Chapter 13

Heart physiology

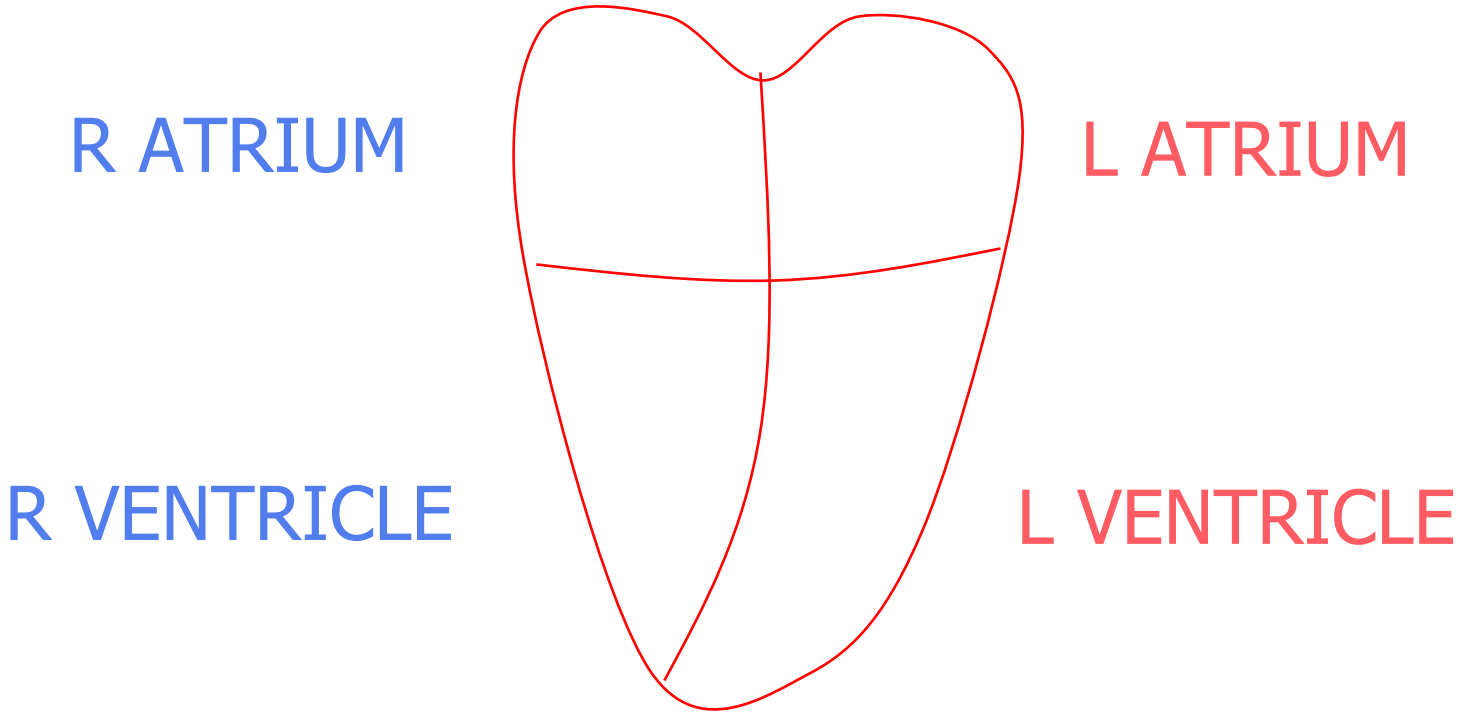
Lecture plan

Heart physiology

- Blood path
- Valves
- Cardiac cycle
- Heartbeat
- EKG
- Disease

Blood path and valves

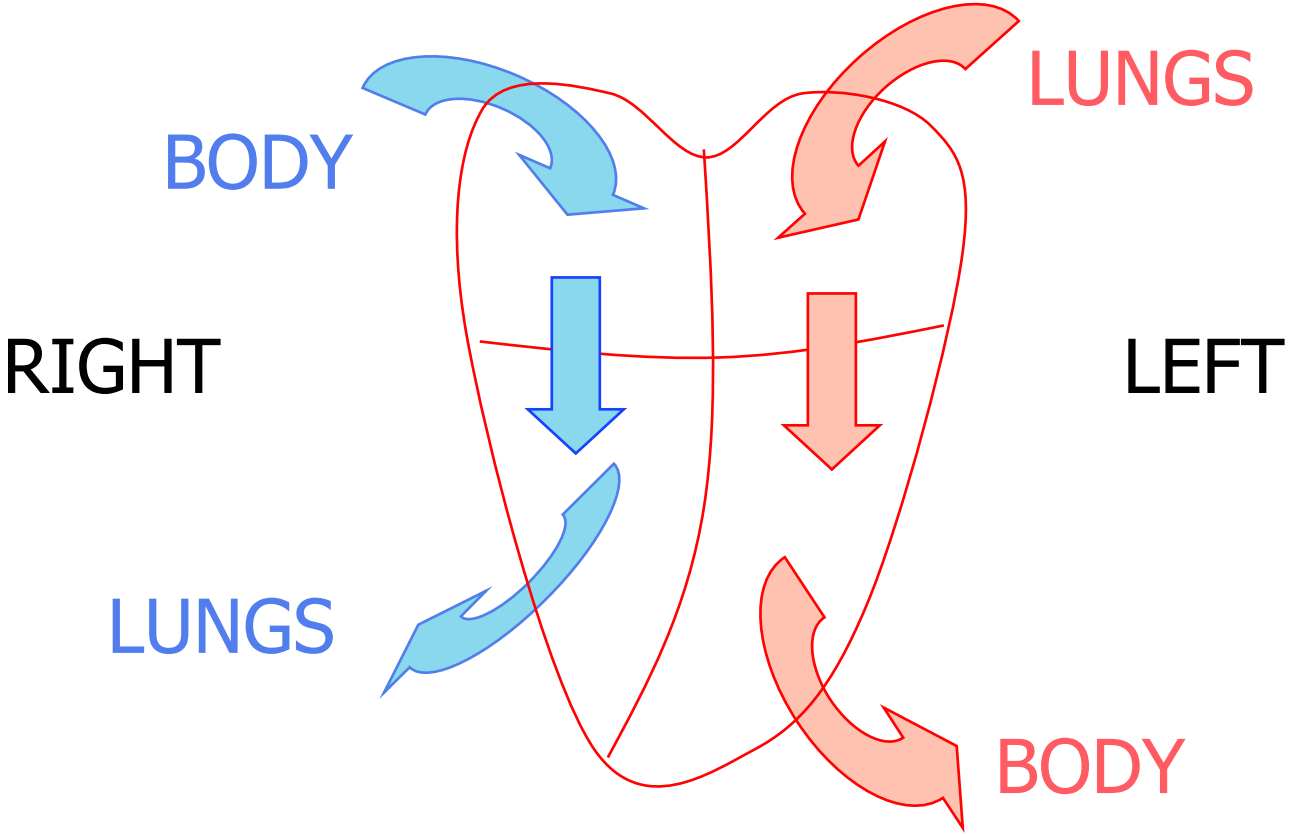
Heart



HEART

Body -> capillaries -> venules -> veins -> superior and inferior vena cava -> R atrium -> R ventricle -> pulmonary trunk -> pulmonary arteries -> lungs -> pulmonary veins -> L atrium -> L ventricle -> aorta -> arteries -> arterioles -> capillaries -> body

Heart



Valves

Body -> capillaries -> venules -> veins -> superior and inferior vena cava -> R atrium -> **TRISCUSPID VALVE** -> R ventricle -> pulmonary trunk -> pulmonary arteries -> lungs -> pulmonary veins -> L atrium -> **MITRAL VALVE** -> L ventricle -> aorta -> arteries -> arterioles -> capillaries -> body

Atrioventricular Valves (AV)

TRISCUSPID VALVE

Full atria: open

Ventricle contracts: closed

MITRAL VALVE

Full atria: open

Ventricle contracts: closed

Valves

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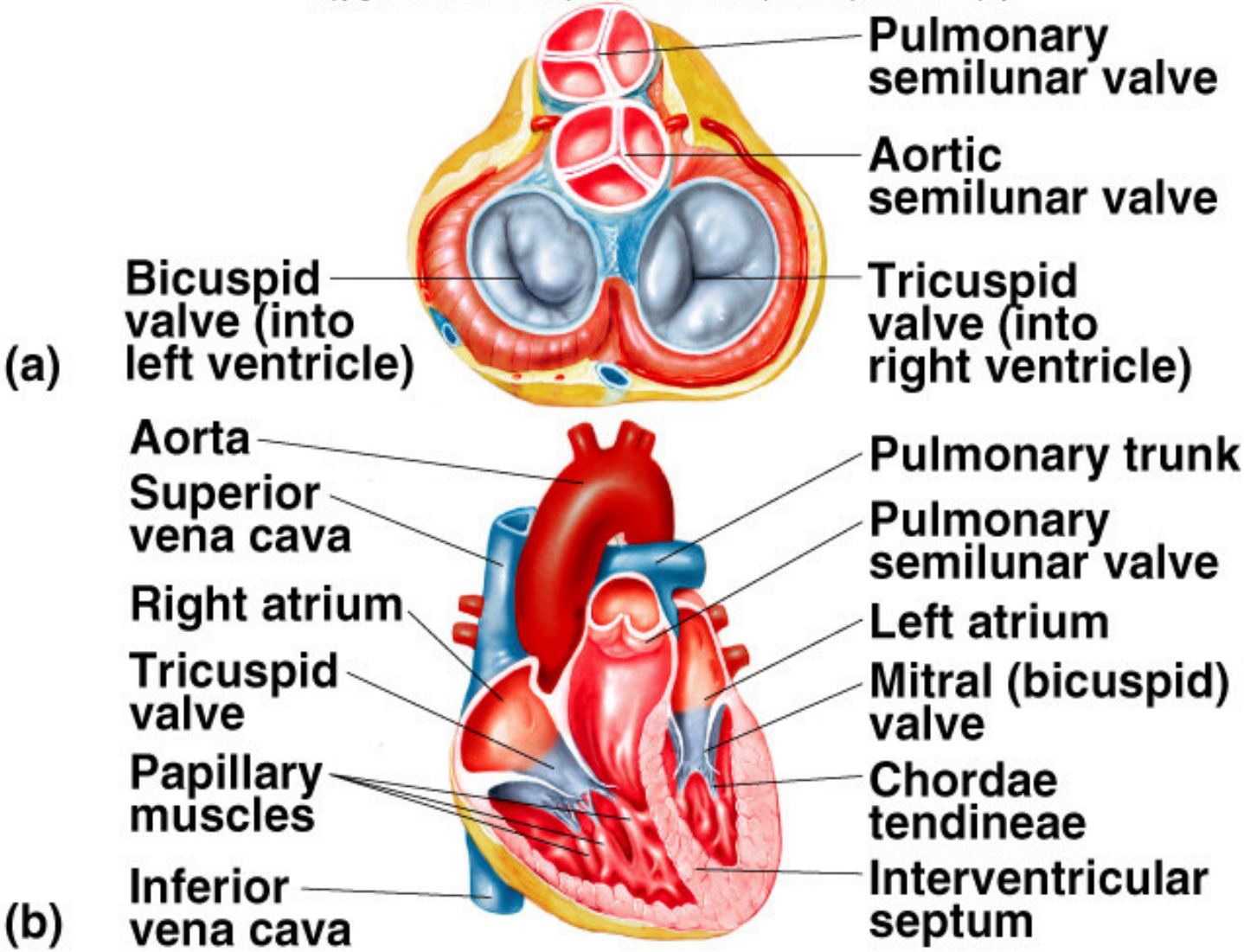


Valves

Body -> capillaries -> venules -> veins -> superior and inferior vena cava -> R atrium -> **TRISCUSPID VALVE** -> R ventricle -> **SEMILUNAR VALVES ->** pulmonary trunk -> pulmonary arteries -> lungs -> pulmonary veins -> L atrium -> **MITRAL VALVE** -> L ventricle -> **SEMILUNAR VALVES ->** aorta -> arteries -> arterioles -> capillaries -> body

Valves

SEMILUNAR VALVES

Ventricle contracts: open

Ventricle relaxes: closed

Cardiac cycle

Cardiac Cycle

Systole: contraction.

Diastole: relaxation.

Heart Sounds

Lub (first sound):

closing of the AV valves

contraction of ventricles.

systole

Dub (second sound):

closing of the semilunar valves

ventricles relax

diastole

Heart Murmurs

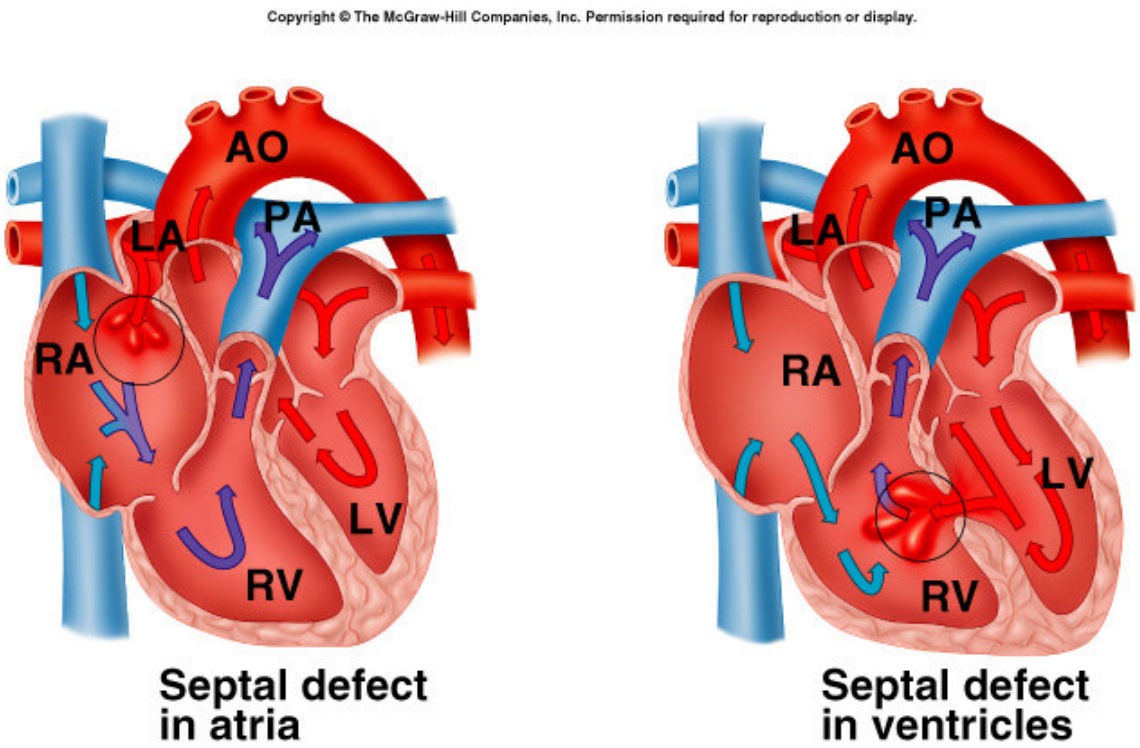
Heart murmurs:

- abnormal heart sounds produced by abnormal patterns of blood flow.
- often due to defective heart valves
  - damaged by an infection, or congenital defects.

Heart Murmurs

Septal defects

- Usually congenital.
- Holes in septum.
- Blood passes from left to right.



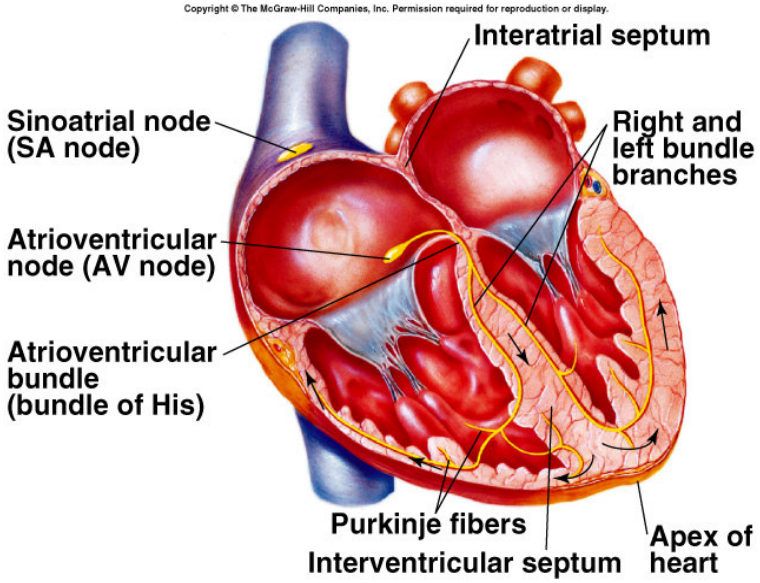
Heartbeat

Heart

SA node:

- Sinoatrial node
- Top of R atrium
- pacemaker
- Spontaneous, cyclic depolarization
  - Slow Ca^{2+} channels.
  - No RMP

Ectopic pacemakers (around SA node).



SA node AP

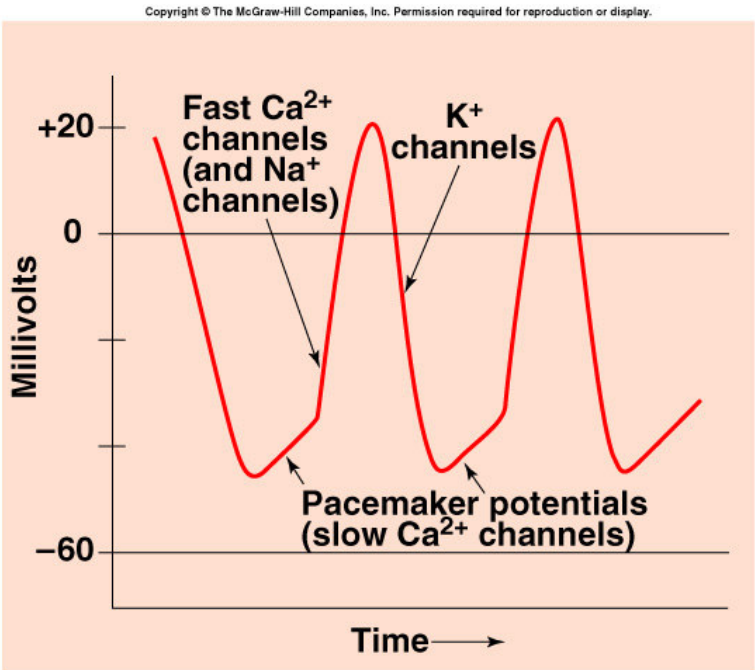
Unique, rhythmic action potentials (AP) at the SA node.

Depolarization:

VG fast Ca^{2+} channels

Repolarization:

VG K^+ channels.



Myocardial APs

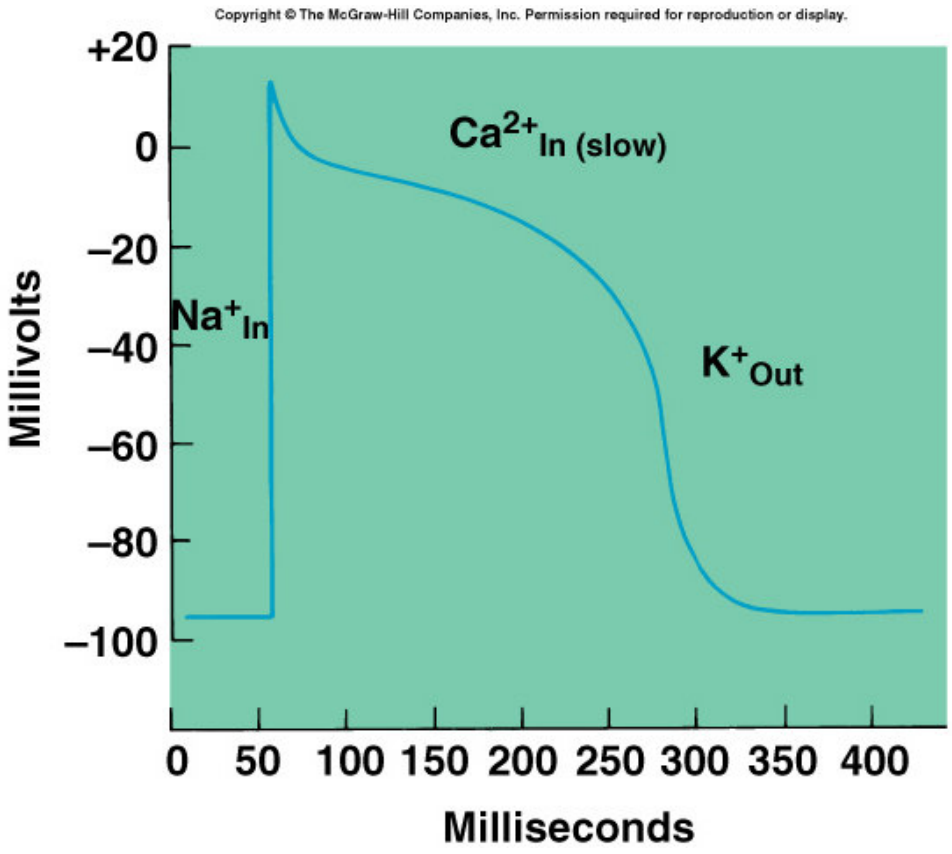
SA node spreads APs to myocardial cells.

Depolarization: VG Na^+ channels

Plateau phase: VG slow Ca^{2+} channels open.

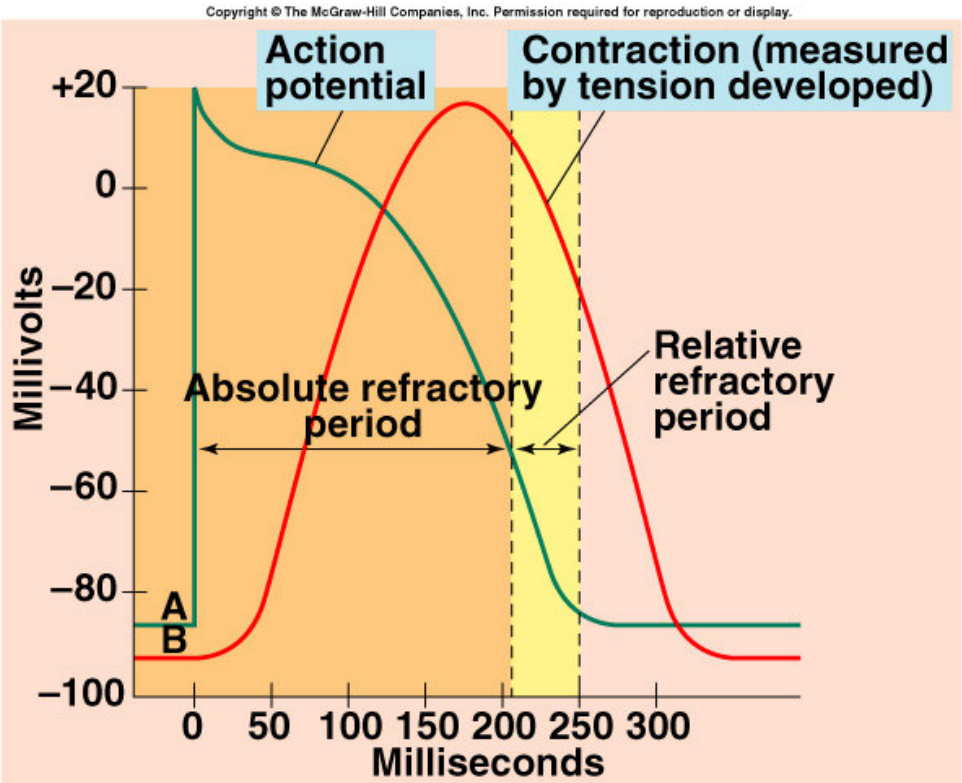
- Slow inward Ca^{2+} balances outflow of K^+.

Repolarization: VG K^+ channels.



Myocardial APs

Long AP due to plateau phase leads to refractory period and periodic beating of heart!



Heart

- APs spread from cell to cell through through gap junctions (intercalated discs).

- myocardial cells contract as syncytium (one giant, multinucleate cell).

- contraction lasts almost 300 msec.

- Lifelong periodic beating!

Heart

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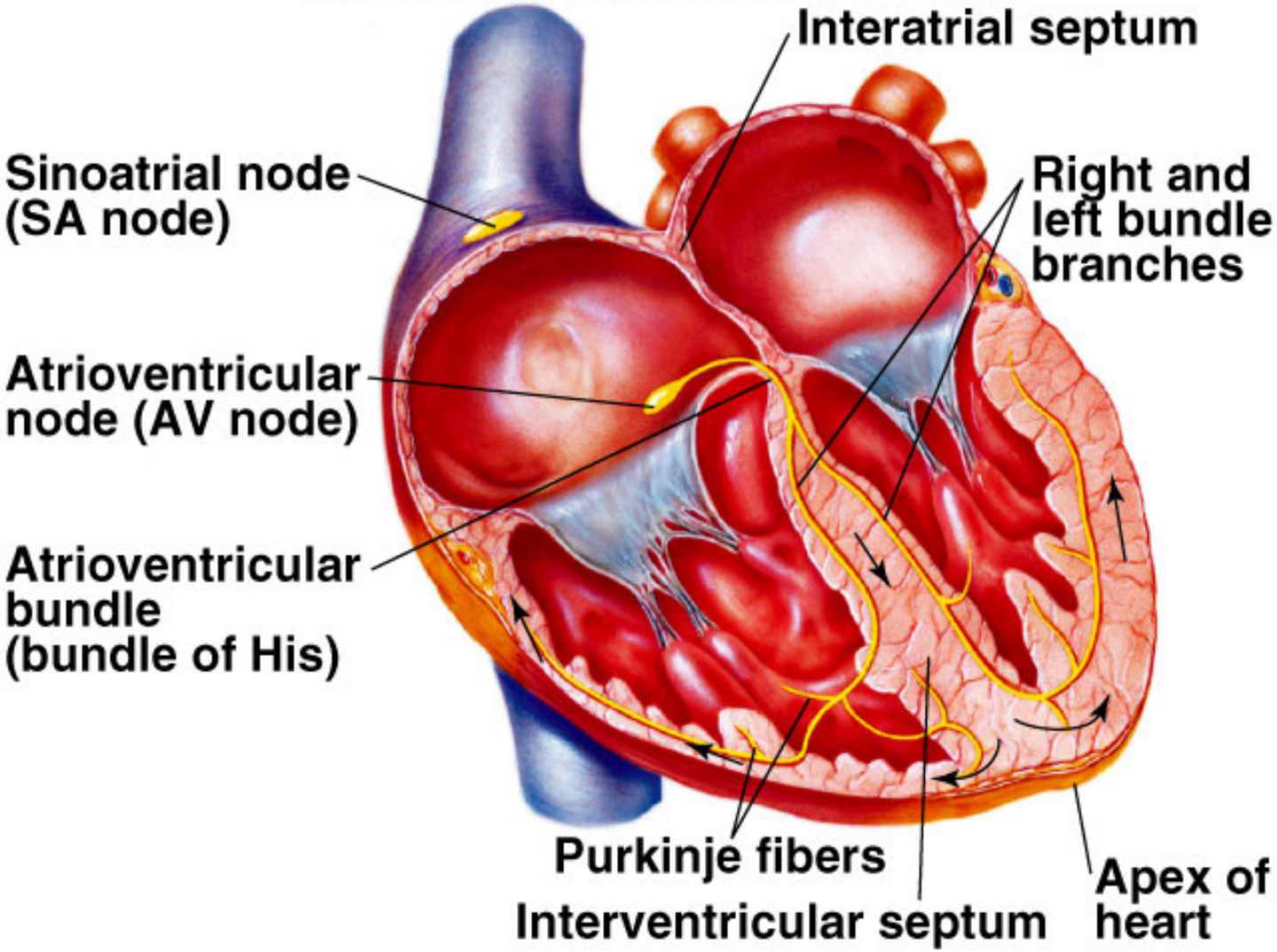


Contraction

- SA directly causes atria to contract but…

- Impulses cannot spread to ventricles directly because of fibrous tissue.

- Special myocardial cells (AV node, bundle of His) and Purkinje fibers cause both ventricles to contract simultaneously (but slightly after atrial contraction).

Contraction

Striated muscle!

Contraction
- similar to skeletal muscle
- except that calcium comes from internal stores

- sarcomeres, with actin filaments sliding over myosin filaments
- calcium releases troponin/tropomyosin block

Contraction

Ca^{2+} stimulated Ca^{2+} release (Crac!)

- VG Ca^{2+} channels in sarcolemma lead to opening of Ca^{2+}-release channels in sarcoplasmic reticulum.
- Ca^{2+} binds to troponin and stimulates contraction of sarcomeres (as in skeletal muscle).

During repolarization Ca^{2+} actively transported via a Na^{+}-Ca^{2+} exchanger.

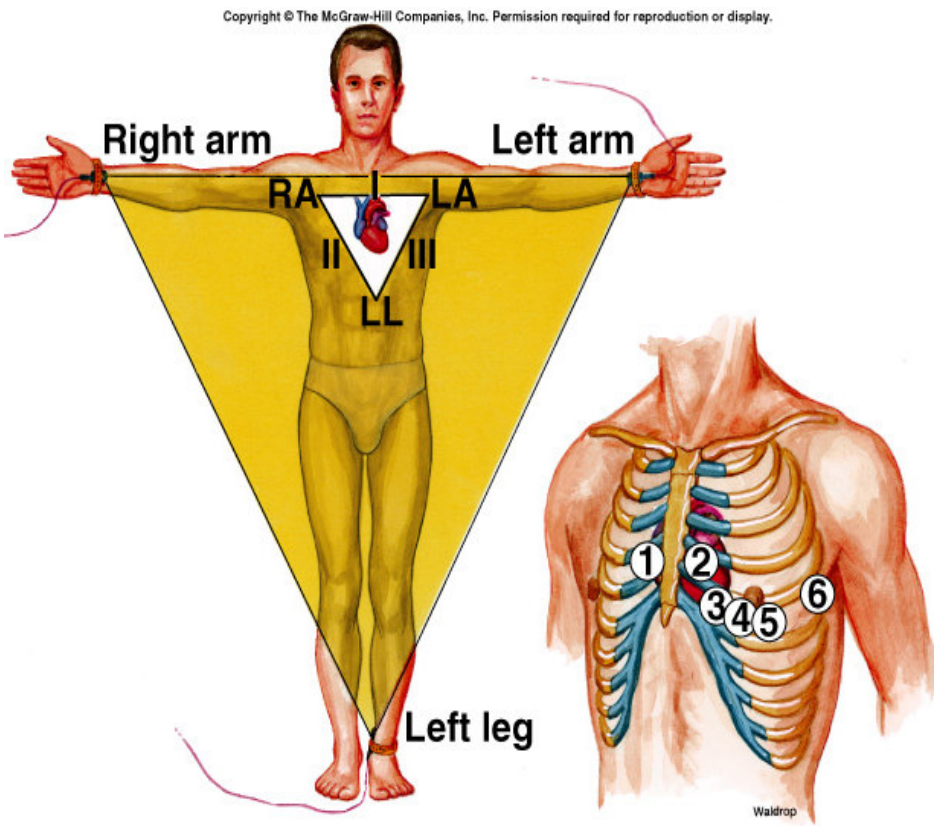
EKG

Electrocardiogram (ECG/EKG)

Note: Tissue fluids conduct electricity.

EKG:

Measure of the **<u>electrical activity</u>** of the heart.



ECG

P wave:

Atrial depolarization, contraction.

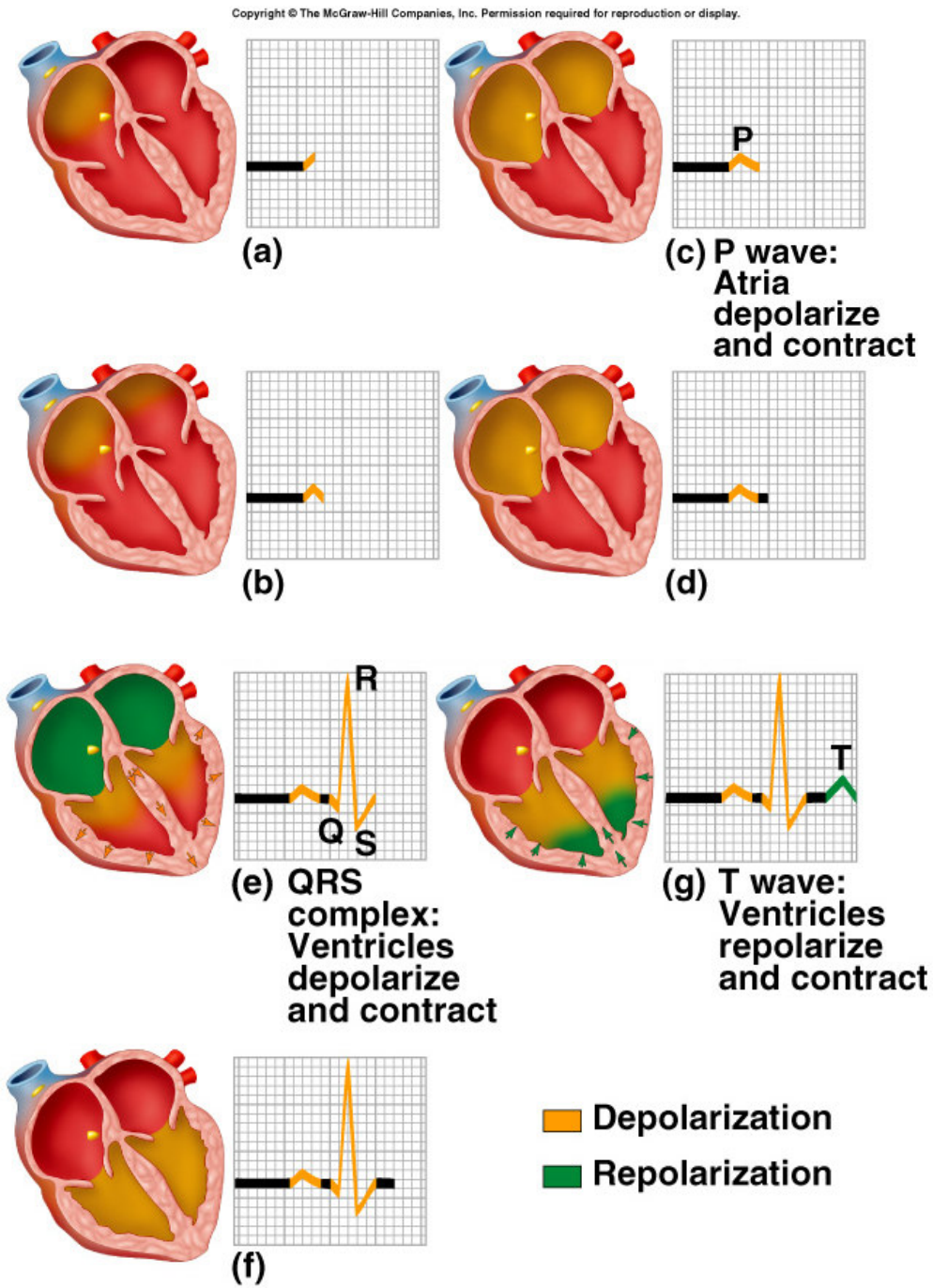
QRS complex:

Ventricular depolarization, contraction

Atrial repolarization.

T wave:

Ventricular repolarization.



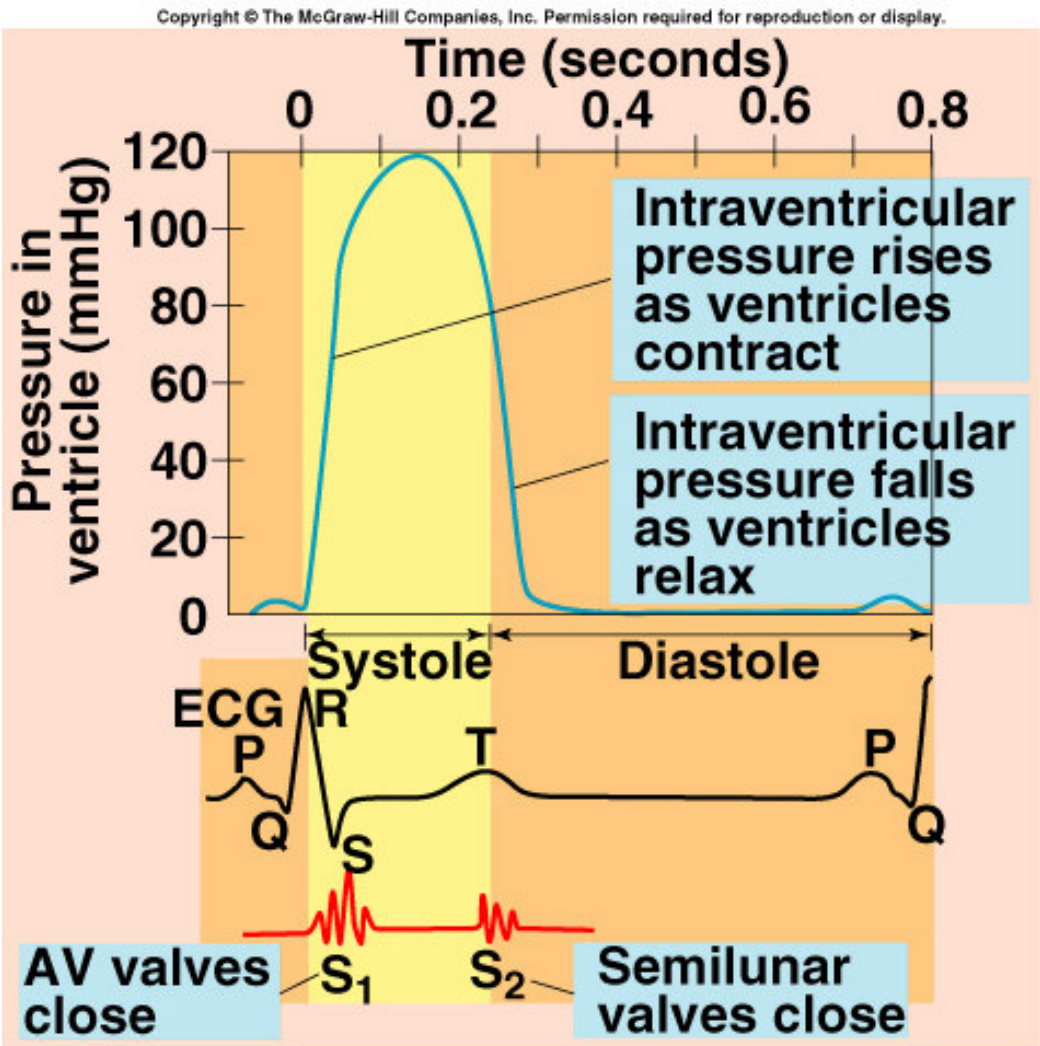
Summary

Systole

- Lub (AV closes)
- ~ QRS to T
- Ventricles contract

Diastole

- Dub (semilunar close)
- T to ~ QRS
- Ventricles relax



Note

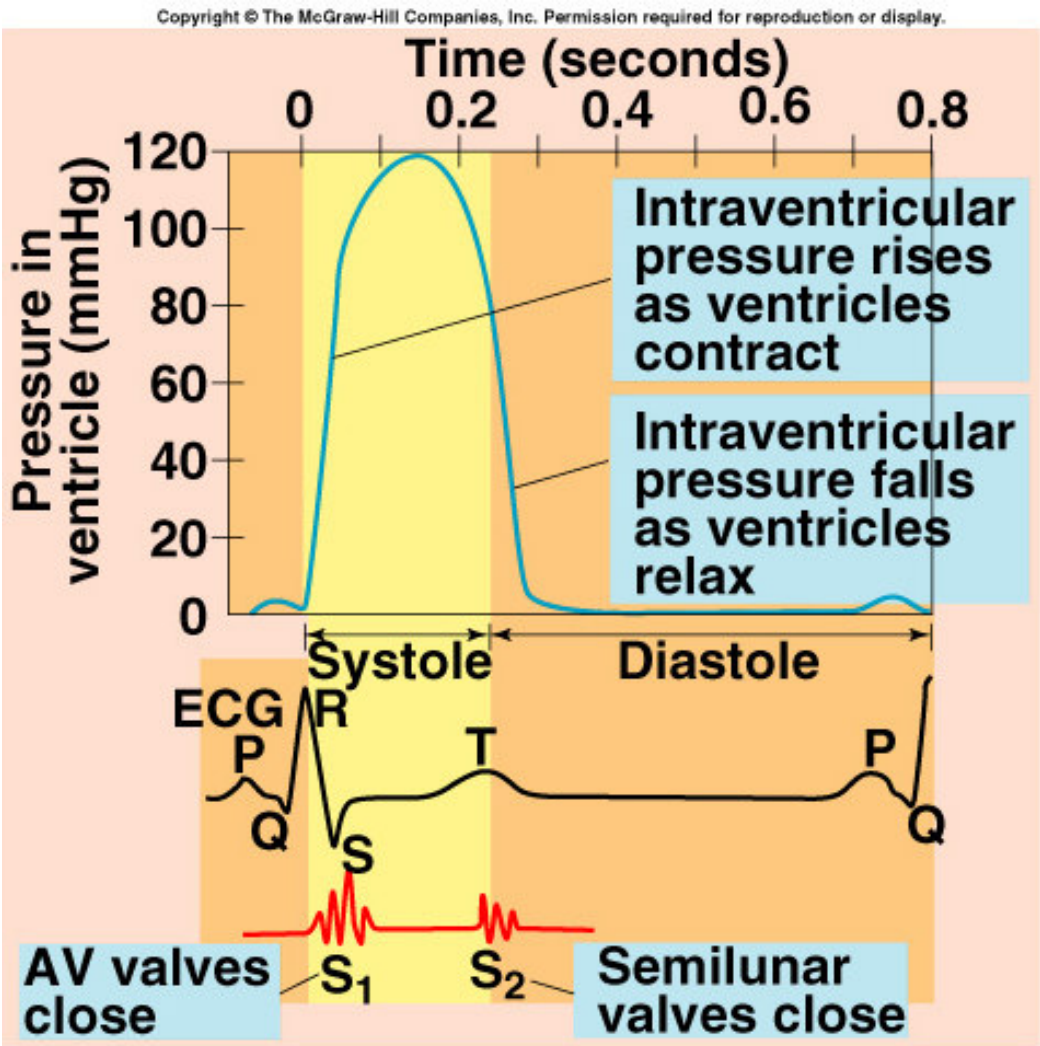
Heart contracting:

P-T (300 ms)

Heart not contracting:

T-P

- can change



Heart disease

Heart Disease

Arrhythmias = abnormal heart rhythms.

Bradycardia = slower

Tachycardia = faster (exercise!)

Flutter: extremely rapid

Fibrillation:

- Contractions of different groups of myocardial cells at different times.
- Ventricular fibrillation is life-threatening.

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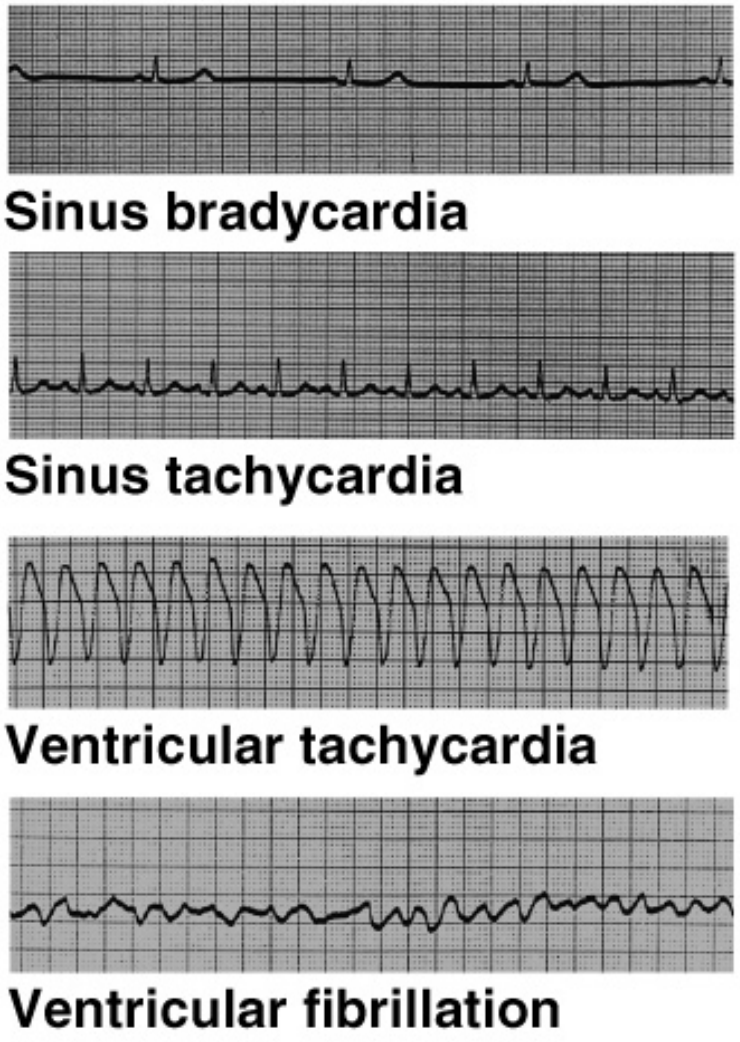

Heart Disease solutions

Electrical defibrillation: depolarize all myocardial cells (stops them!) so they start up in sync again.

Amazing devices:

Artificial pacemakers (always set the pace)

ICD (Implantable cardioverter devices)

- monitor and record heartbeat
- administer electrical defibrillation if needed
- size of a pack of cards, 1 hour surgery
- portable paramedics!

Nutrition, exercise, no smoking!