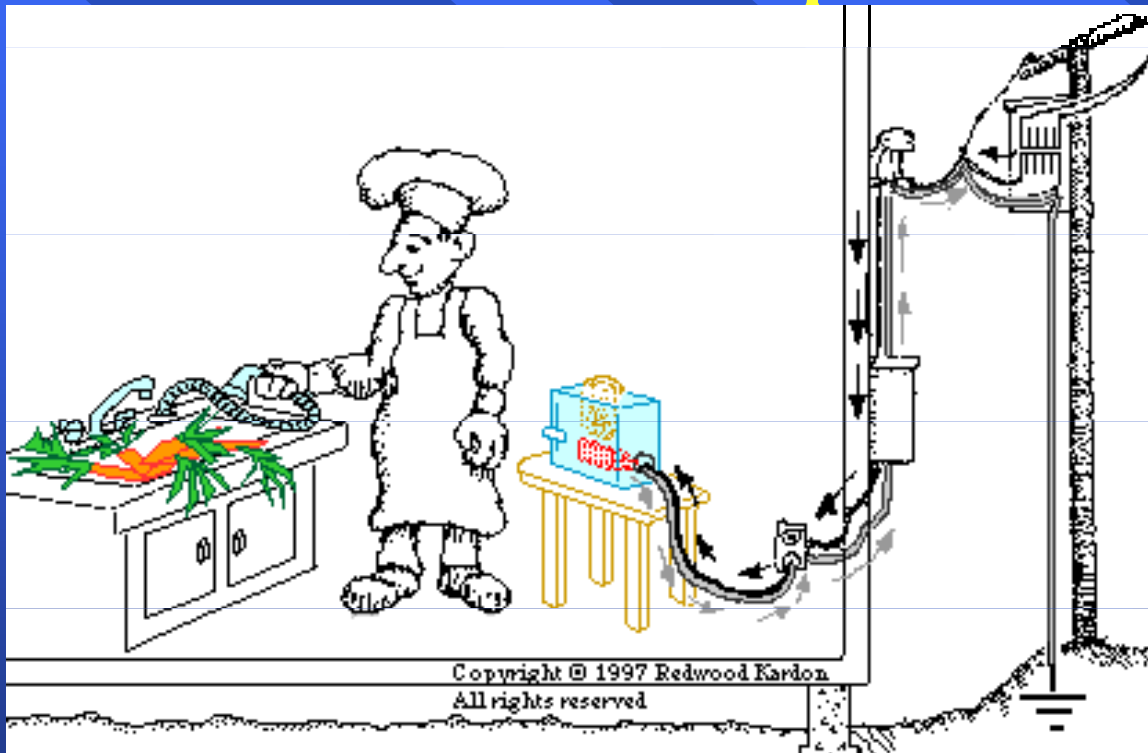
A Summary of Surveillance Findings and Investigative Case Reports

U.S. Department of Health and Human Services
Public Health Service
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

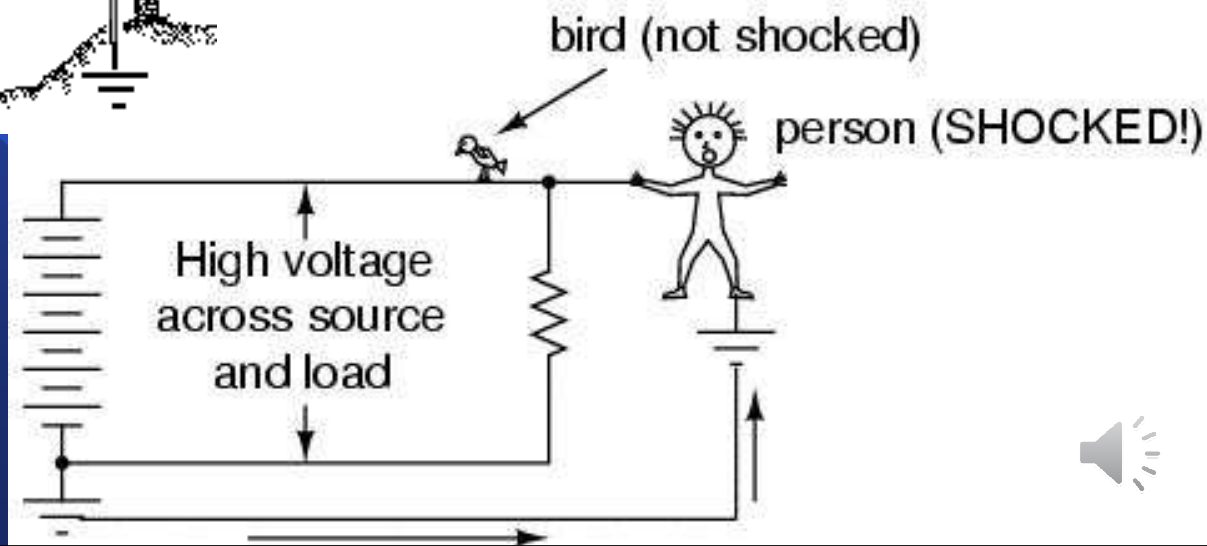
CDC
CENTERS FOR DISEASE CONTROL
AND PREVENTION



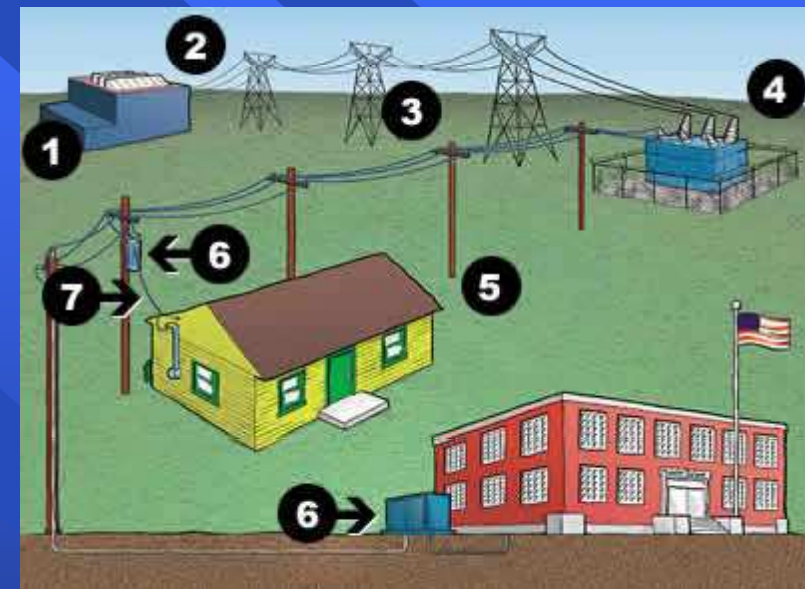
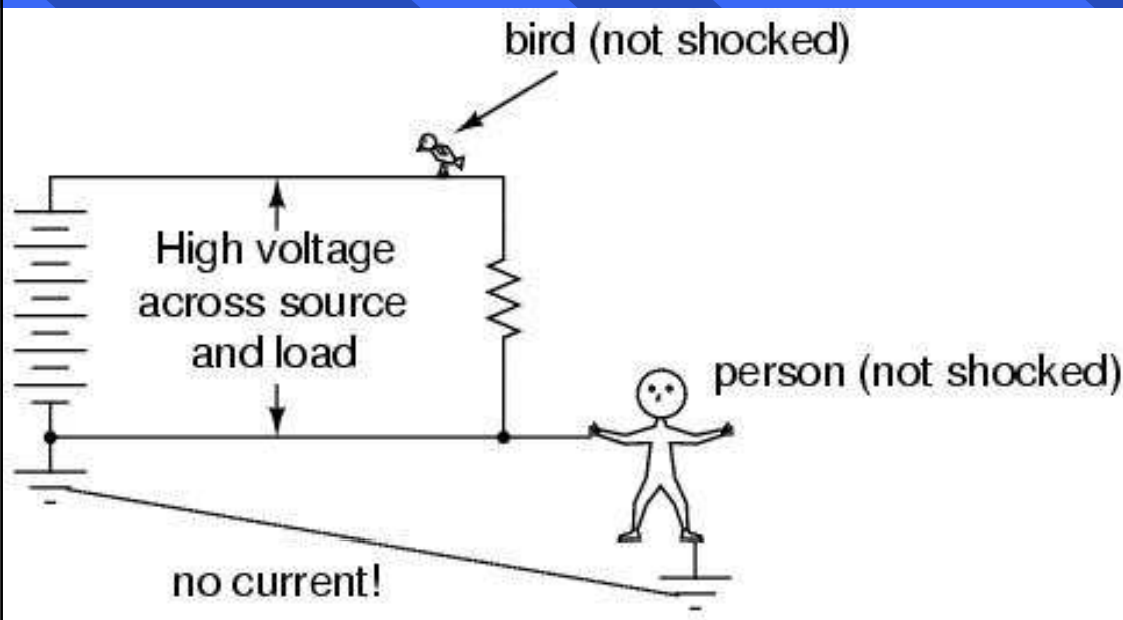
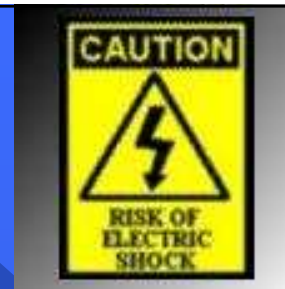
Zkrat – úraz elektrickým proudem



Pojem země, proud hledá cestu
nejmenšího
Odporu, oddělení
trasformátorem,



Vysoké napětí

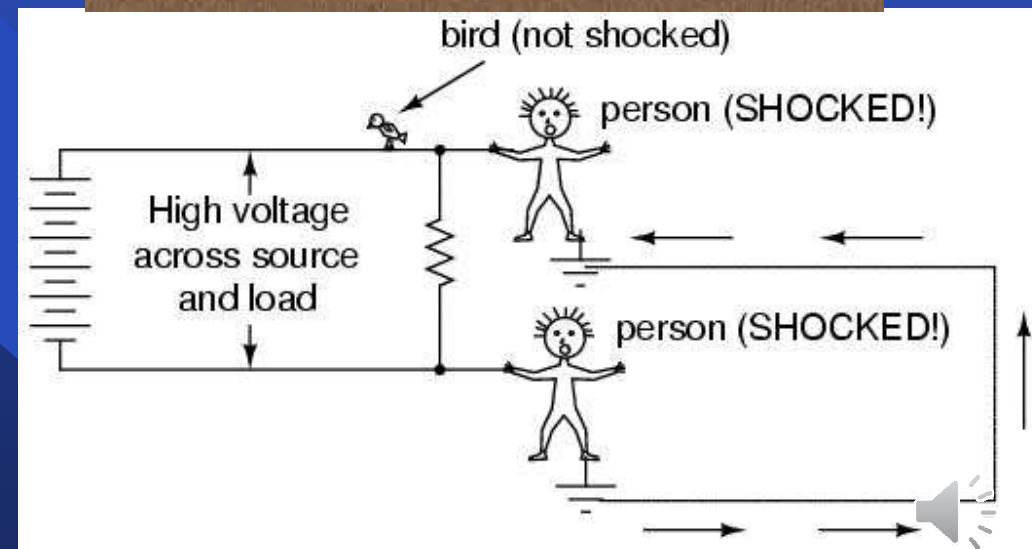


**Ztráty na vedení drátu je energie = RI^2
a jde o přenesení max. výkonu**

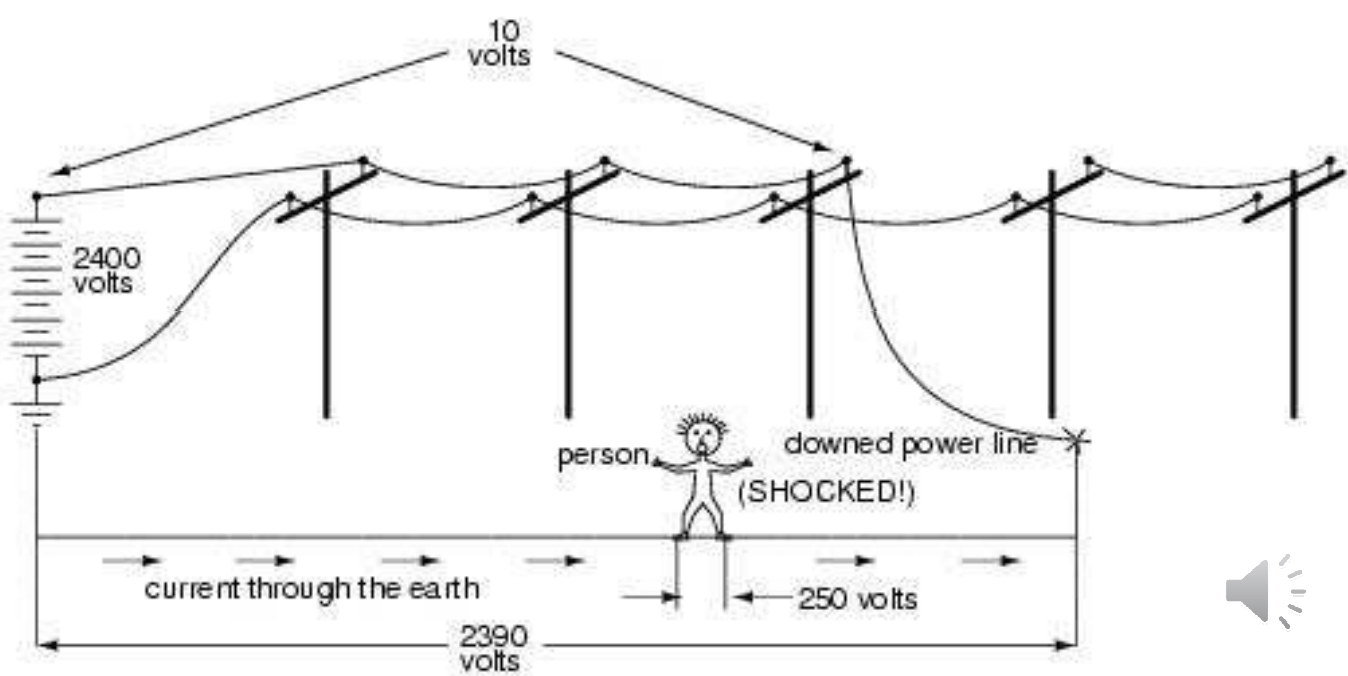
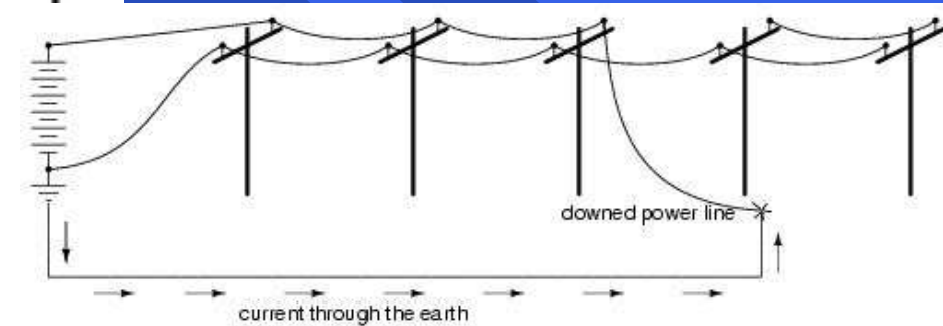
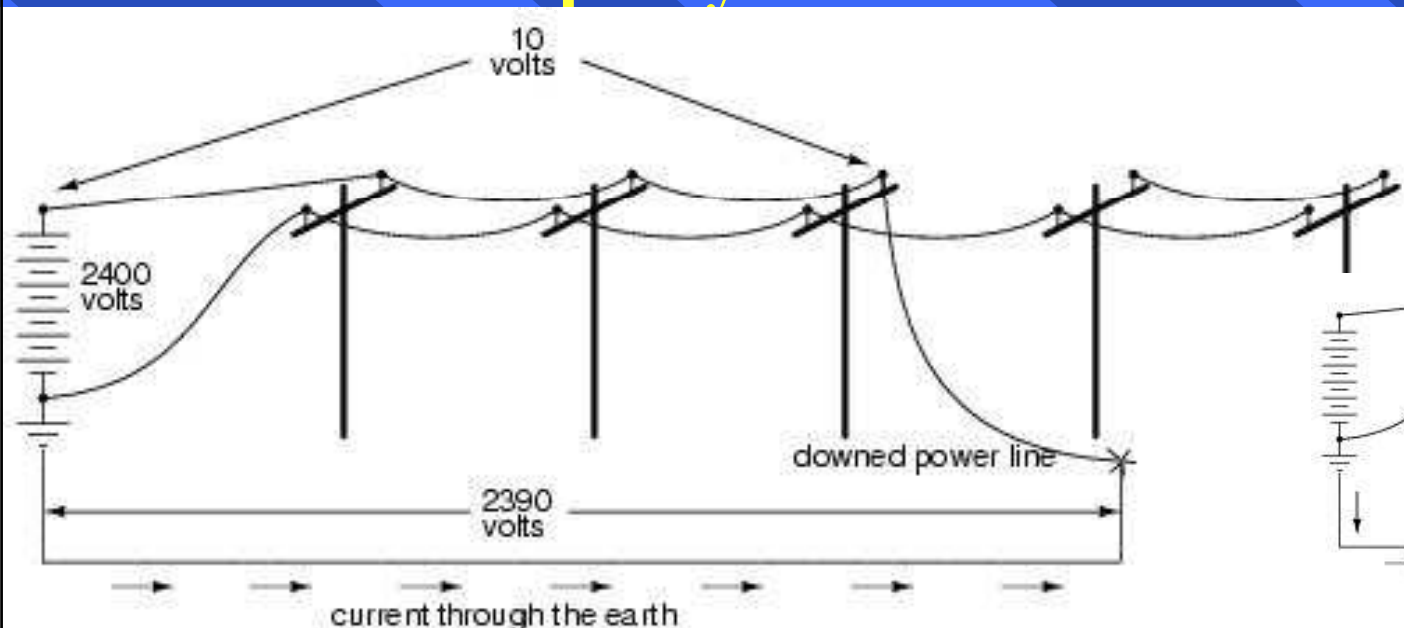
Výkon je proud x napětí.

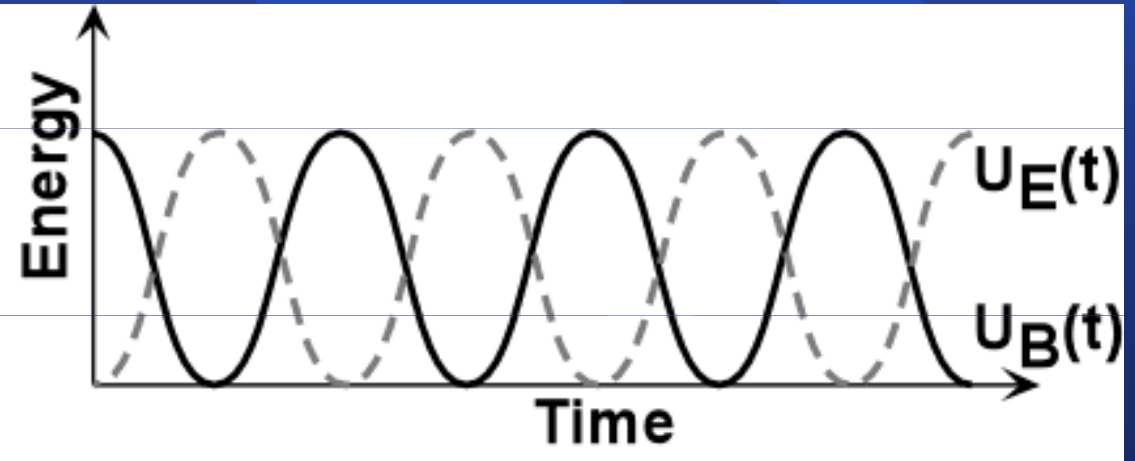
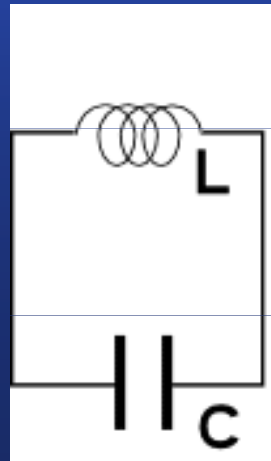
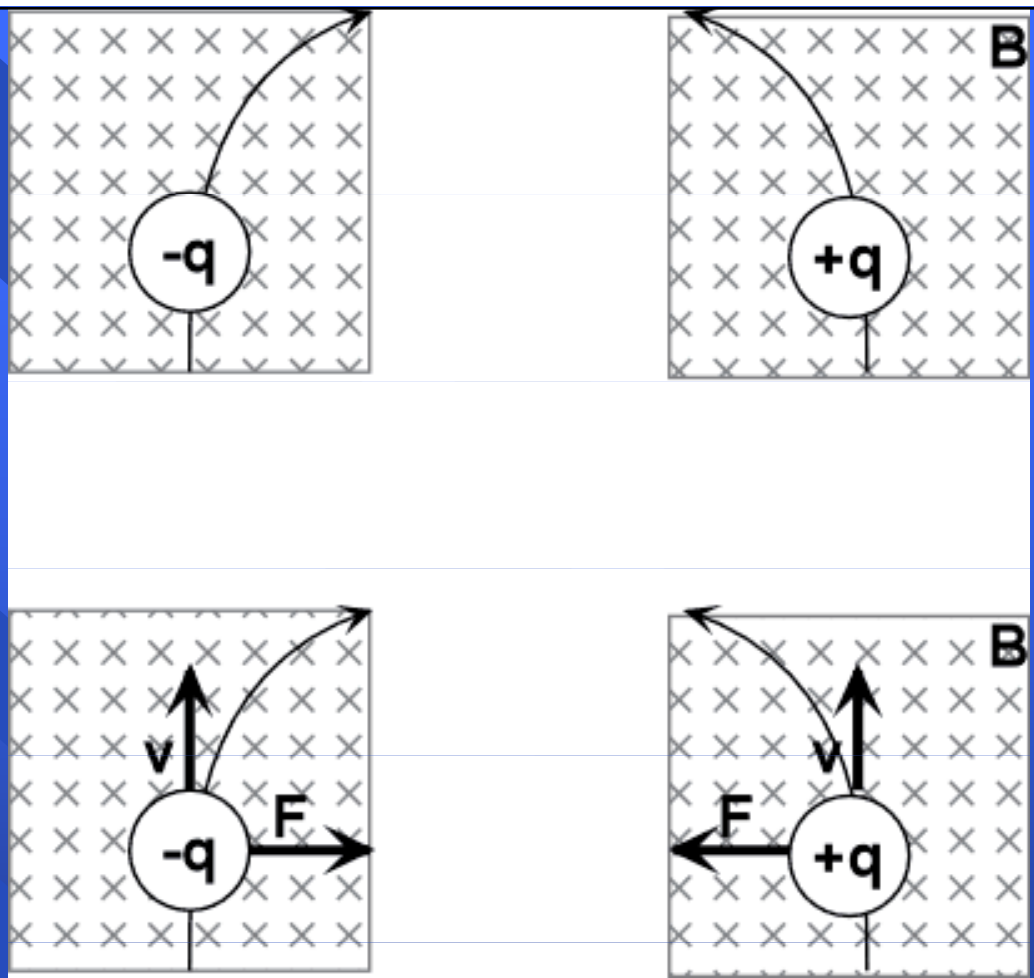
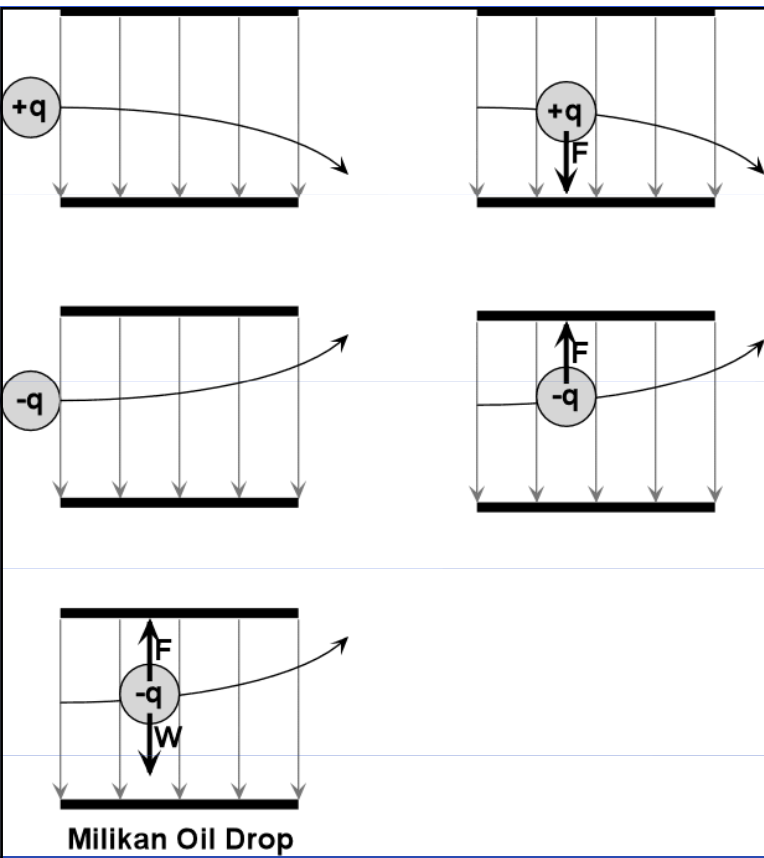
Pevnost vzduch a vody

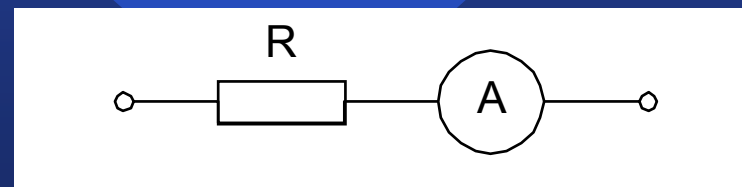
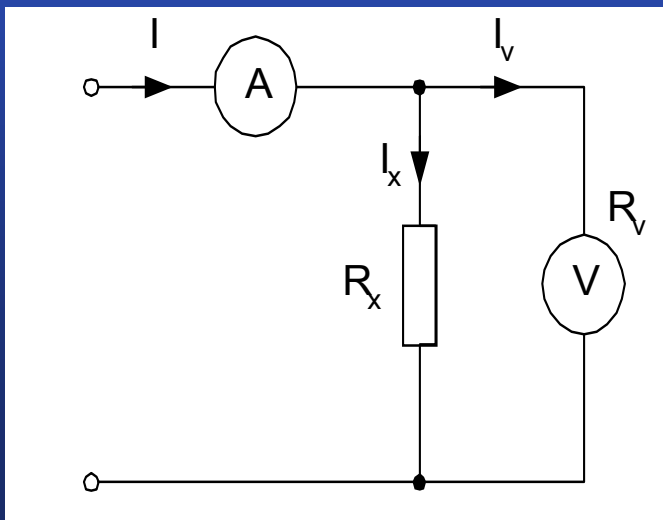
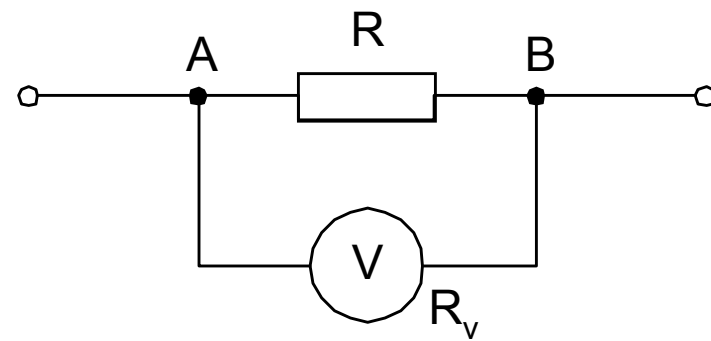
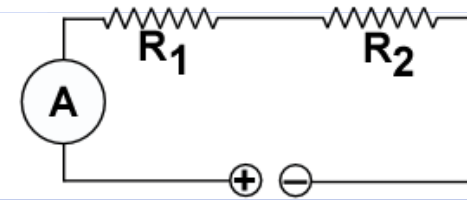
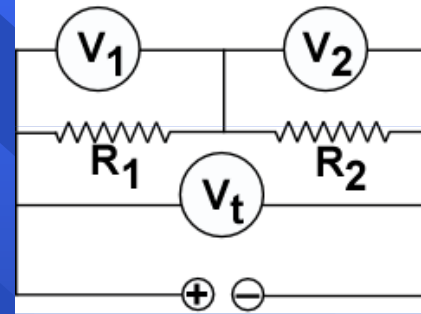
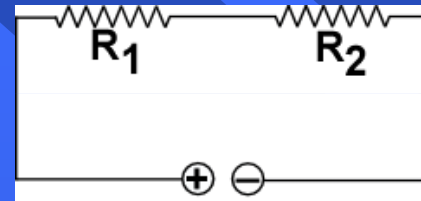
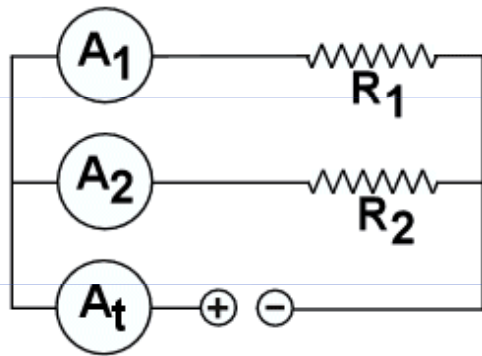
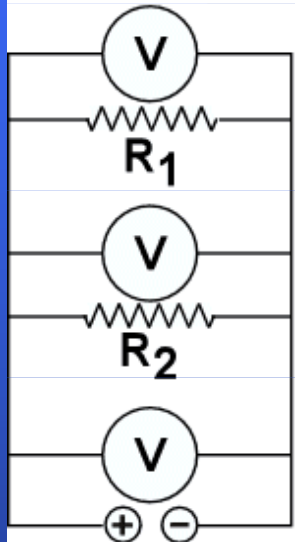
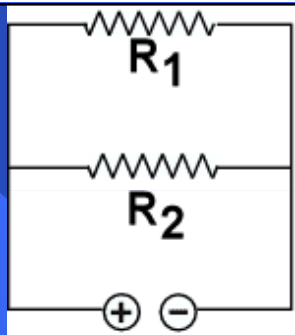
Nesouvisí s vodivostí - Siemens

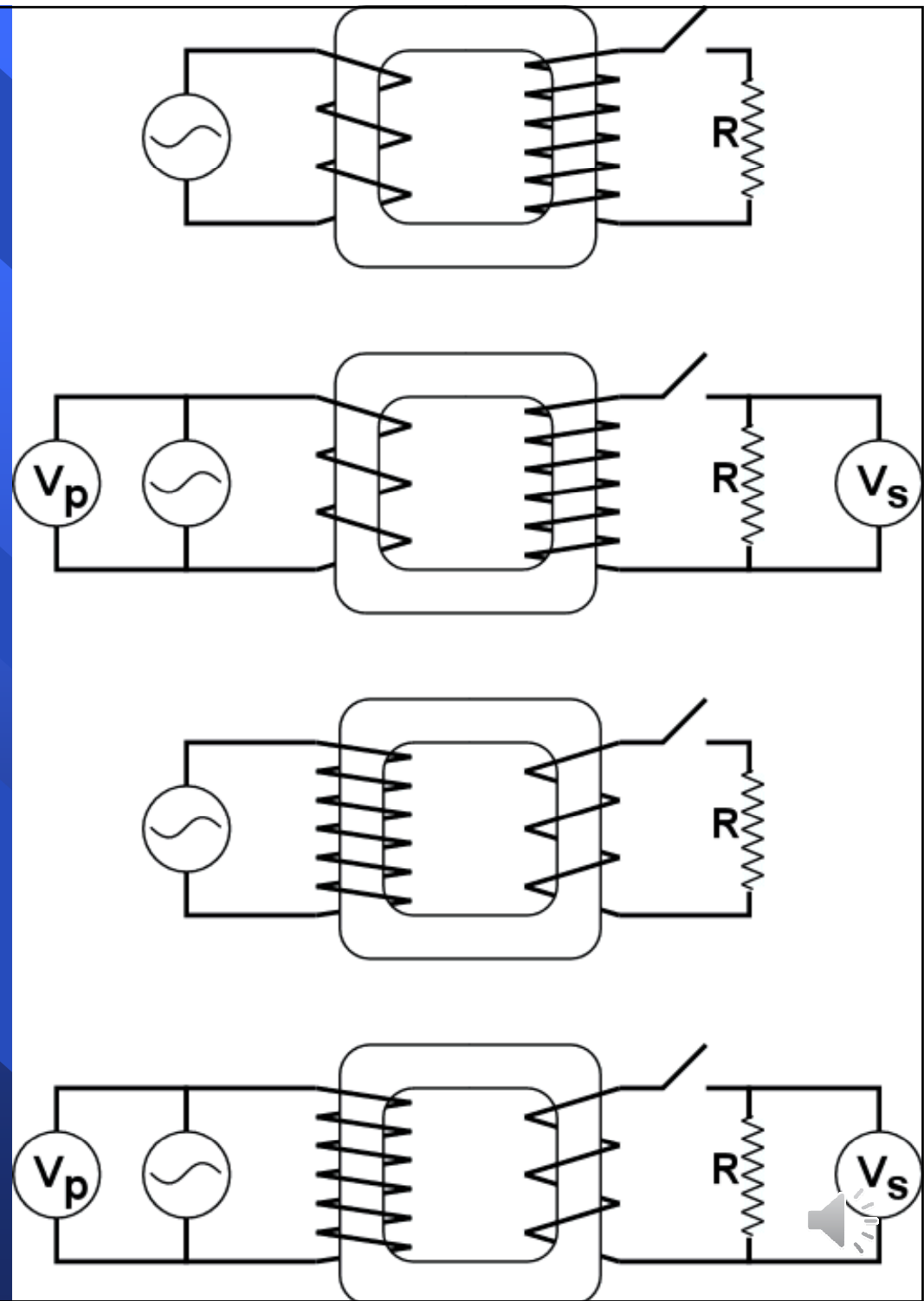
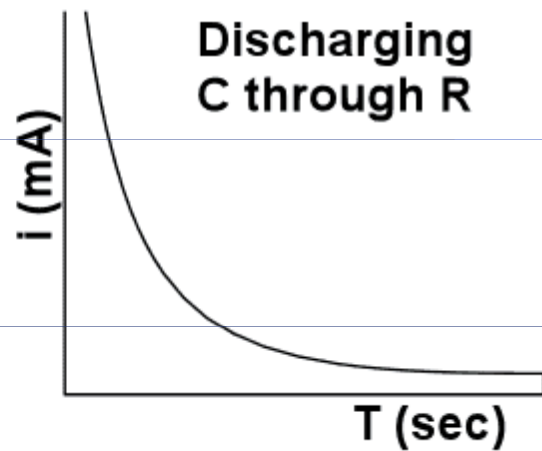
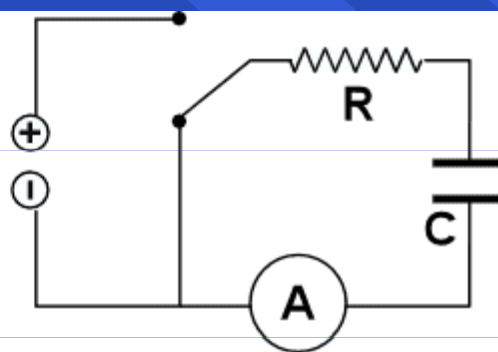
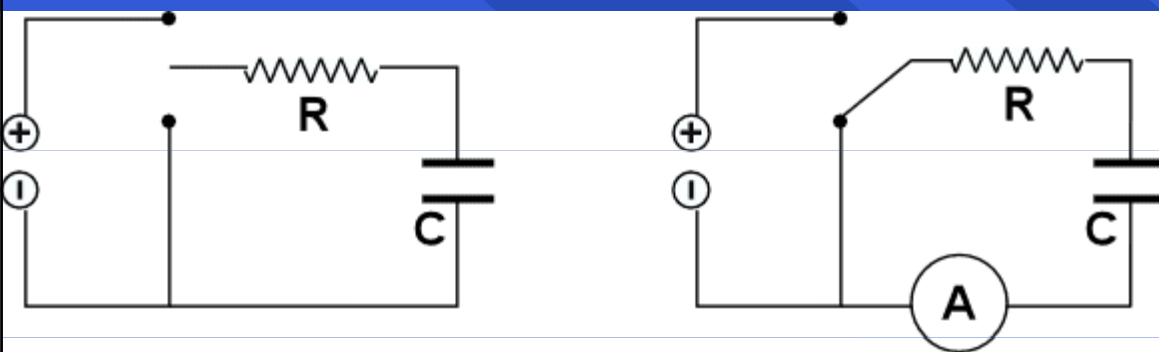


Nedotýkejte se ani drátů na zem spadlých









Proud

- Ampér je proud při průchodu dvěma nekonečně dlouhými vodiči, zanedbatelného průřezu ve vakuu od sebe jeden metr je jeden metr délky sílu $2 \cdot 10^{-7}$ newtonu
- $e = 1,602 \cdot 10^{-19}$ C opačně $1 \text{ C} = 6,242 \cdot 10^{18}$ nábojů
- Volt ampérová charakteristika
- Odpor na teplotě
- Elektroměr – měří joule
- Změny rozsahu ampérmetr a voltmetru
- Vnitřní odpor zdroje

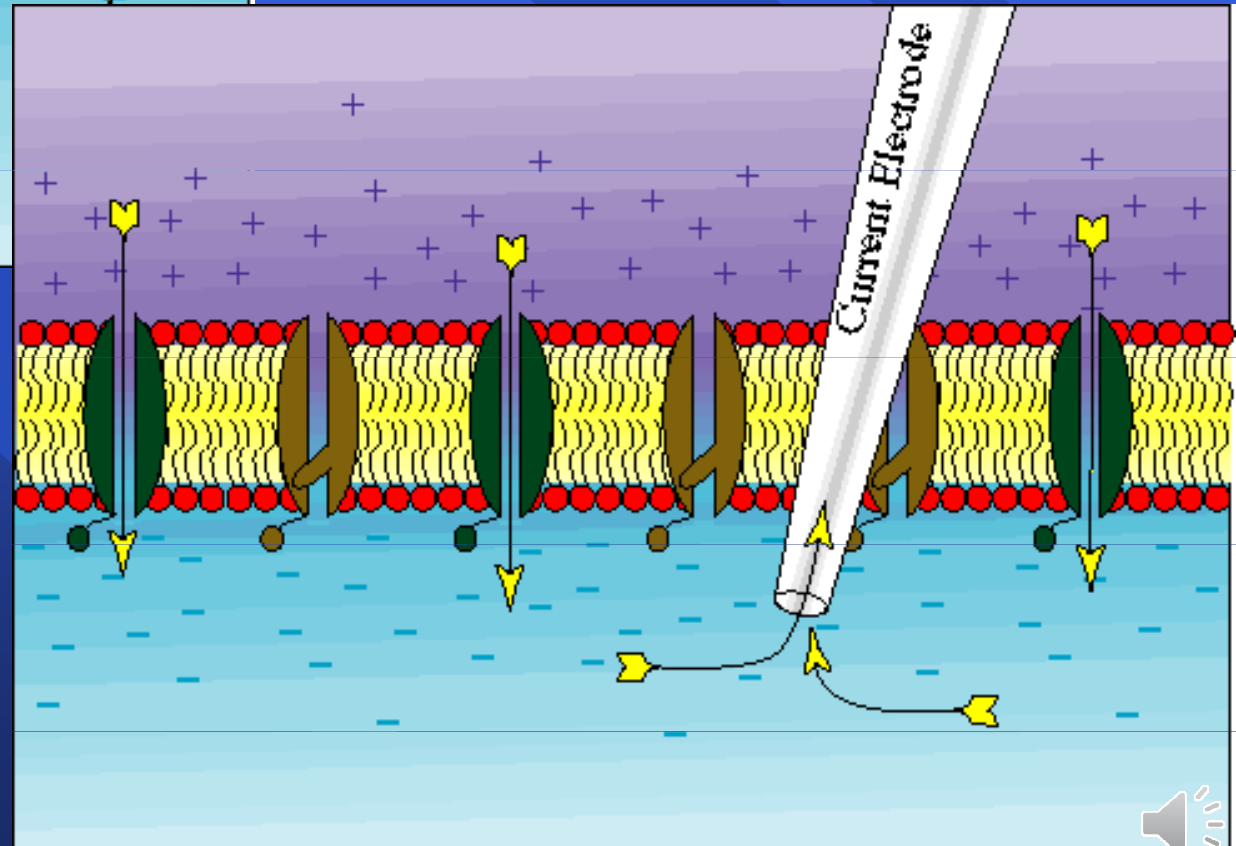
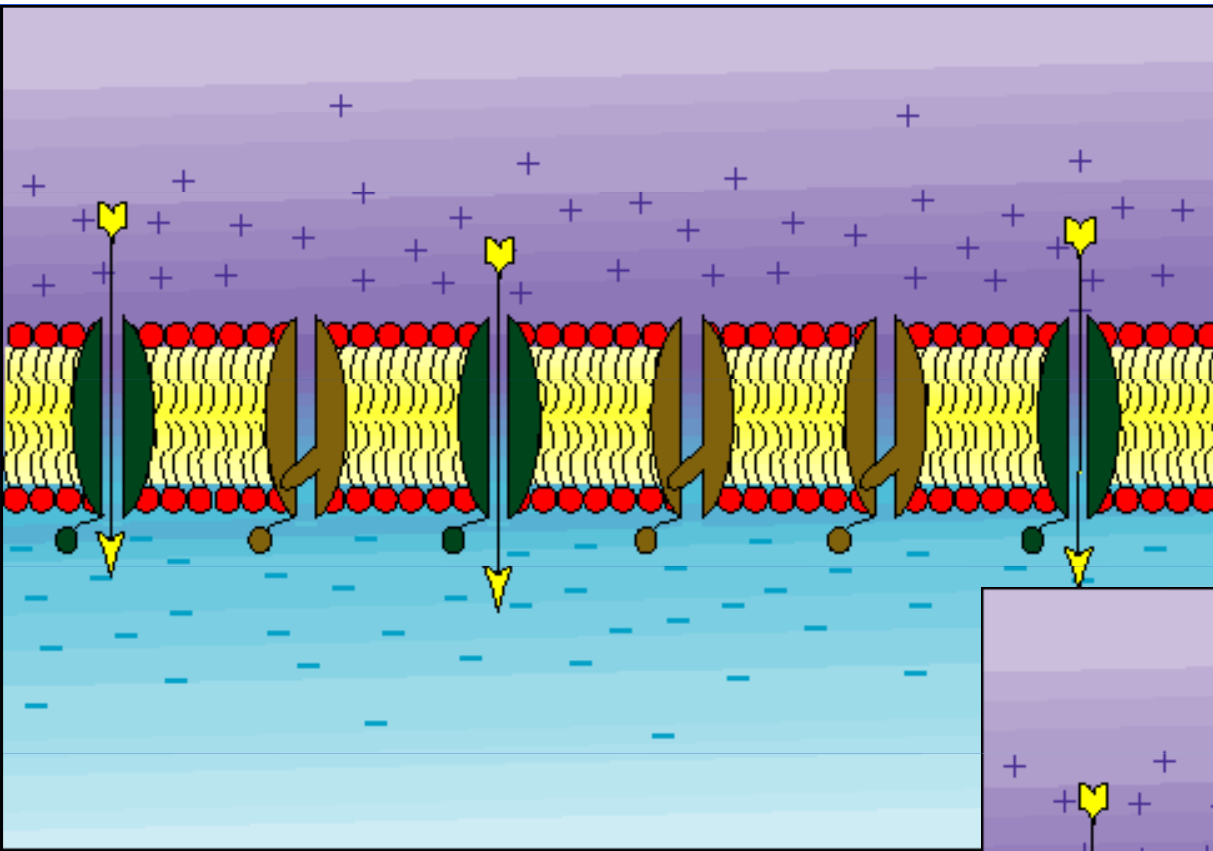


Intenzita proudu

- Proudý kolem 25 mA křeče, pro srdce podprahové
- 80 mA až 3 A – nebezpečné – fibrilace komor irreversibilní
- Proudý nad 3 A již nejsou pro srdce nebezpečné – způsobují popáleniny (těžké a smrtelné)
- Střídavý 4x nebezpečnější než stejnosměrný
- 30 až 150 HZ nejhorší (vysokofrekvenční proud tam poškození až 500 mA !!!!)
- Doba kontaktu – křeč a on se drží
- Cesta v těle
- Zocelení lidé - elektrikáři

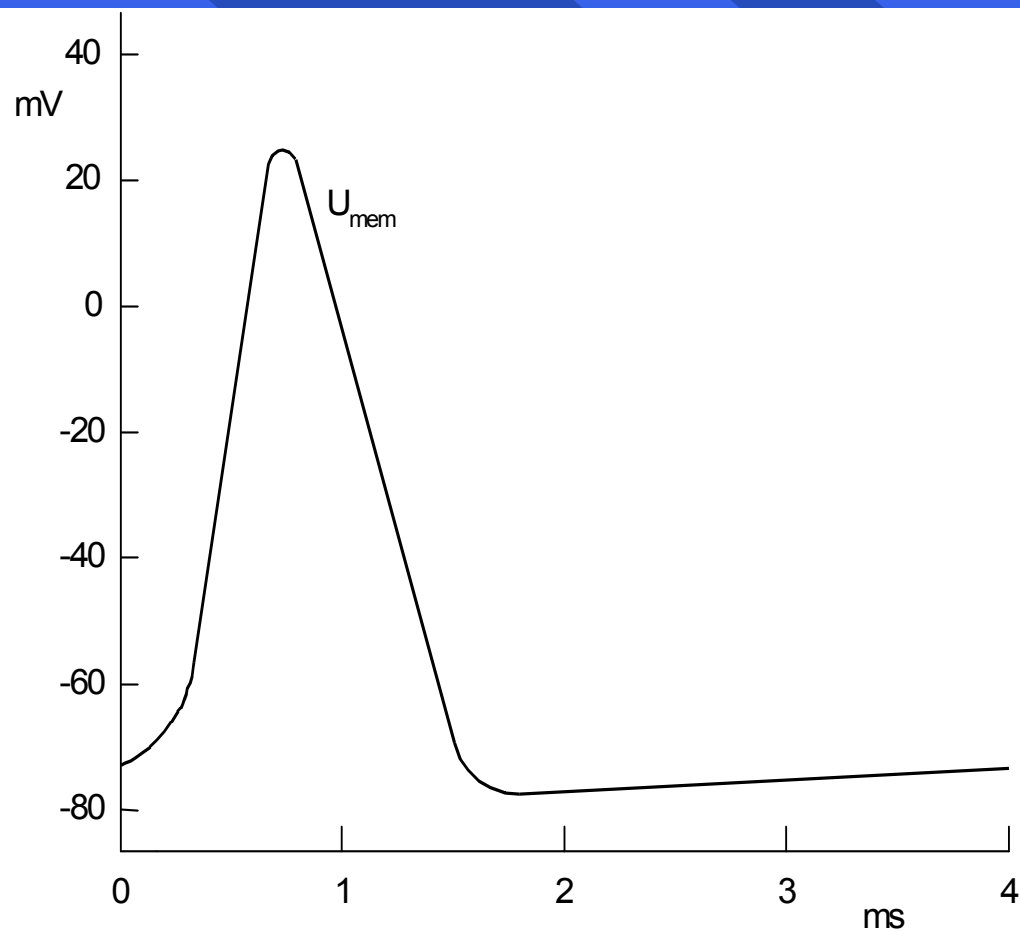


Záporné napětí-70 mV

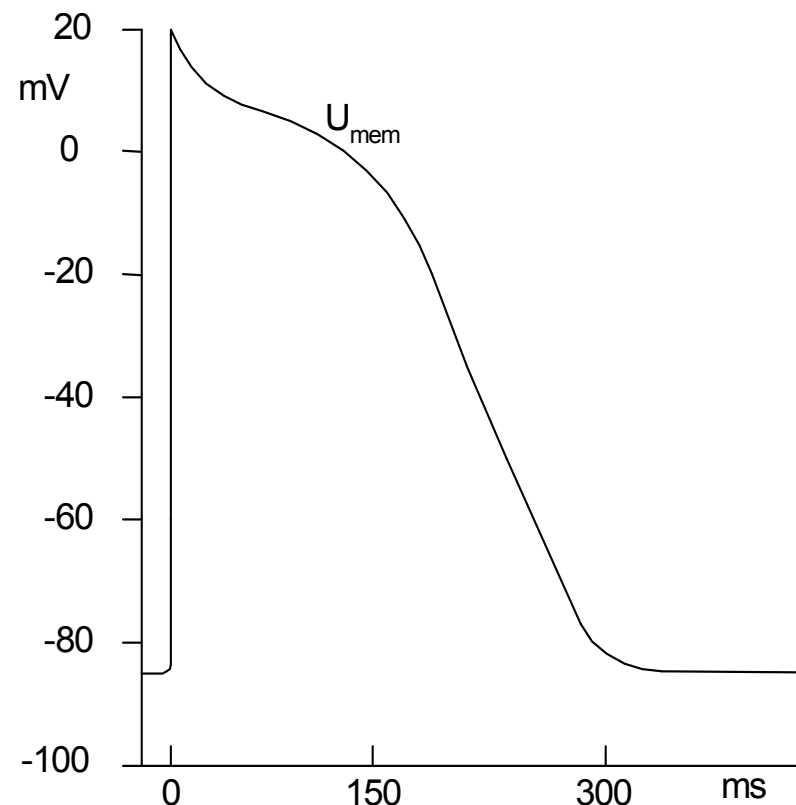


Rozdíl mezi myocytem a ostatní dráždivou svalovou a nervovou tkání

(neplatí pro hysterické osoby)



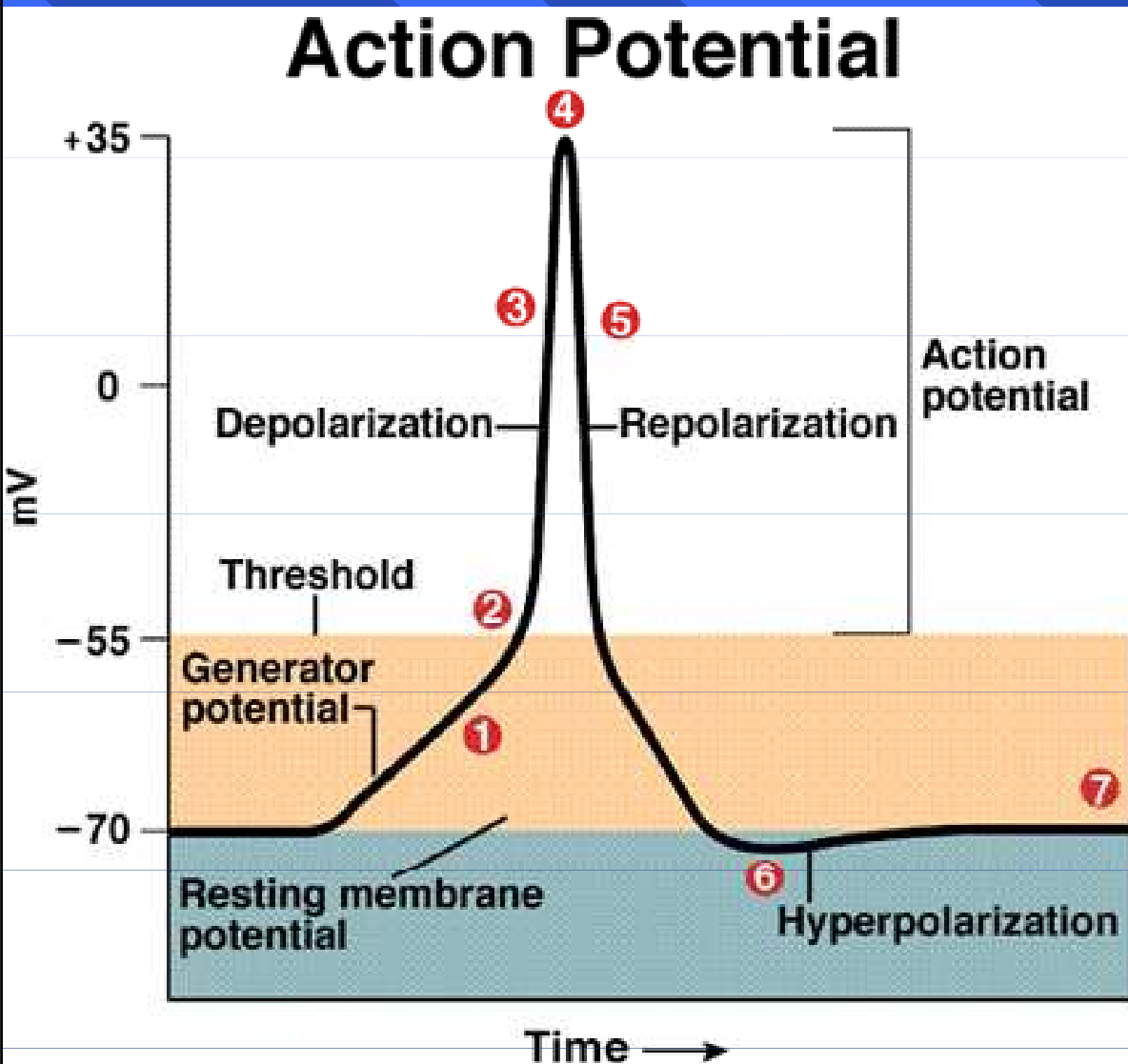
Průběh akčního potenciálu na membráně nerovného vlákna



Průběh akčního potenciálu na membráně buňky srdečního svalu

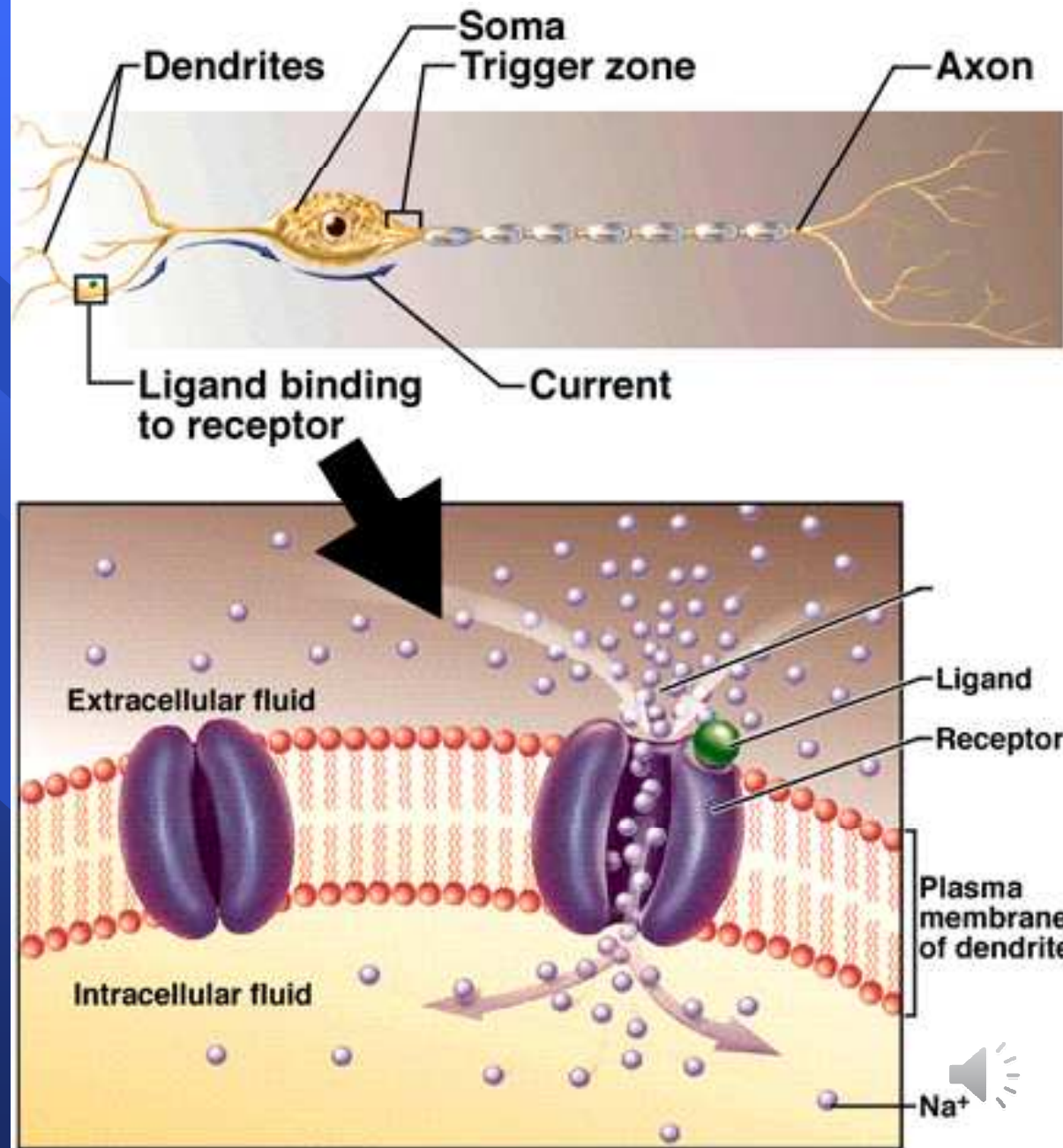
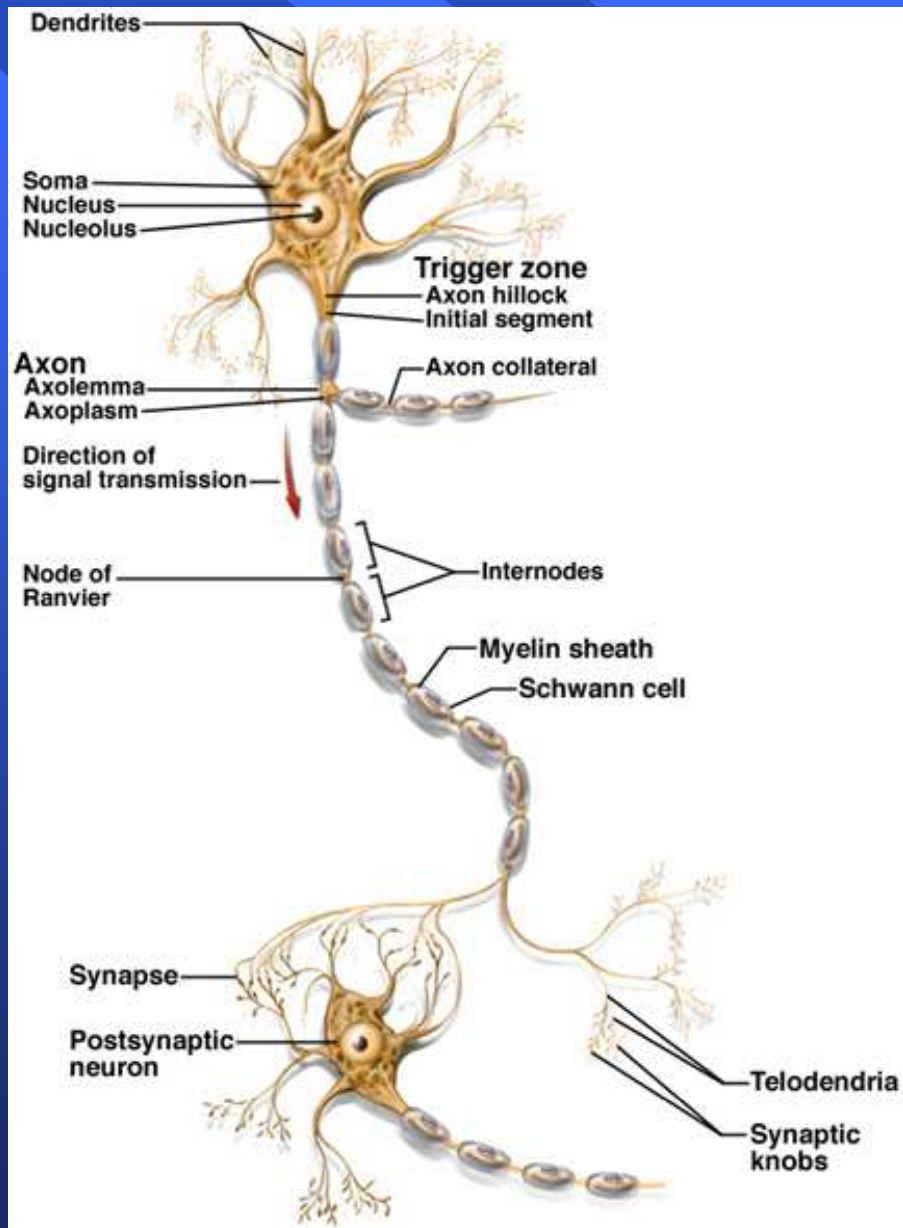


Dva pojmy mezi fyzikou a fyziologií

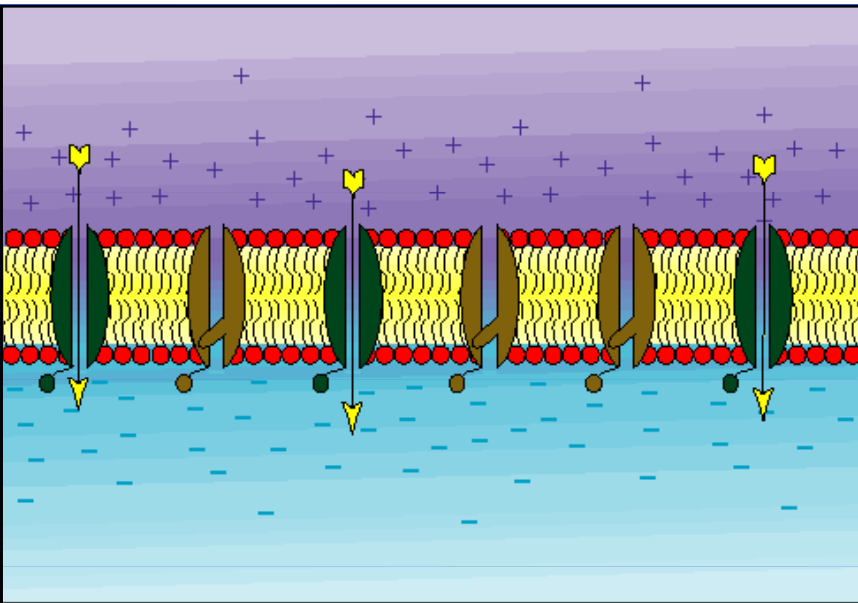


- Dráždivost tkání (např. svalů) vyjádřit pomocí reobáze a chronaxie. proudovými impulsy, existuje určitá hodnota proudu, pod kterou nelze podráždění vyvolat. Ta se nazývá reobáze. Chronaxie je doba trvání impulsu nutná k podráždění svalu proudem rovným dvojnásobku reobáze.





Donnanova rovnováha napětí-70 mV



Chemický potenciál složky představuje změnu volné entalpie (Gibbsovy energie) G soustavy, při předání či odebrání 1 molu i -té složky ze soustavy při konstantním tlaku a teplotě a při nezměněných množstvích ostatních složek. Proto se též nazývá parciální molární Gibbsova energie.

práce potřebná k převedení 1 molu i -té složky (iontu či elektronu) do nitra uvažované fáze, daná jako součet chemické a elektrostatické složky

$$\mu = \mu_i^0 + RT \cdot \ln a_i$$

$$\mu_i = \mu_i^0 + RT \cdot \ln c_i$$

$$\tilde{\mu}_i^{in} = \tilde{\mu}_i^{ex}$$

$$\mu_i^{in} + z_i F \varphi^{in} = \mu_i^{ex} + z_i F \varphi^{ex}$$

$$RT \cdot \ln a_i^{in} + z_i F \varphi^{in} = RT \cdot \ln a_i^{ex} + z_i F \varphi^{ex}$$

$$z_i F (\varphi_i^{in} - \varphi_i^{ex}) = RT \cdot \ln \left(\frac{a_i^{ex}}{a_i^{in}} \right)$$

$$\Delta \varphi_{mem} = \frac{RT}{z_i F} \cdot \ln \frac{a_i^{ex}}{a_i^{in}}$$

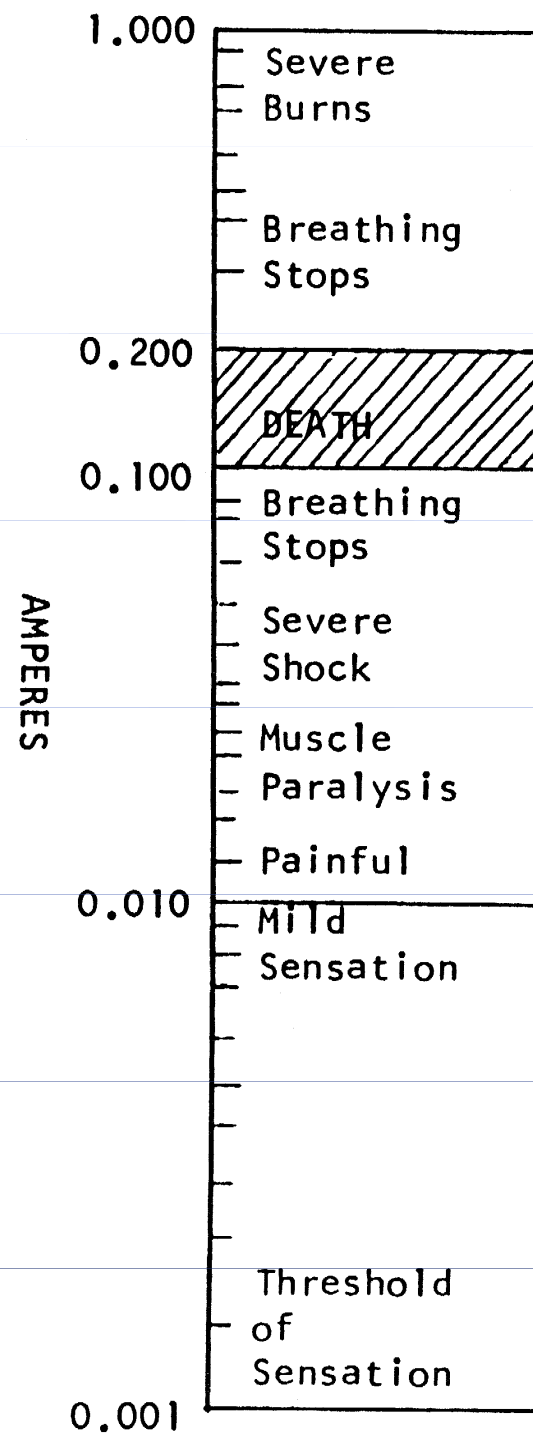
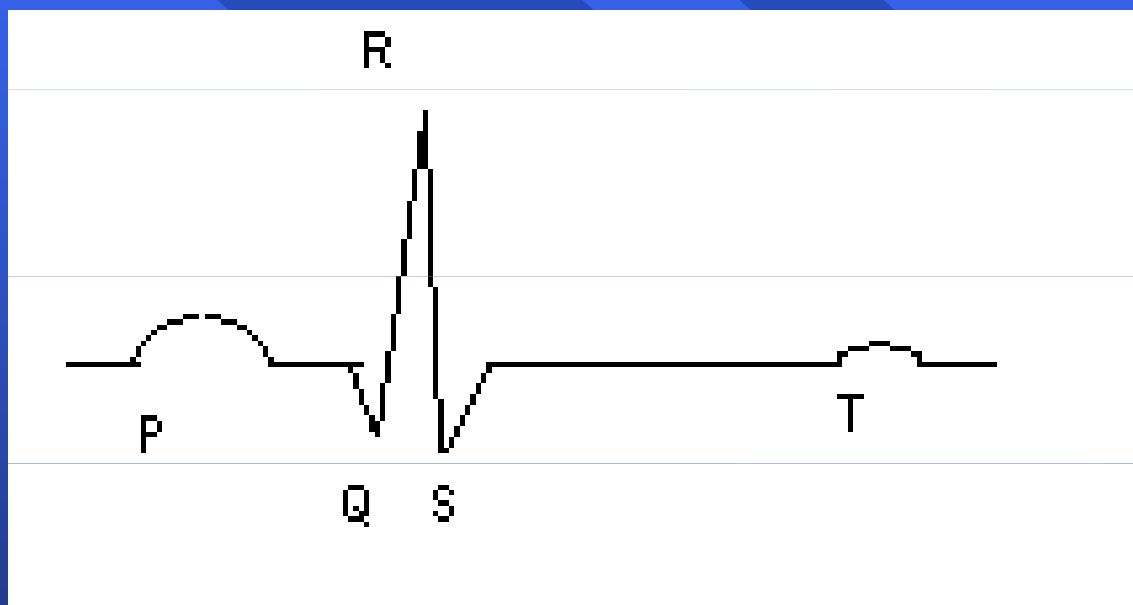
$$\tilde{\mu}_i = \mu_i + z_i F \varphi$$

Donnannův potenciál (Nerstnova rovnice)





Elektrický proud a popis EKG





ECG & Membrane Potential of Ventricular Cell

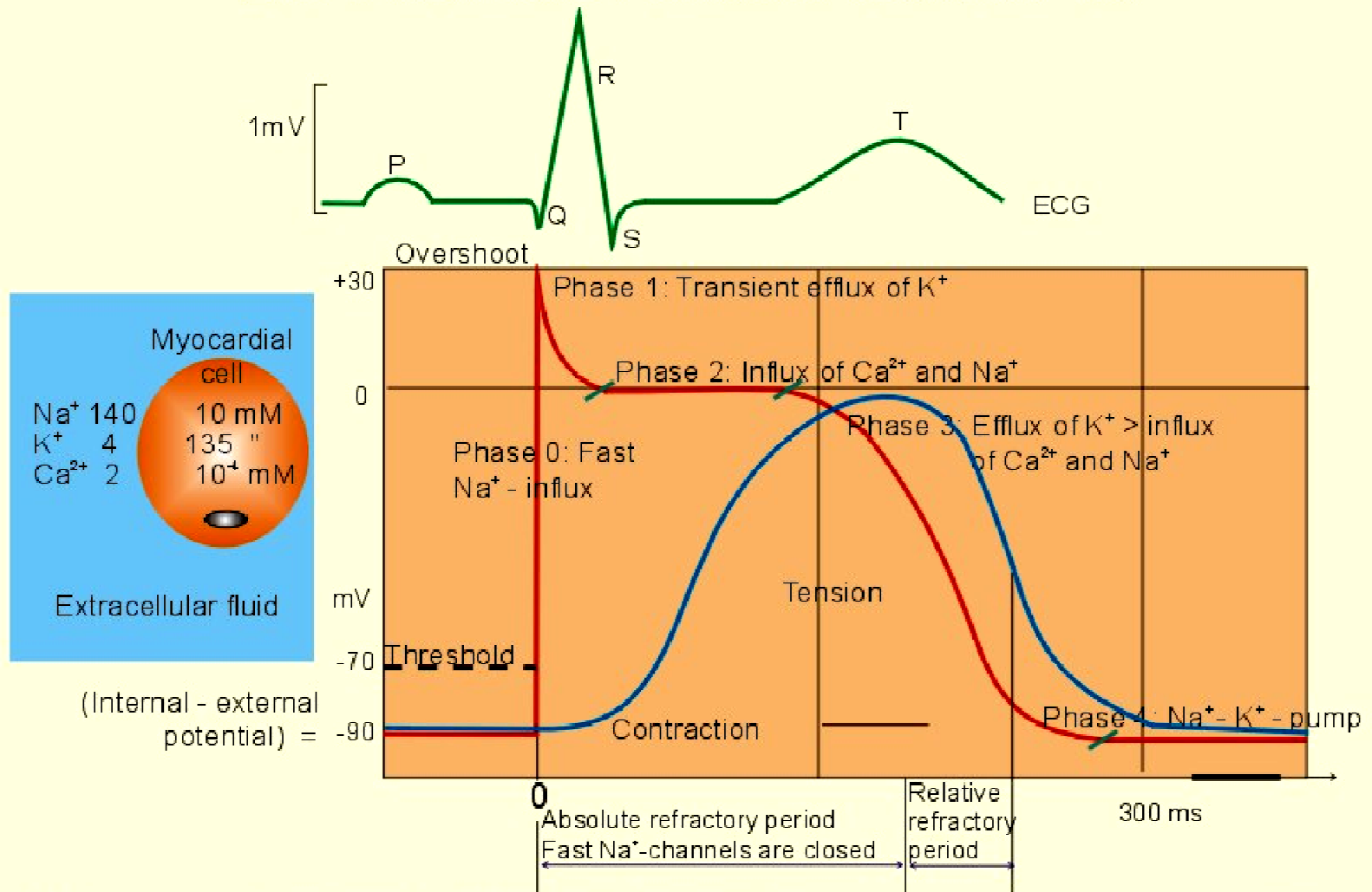


Fig. 11-2

Steep phase 0 means rapid depolarisation

KMc



Přehled tematických okruhů



EKG

Dočasná kardiostimulace

Elektrická kardioverze

Defibrilace

Trvalá stimulace

Diatermie



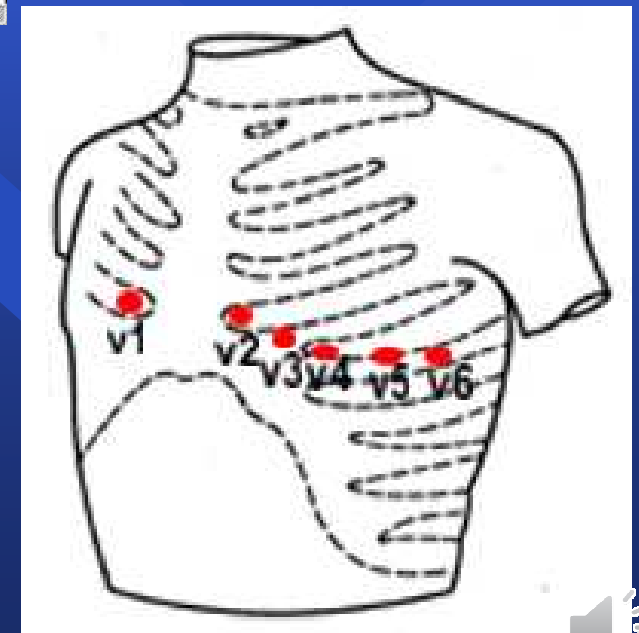
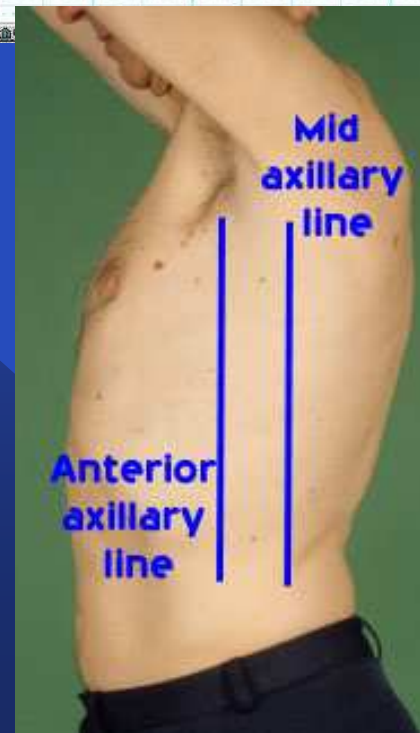
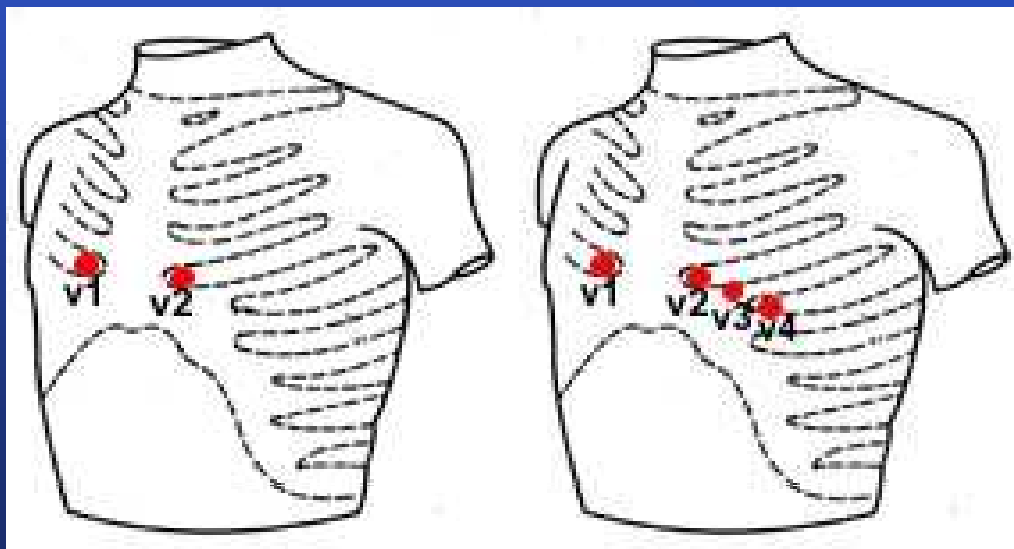
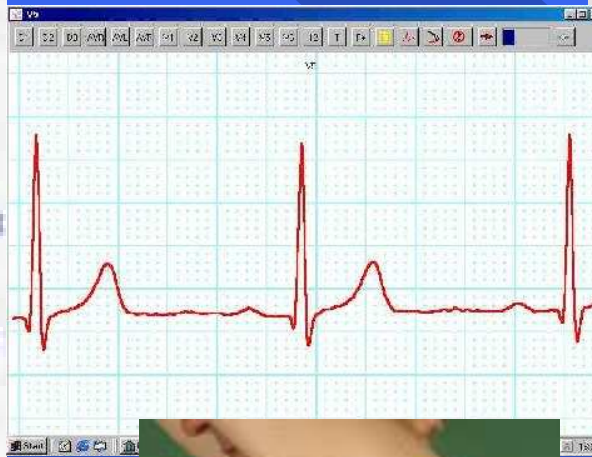
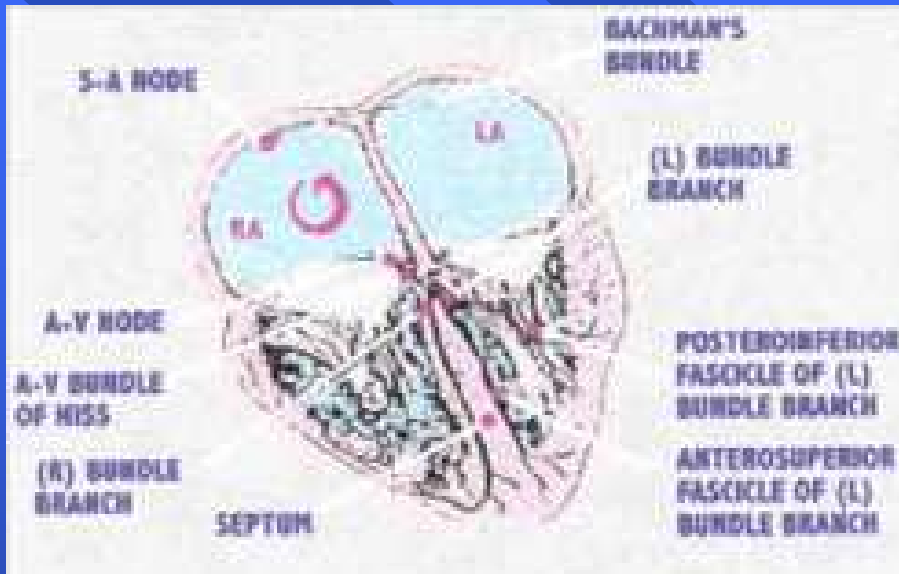
EKG

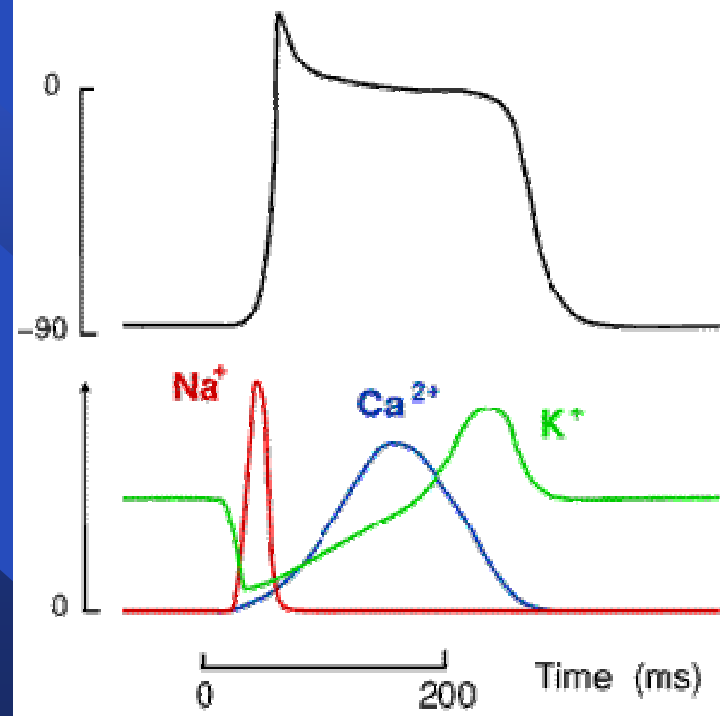
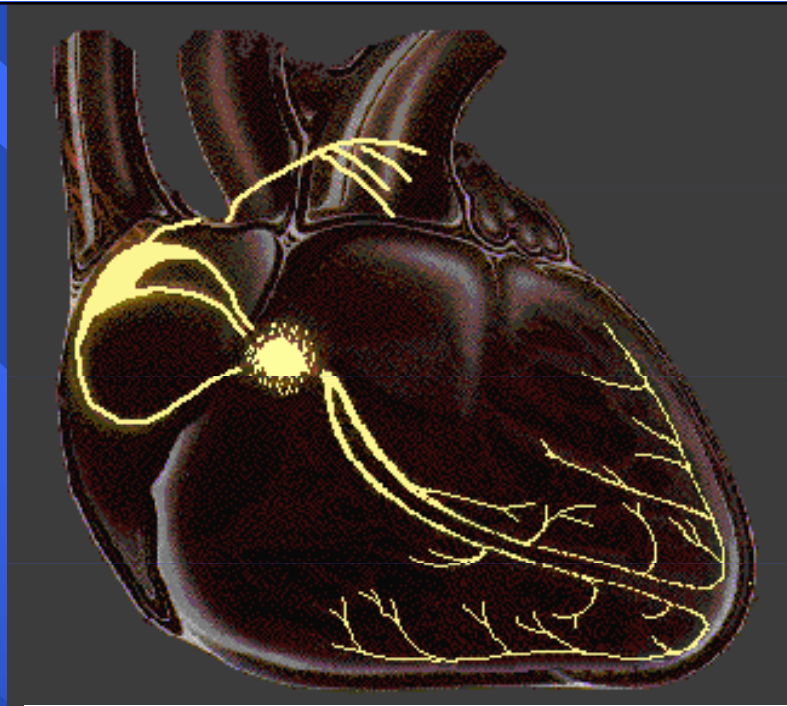
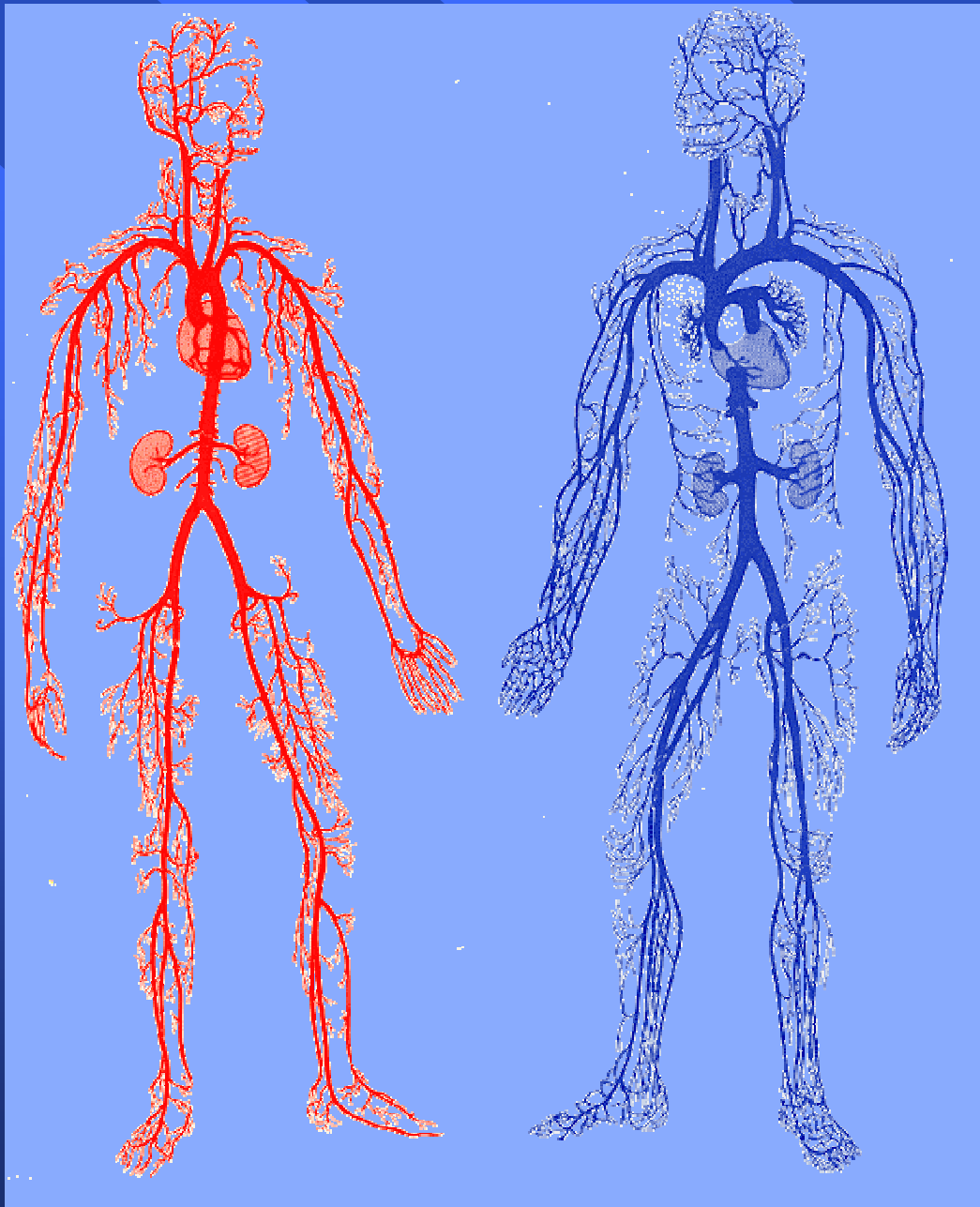


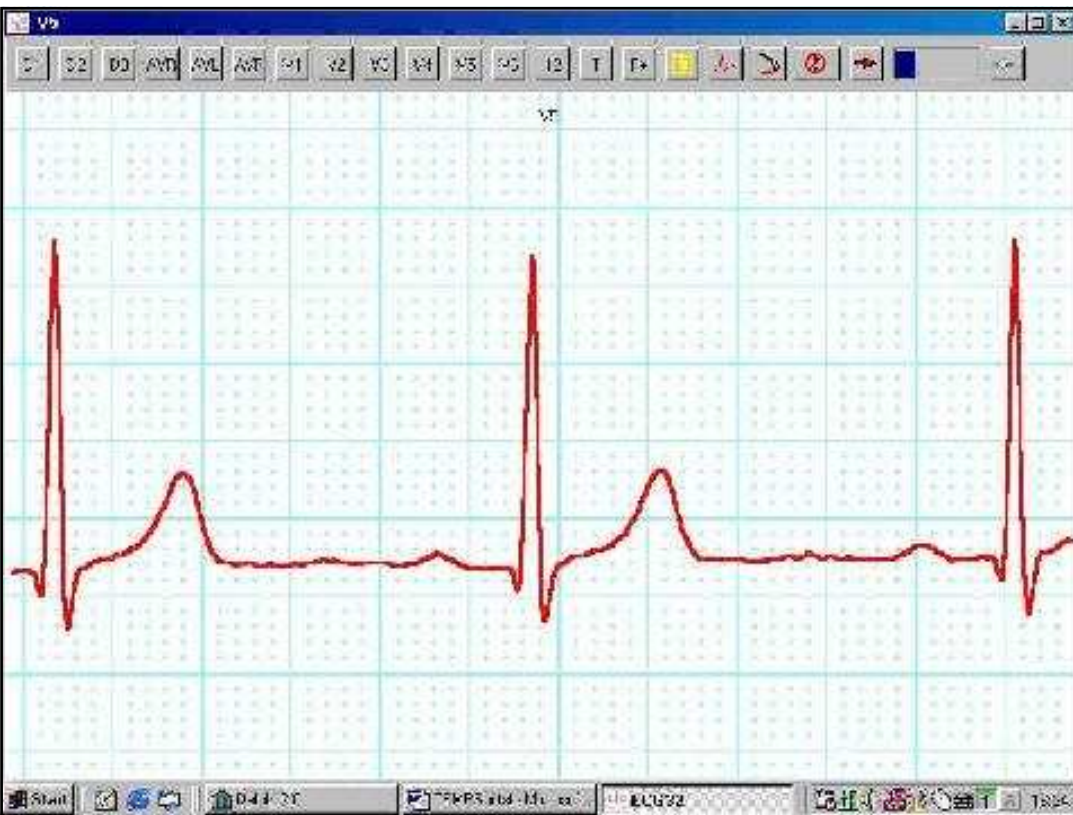
- **Klasické 12 svodové**
- **Kontinuální monitorování**
- **Centrála pro monitorování arytmií**
- **Monitorování ST úseků**



EKG – teorie a praxe







Normální EKG

D1... 1..2.3 AVERAGE ST GRAPH Referentiepunten op

0.17 min Vorige Raster Filter

Fr	68	ASP	31	QRS	32	T	31
PG	156	QRS	90	QT	393	QTC	418

PC LIST PERS

- Linker anterior hemblok
- Linker atrium hypertrofie
- Linker posterior hemblok
- Linker ventrikel hypertrofie
- Normaal EKG**
- Onvollledig linker bundeltakblok

Persoonlijk besluit

Normaal ECG.

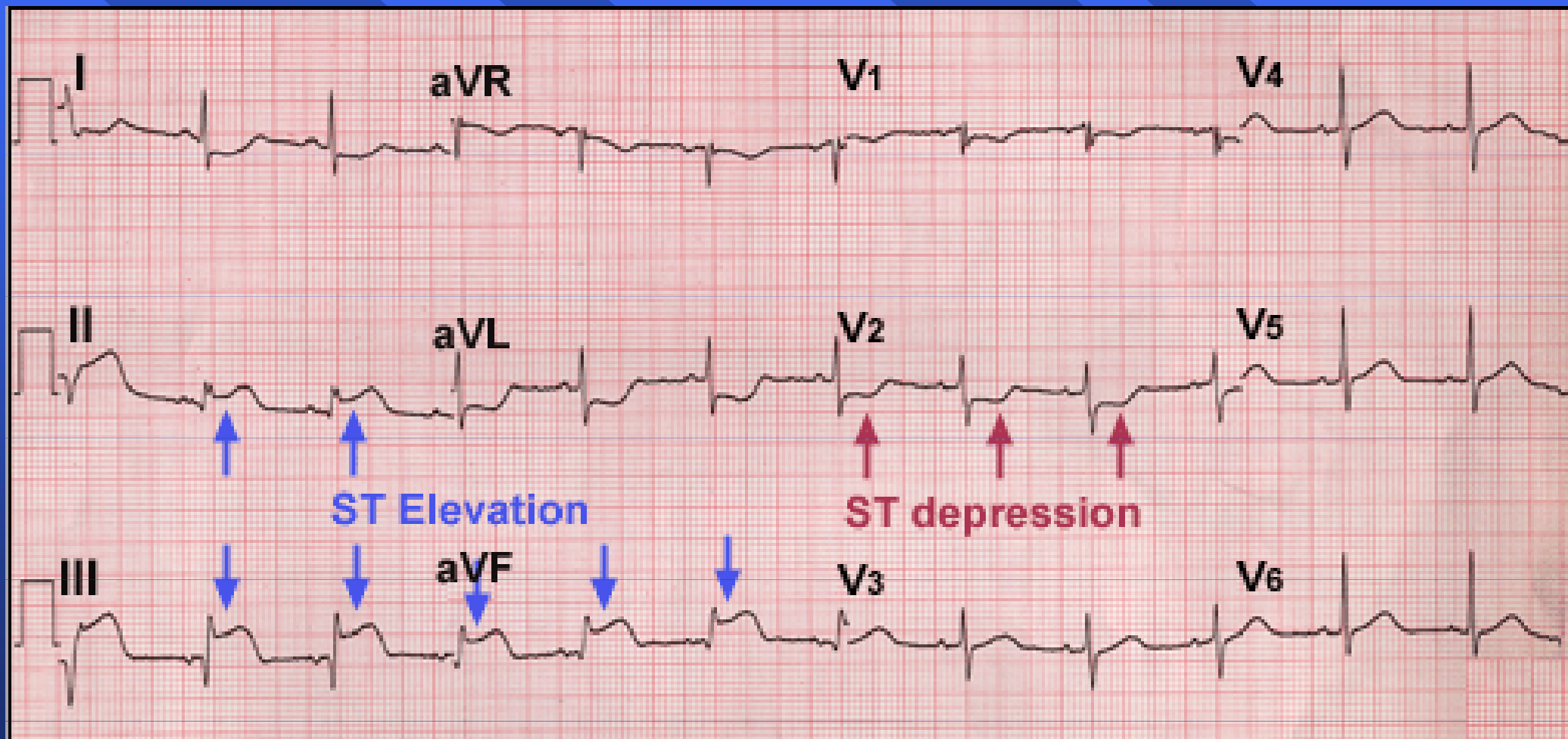
Dokter: GANSEMAN JOSE

? Help Ok Cancel Comp

Rythme D2



Změny úseku ST



Převodní systém srdeční

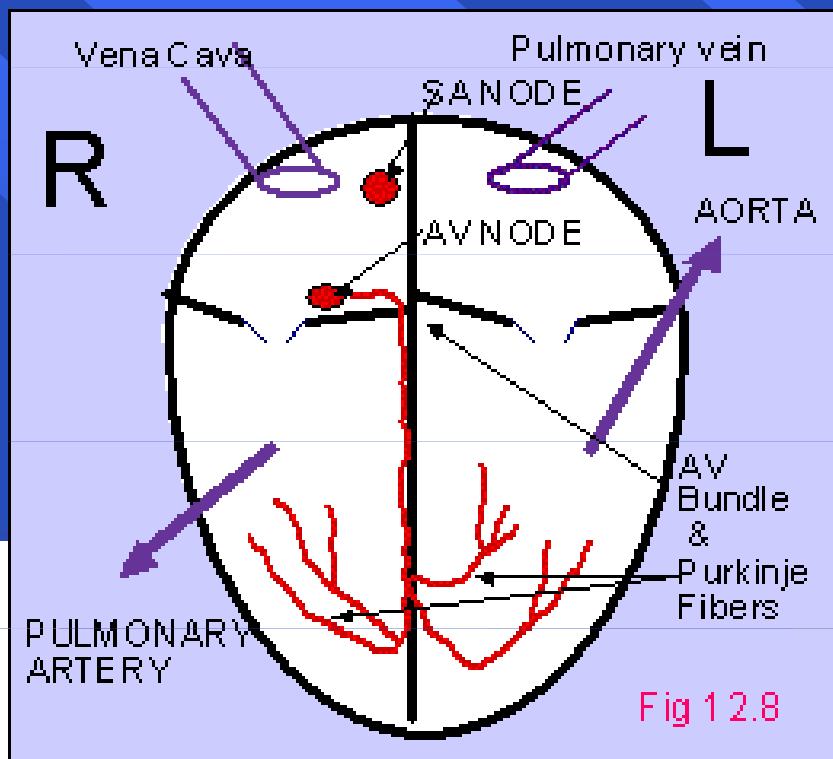
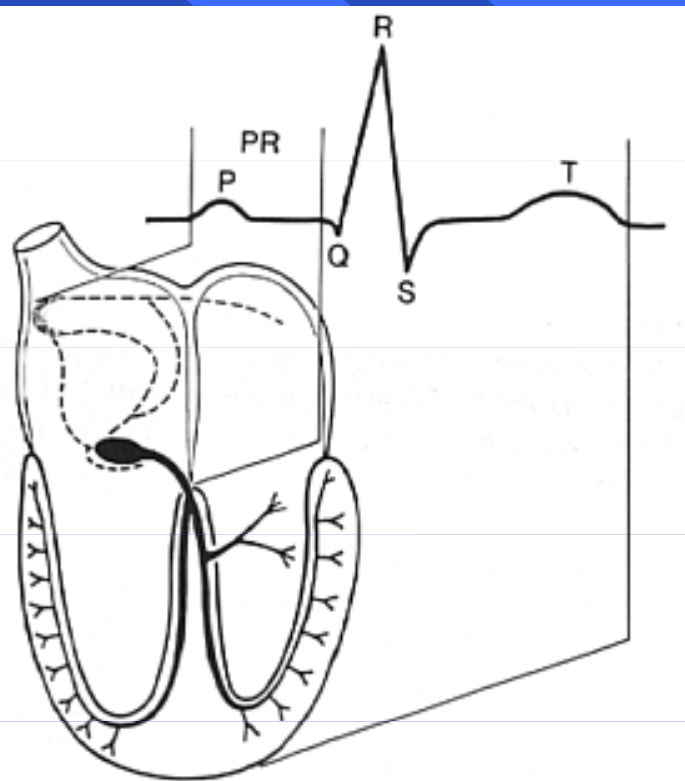
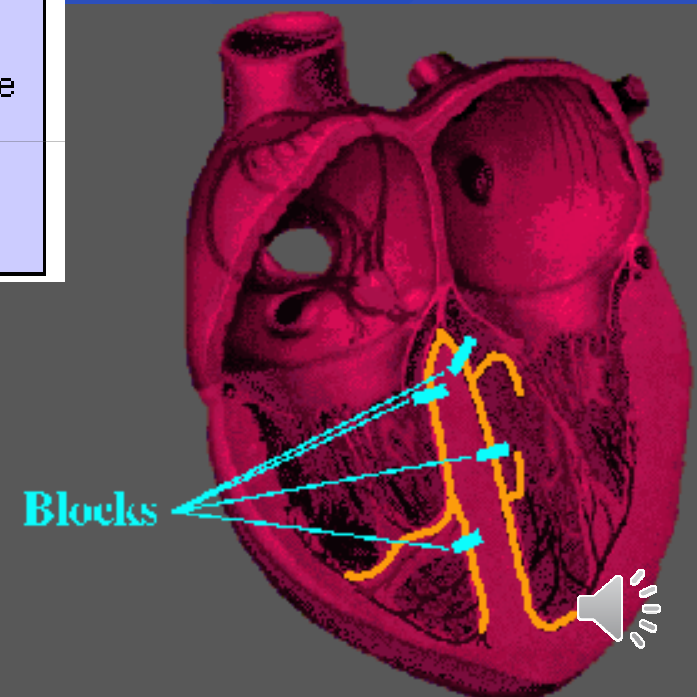
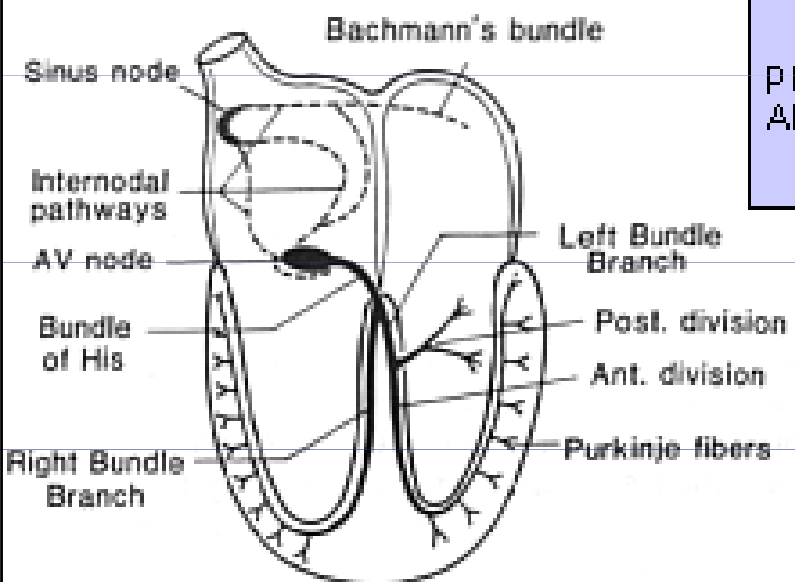
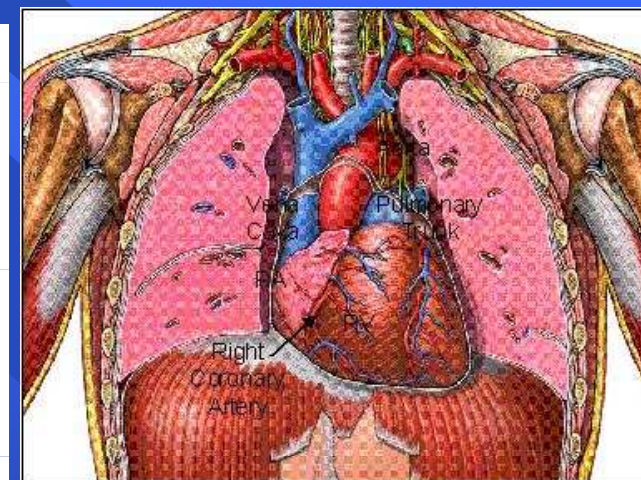
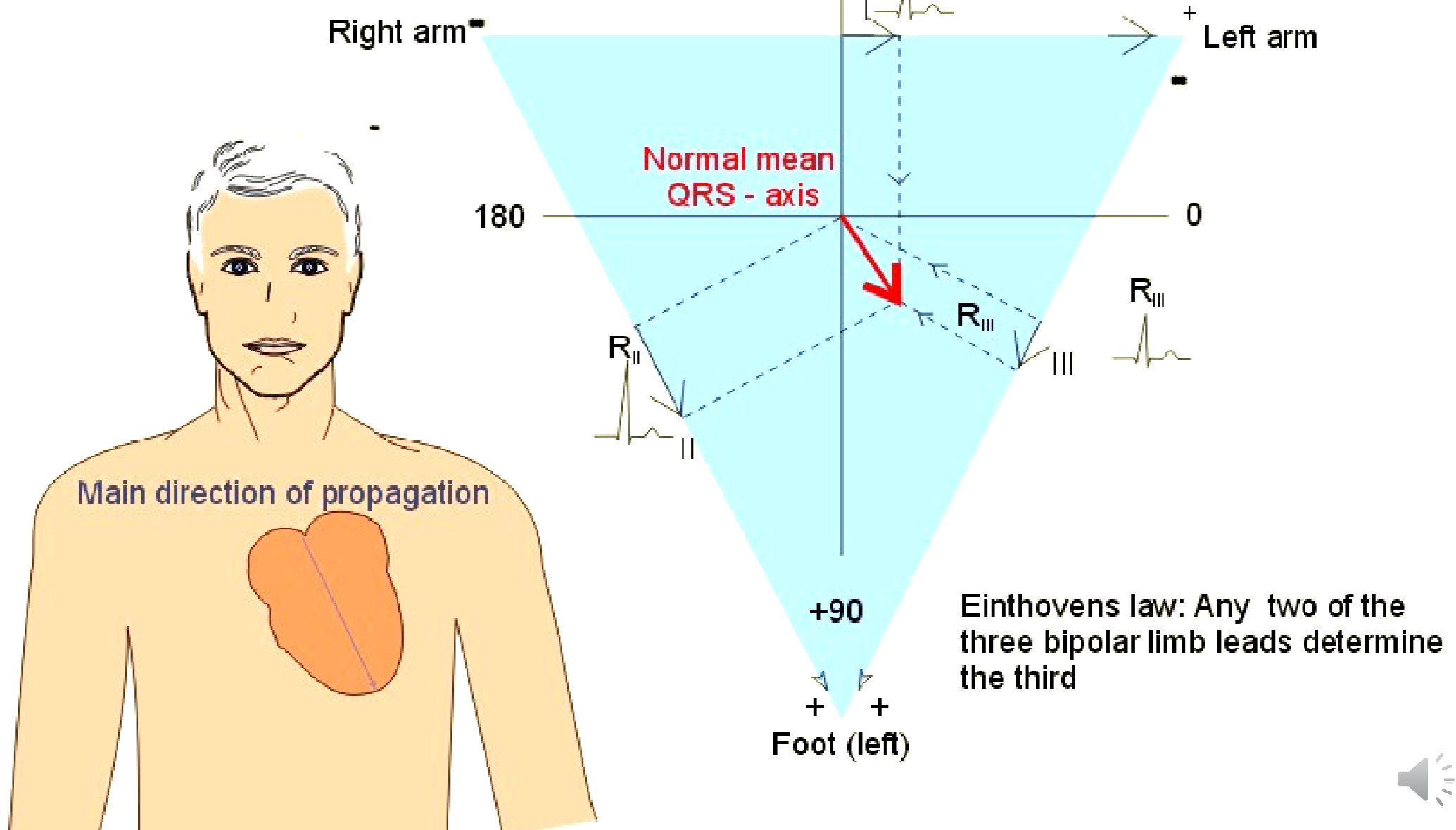


Fig 12.8



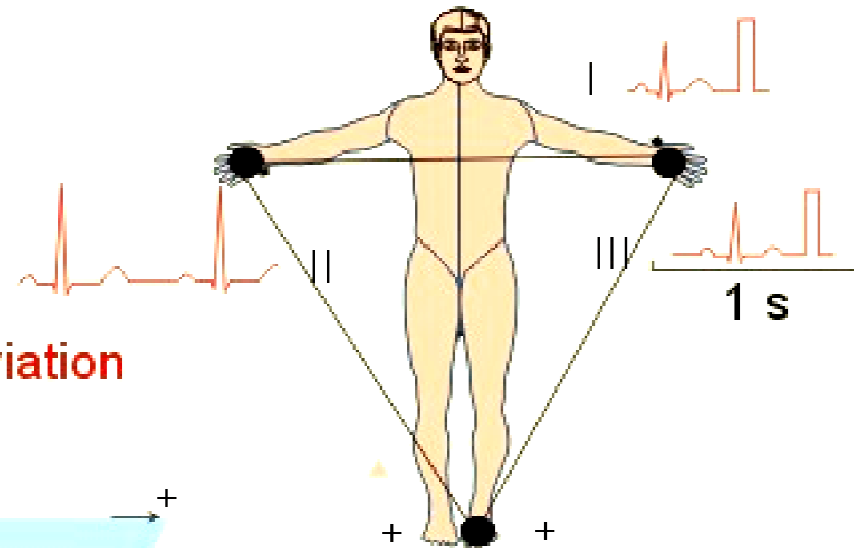
Electrochemical Generator In A Volume Conductor

Einthovens triangle with 3 standard leads in the frontal plane

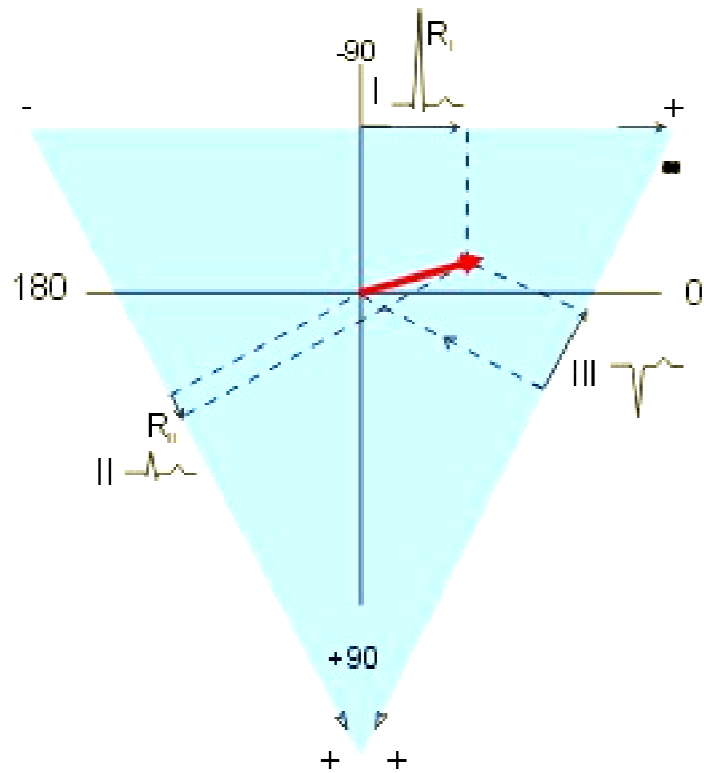


Standard Limb & Precordial Leads

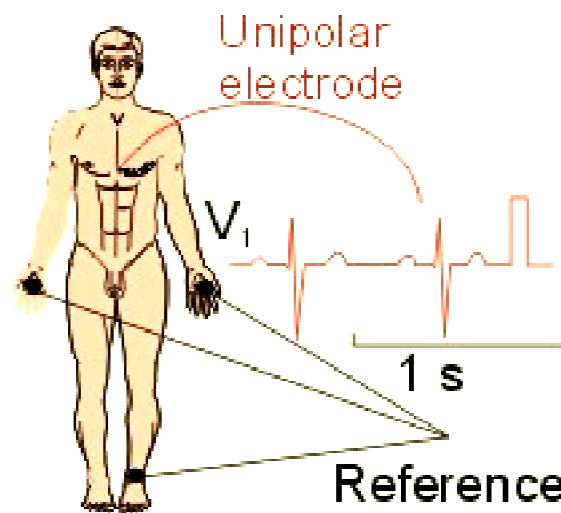
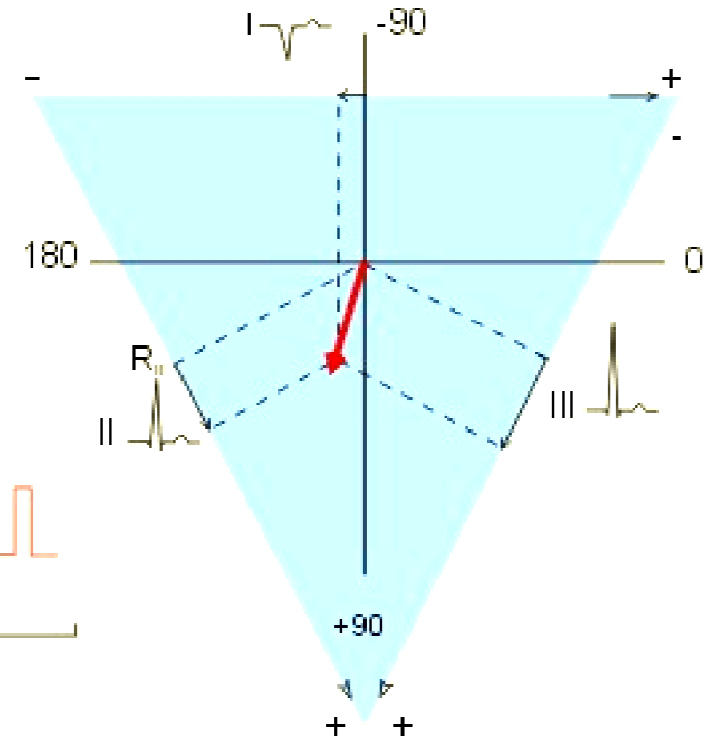
Einthovens triangle (frontal plane)



Left-sided axis deviation



Right-sided axis deviation

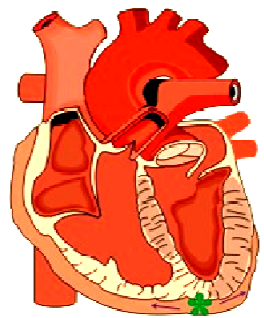
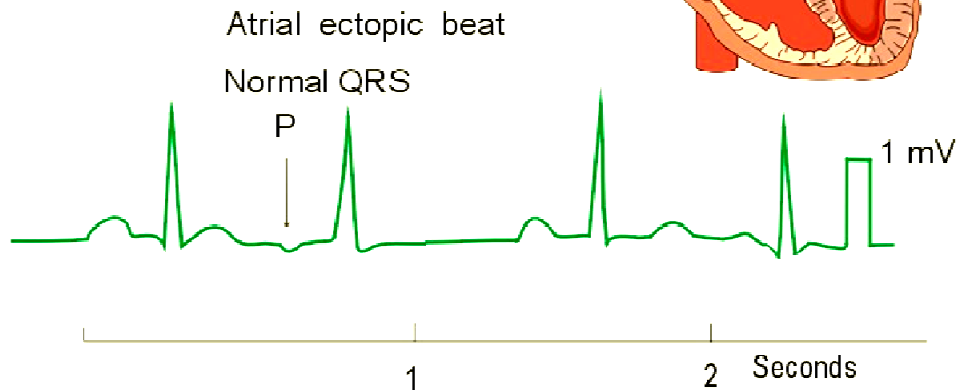
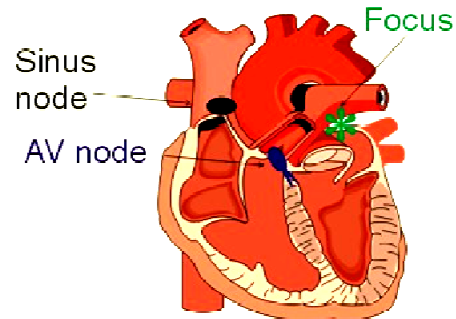


Precordial leads: V₁ - V₆ Reference electrode
(Horizontal plane)



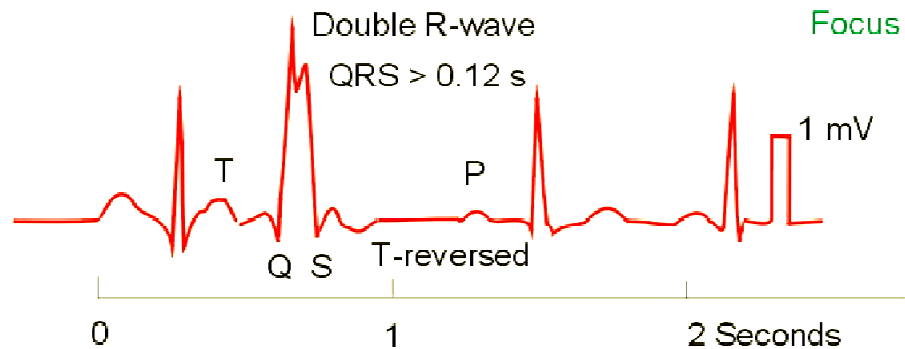
Atrial Ectopic Beat

Overdrive: Increased pump activity --- hyperpolarisation
 -- suppression



Ventricular Ectopic Beat

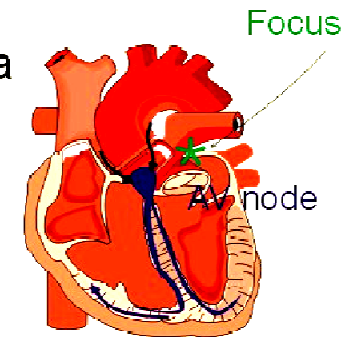
(Extrasystole)



Atrial & Ventricular Tachycardia

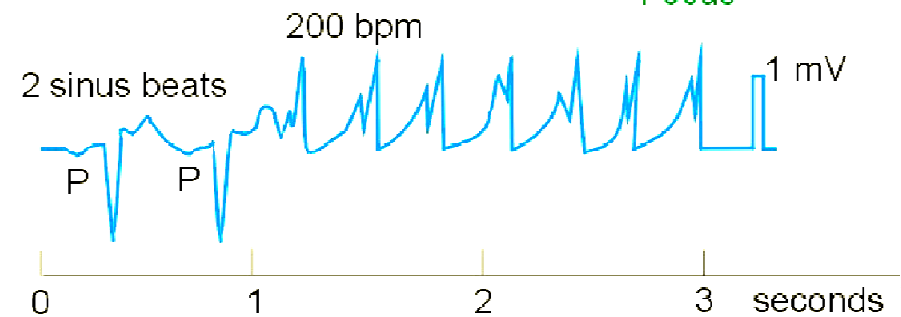
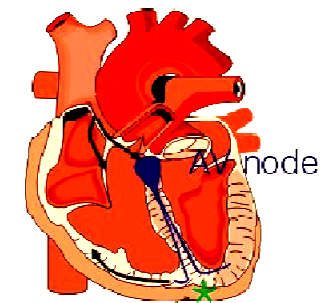
Atrial tachycardia

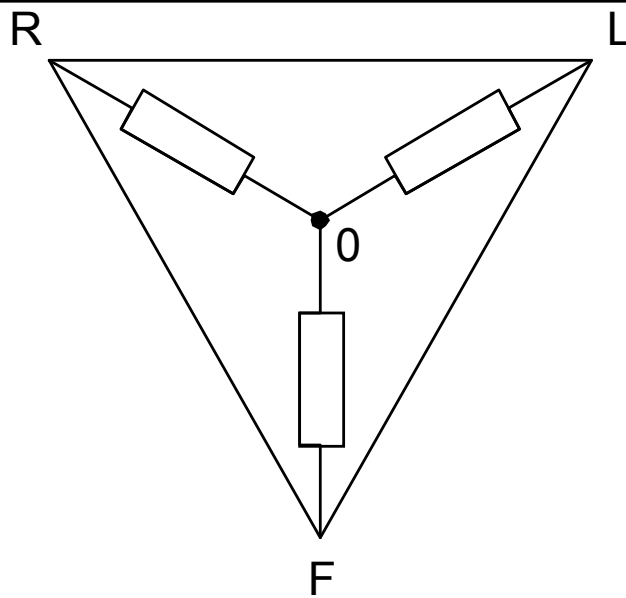
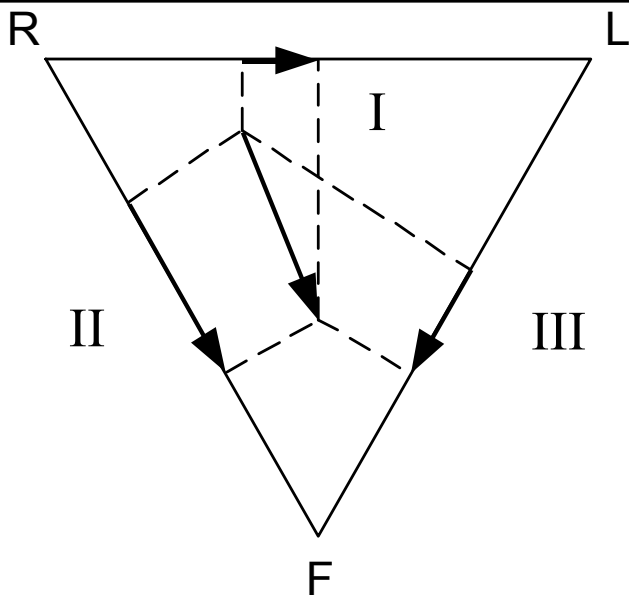
(>200)



Ventricular tachycardia

(>120; disturbed QRS)



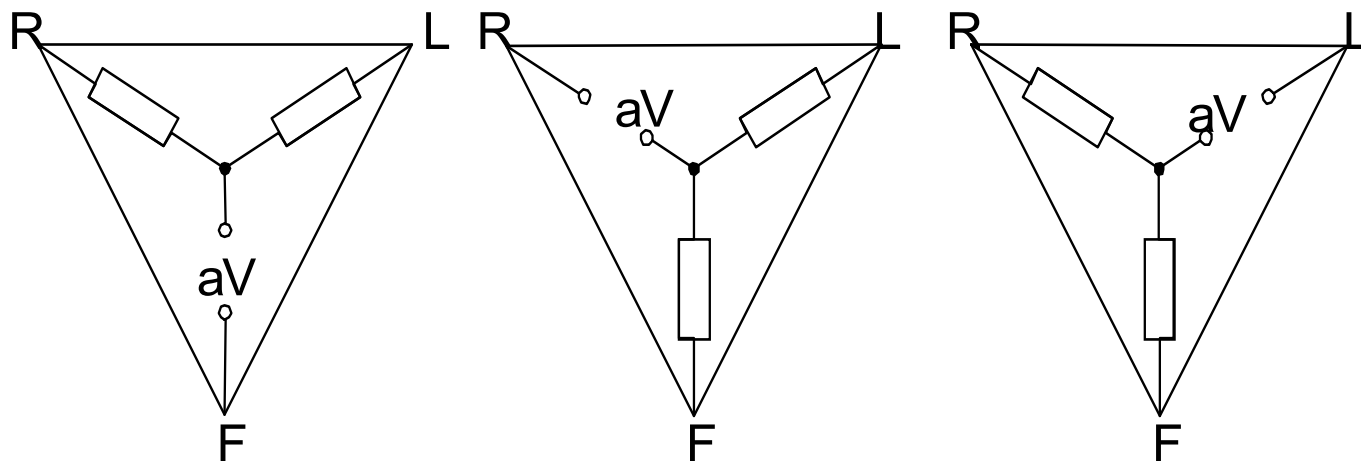


Einthovenův trojúhelník (vlevo) a Wilsonova svorka (vpravo)

- V1-V6
- aVF, aVR, aVL

tří bipolárních
svodů: svod I - RL,
svod II - RF a svod
III - FL

Celkem 12 svodů

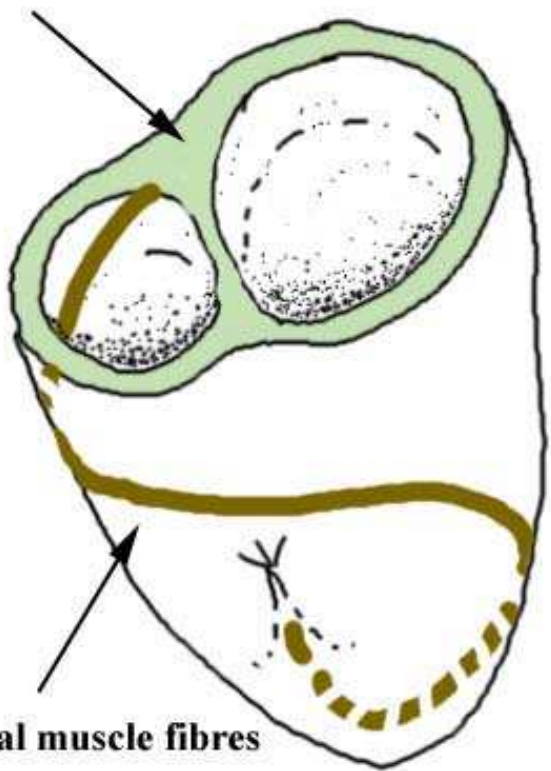


Zesílené Goldbergerovy svody





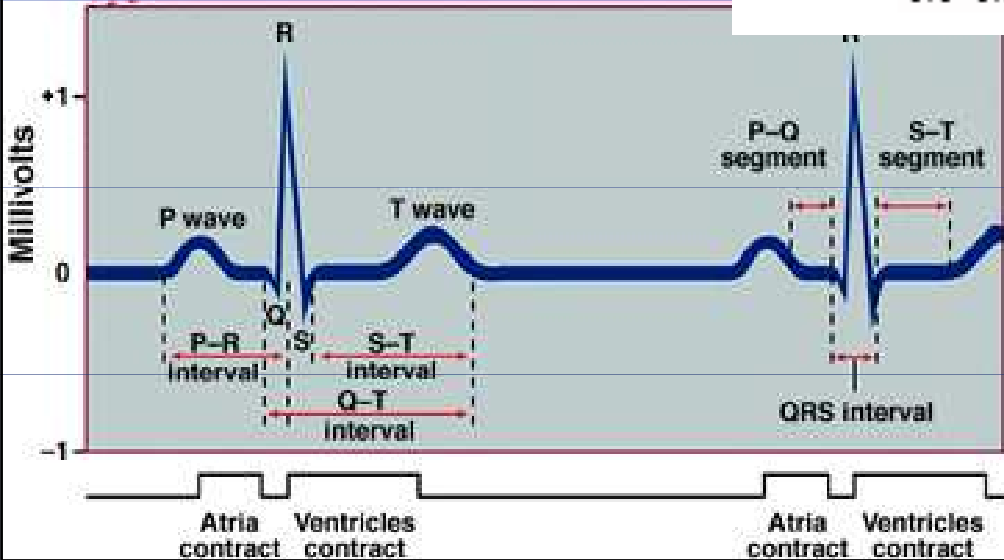
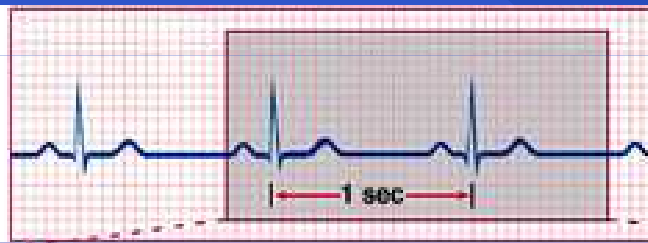
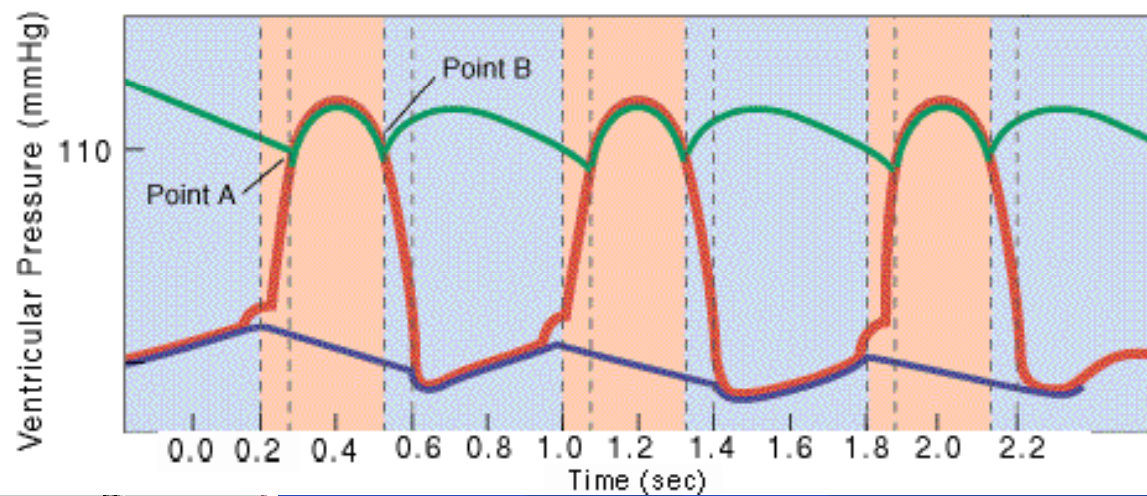
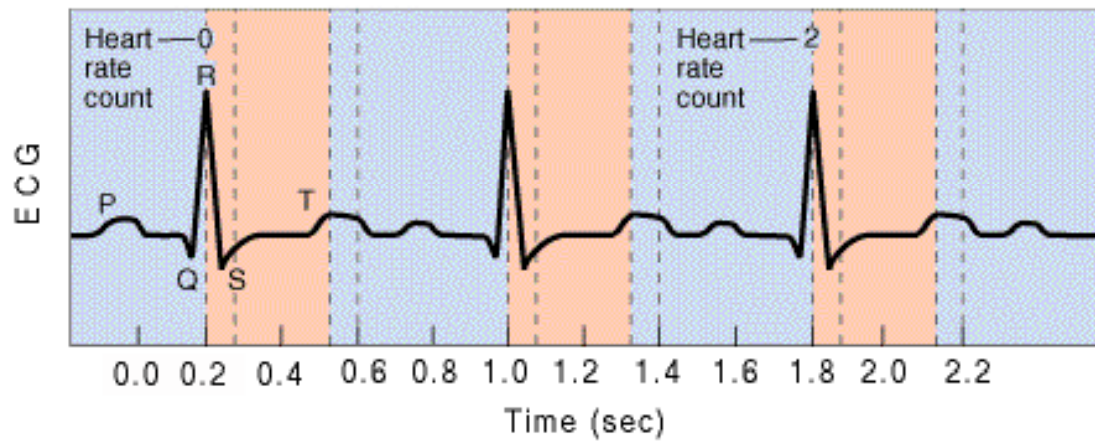
fibrous skeleton



spiral muscle fibres

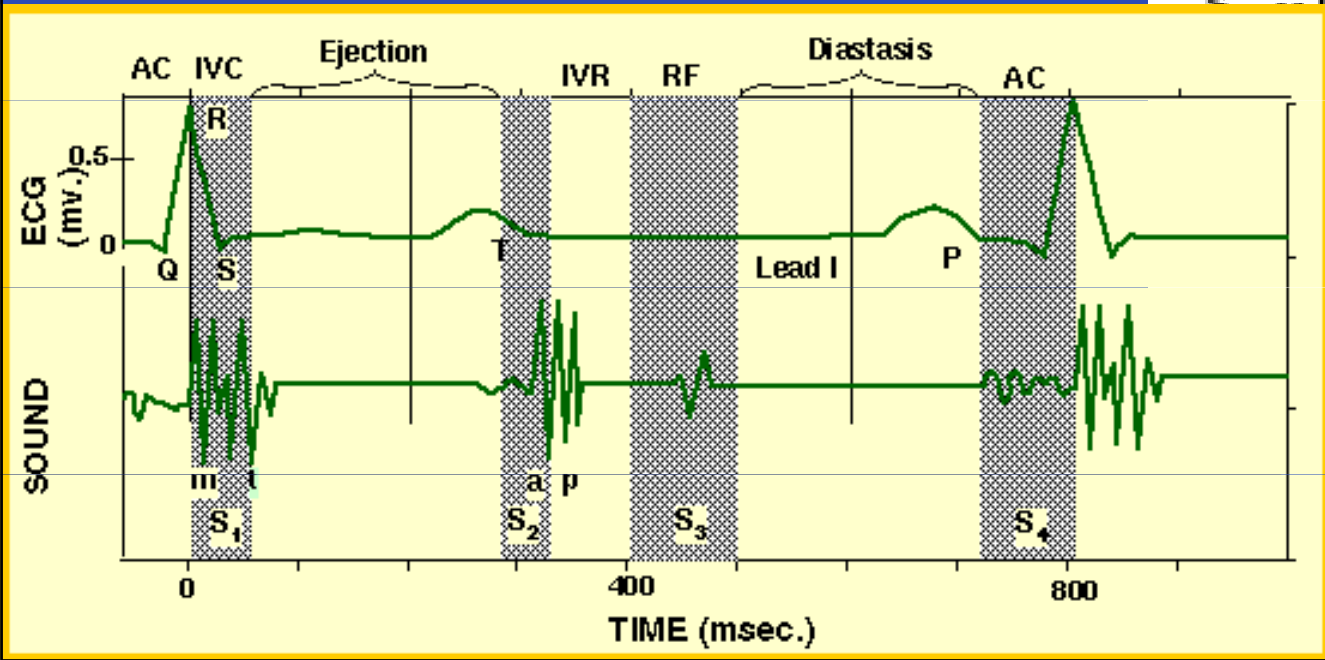
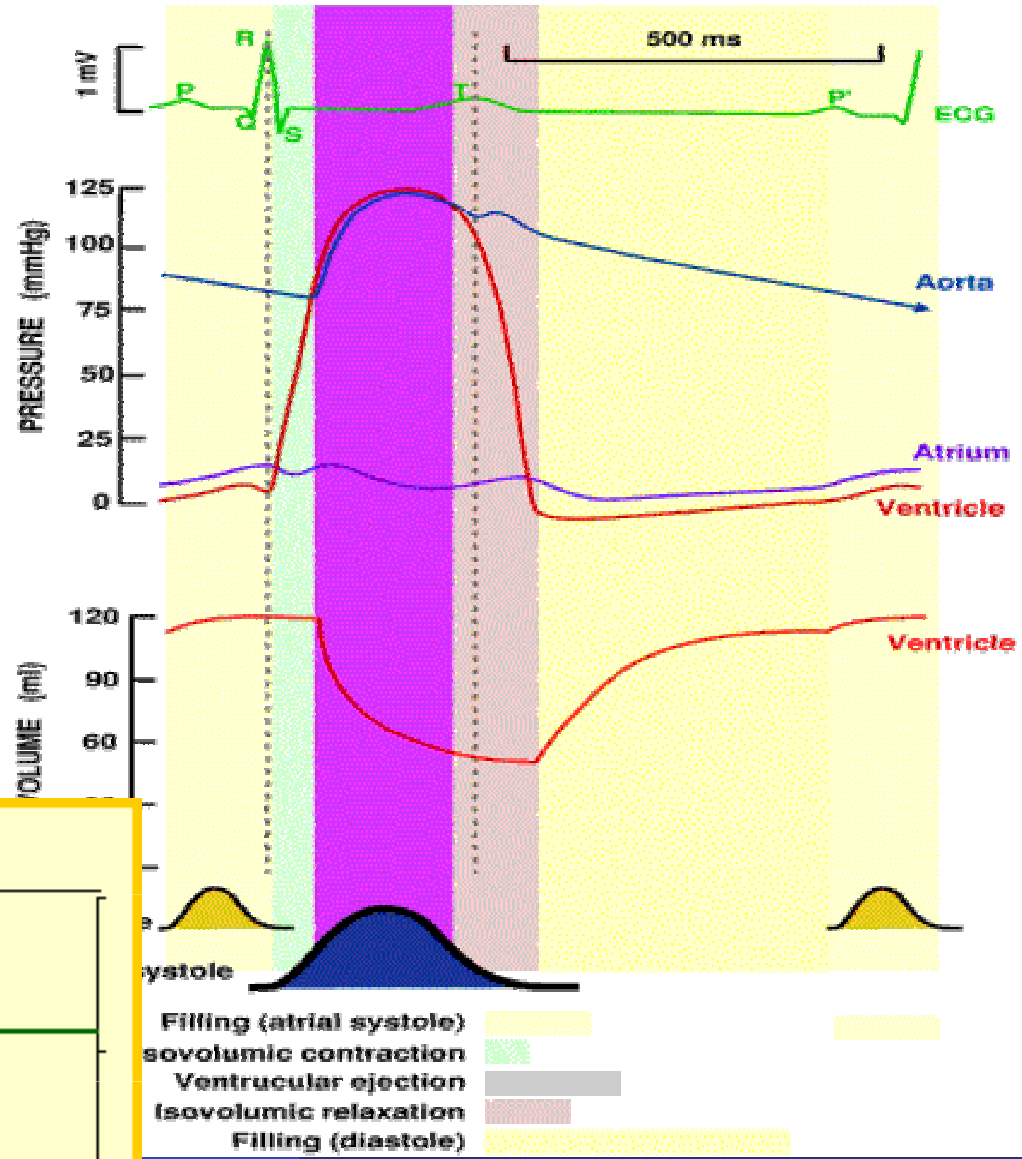
Heart Muscle Organization







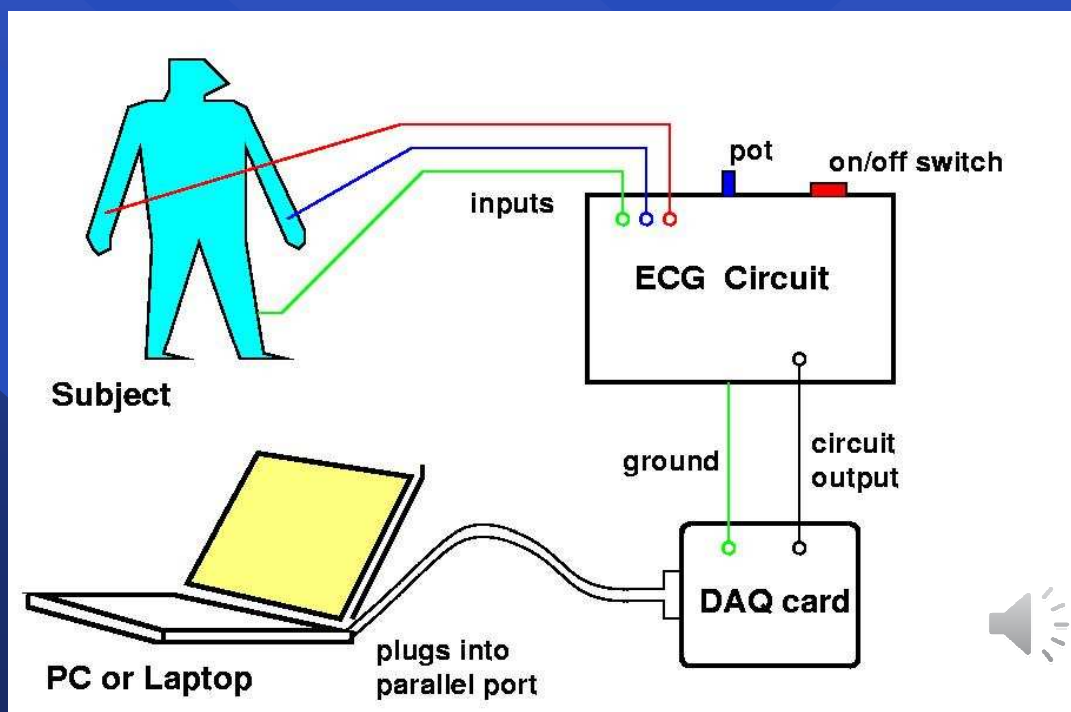
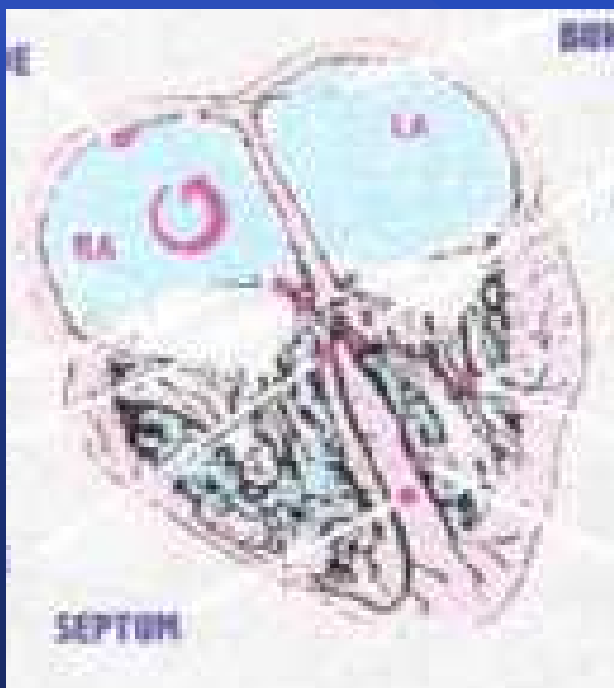
The cardiac cycle in the left side of the heart





Holterovské monitorování

- Záznam 24 hodin,
- Počítač zpracuje
- ES –komorové a síňové

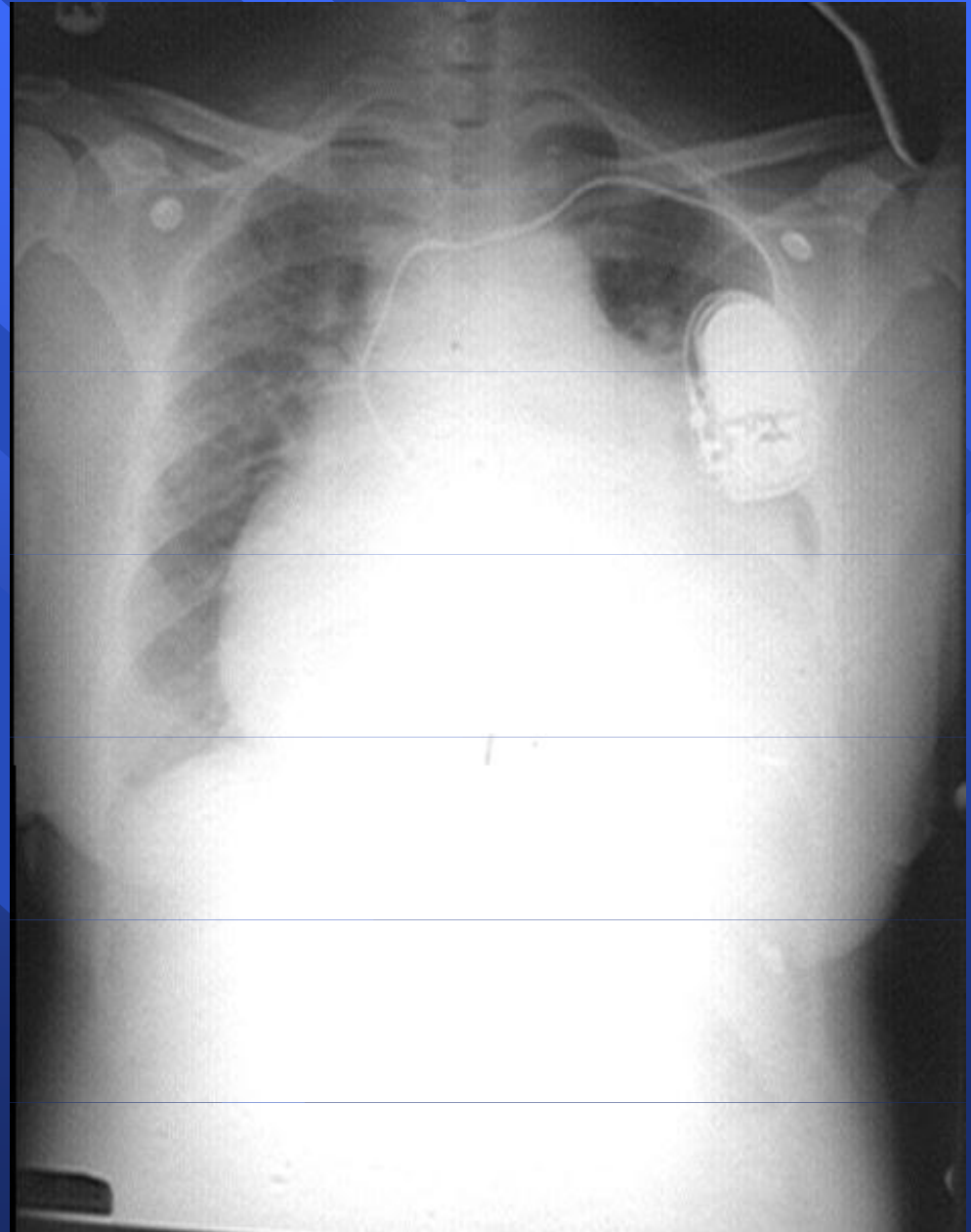
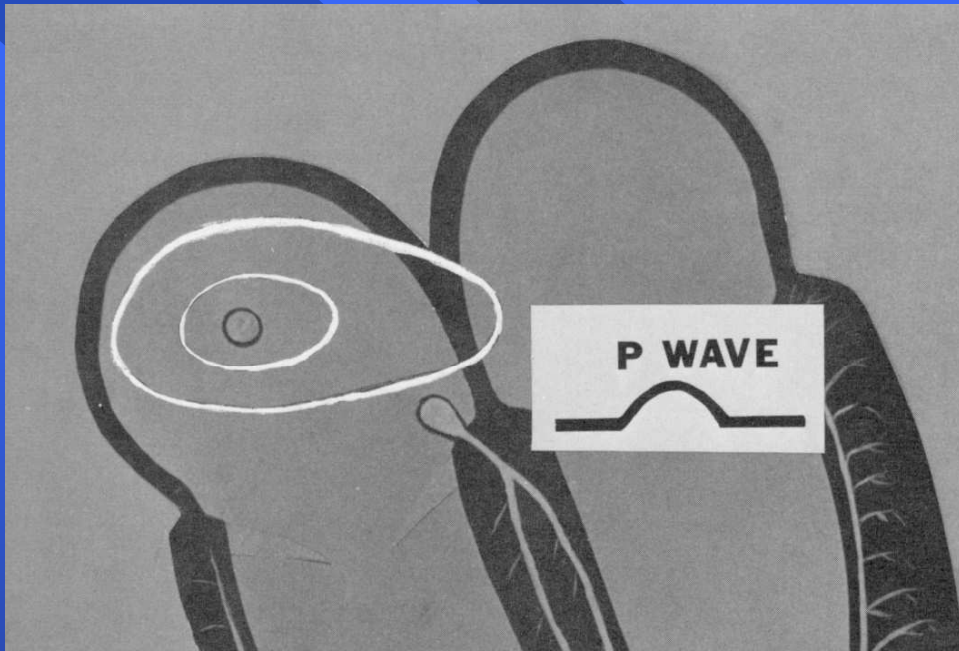


Kardiostimulace

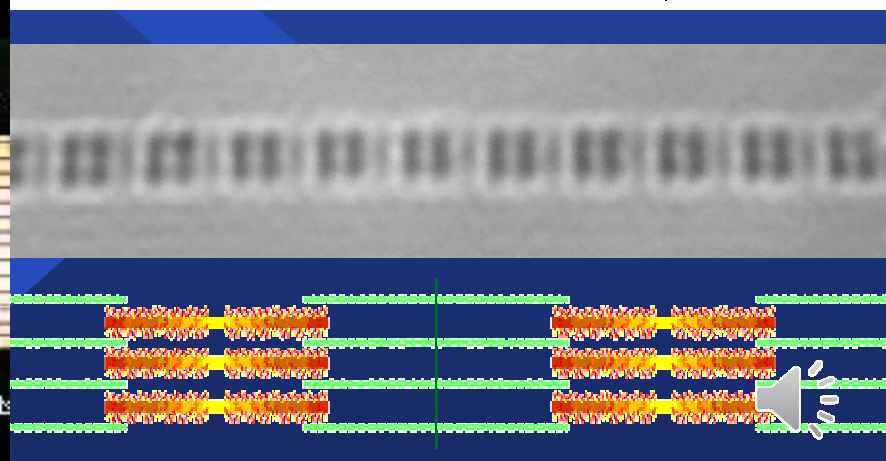
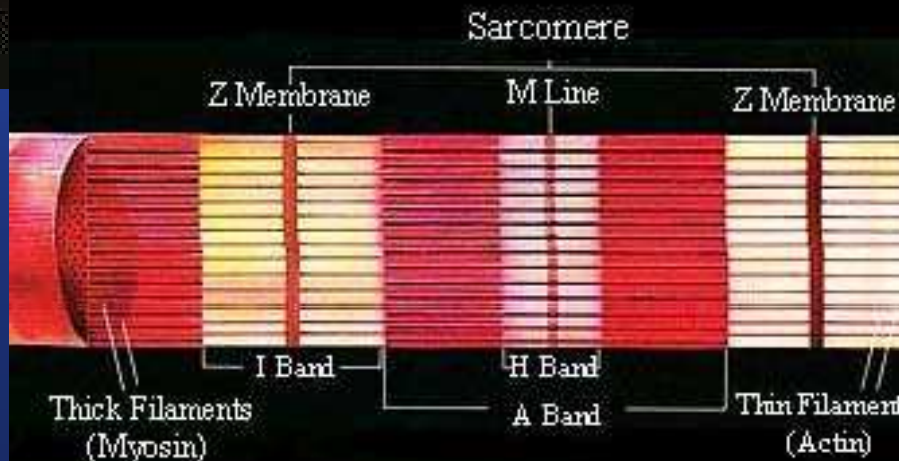
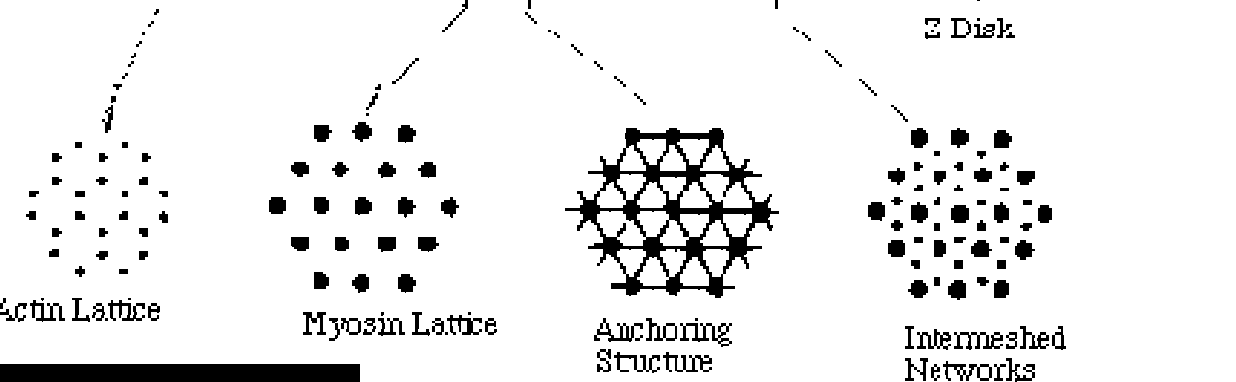
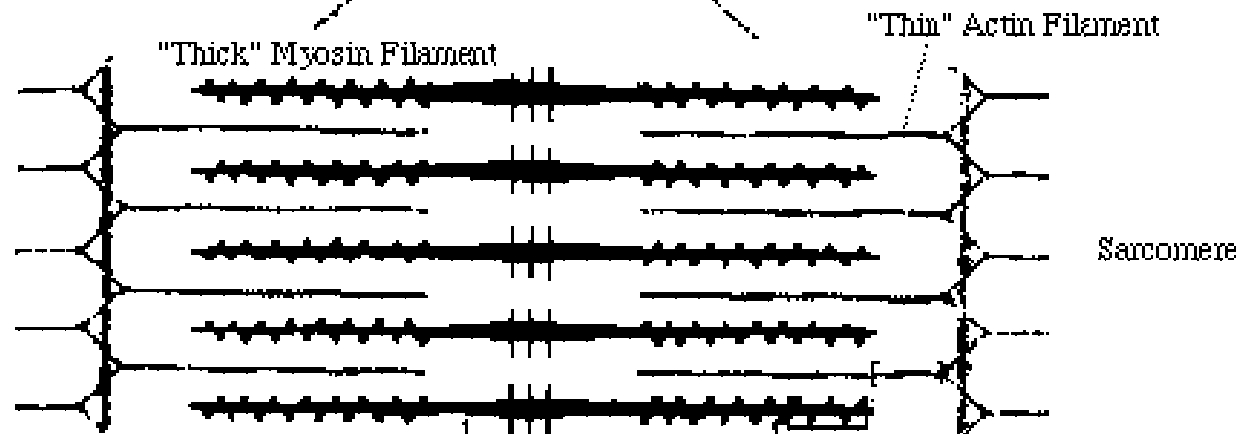
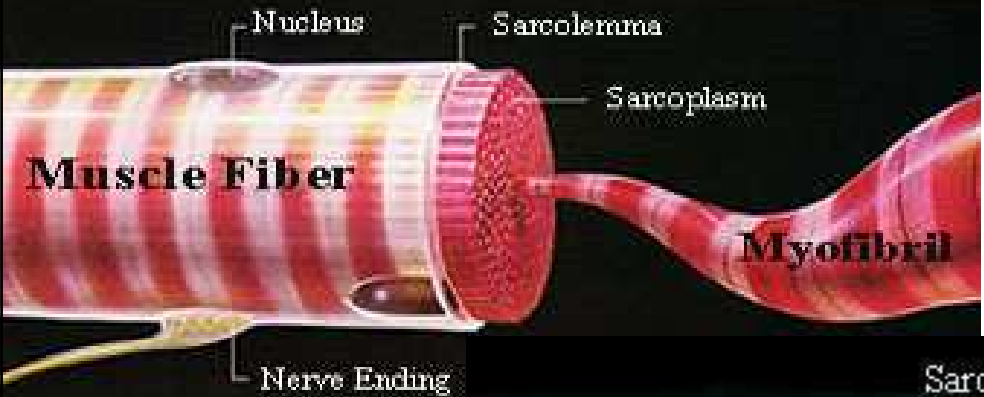


- **dočasná intravasální kardiostimulace**
- **dočasná trastorakální kardiostimulace**
- **dočasná jícnová kardiostimulace**





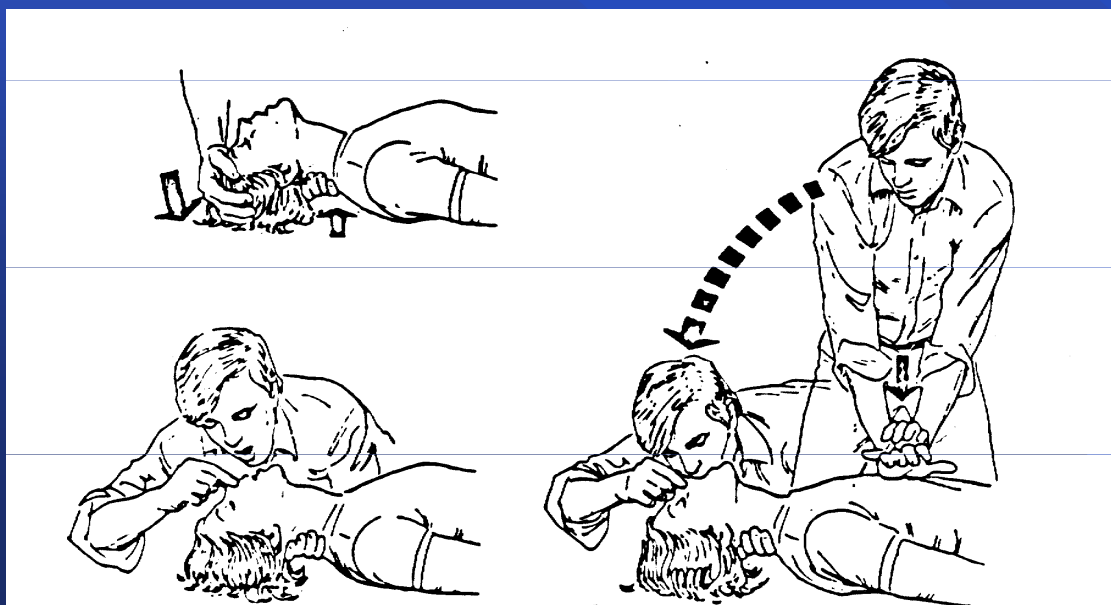
Sval



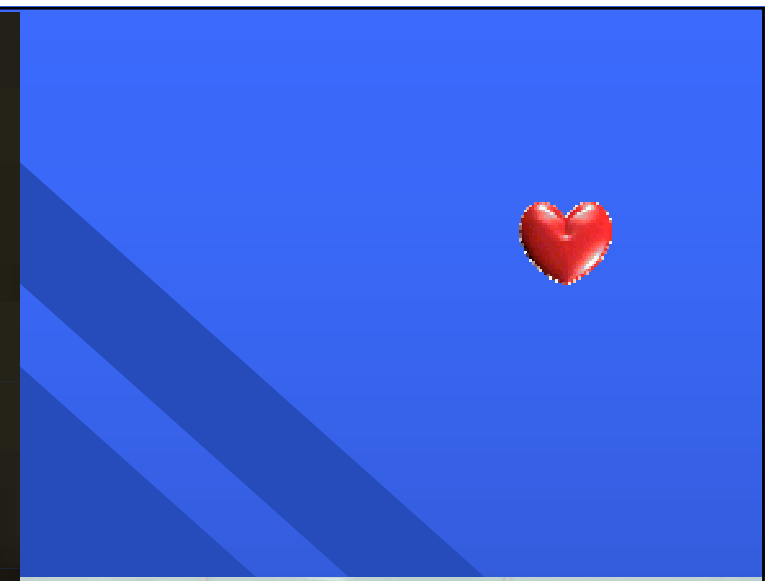
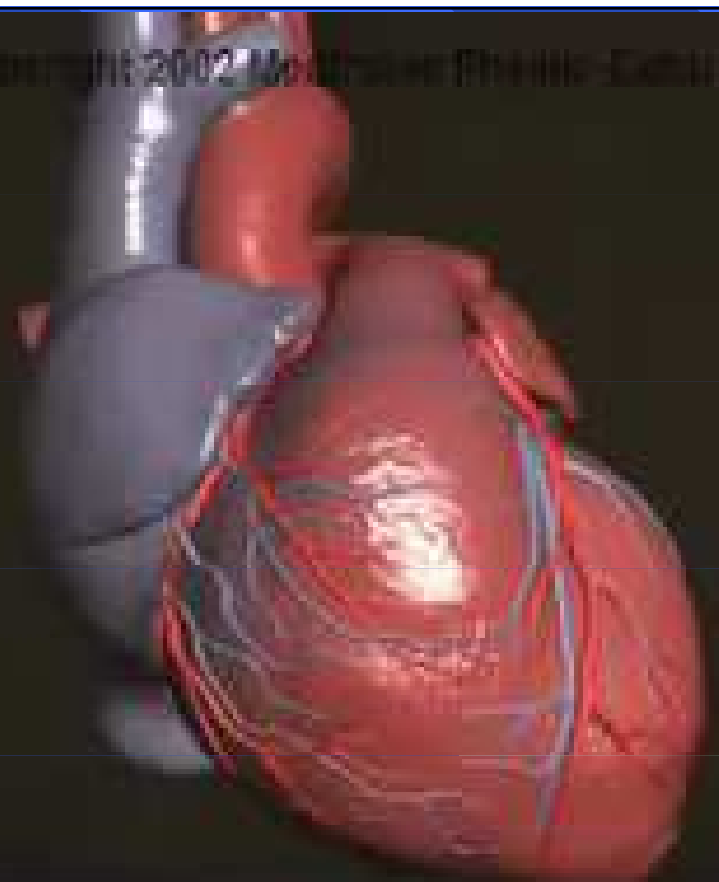
Kardioverze - JIP



- Puls má energii 50 Ws až 300 Ws
- Synchronizace R vlnou na EKG
- Nedotýkat se postele ani pacienta



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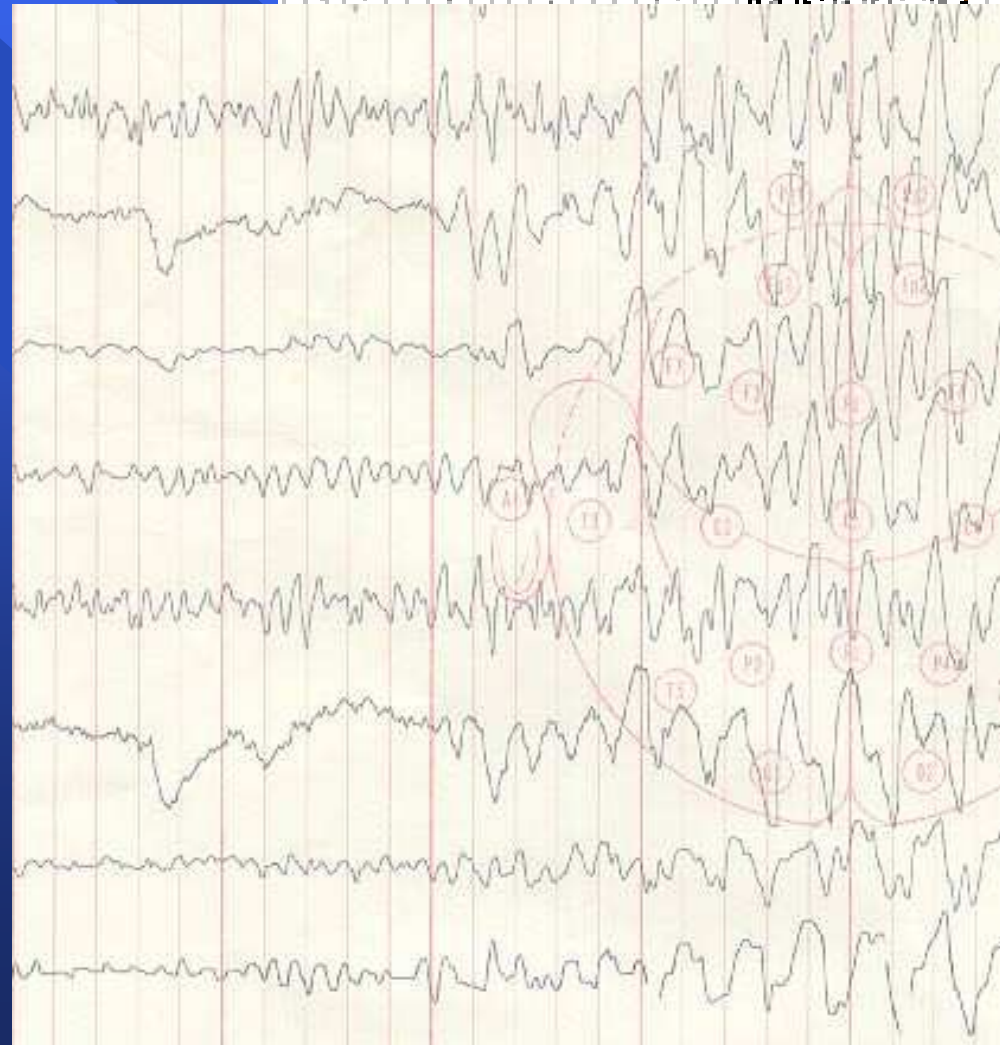
Defibrilace, kardioverze



EEG - epilepsie



EEG's use head sensors to measure brain activity.



Sběr signálů EEG

