Physiology of cardiovascular system. Functional characteristics of myocardium.

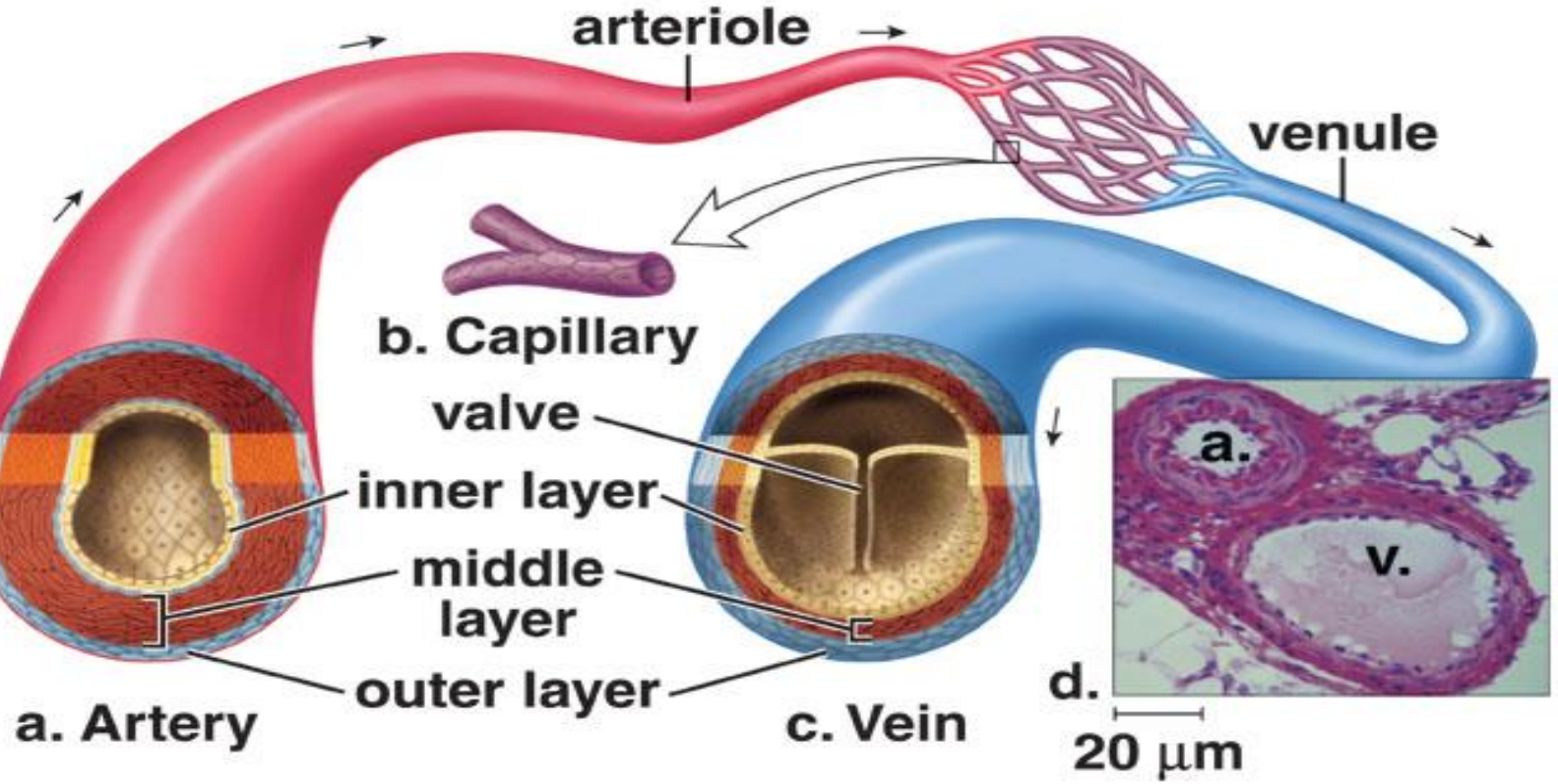
FUNCTIONS

Transportation of hormones, nutrients, wastes, respiratory gases, vitamins, minerals, enzymes, water, leukocytes, antibodies, and buffers.

The Blood Vessels

- The *cardiovascular system* has three types of blood vessels:
- *Arteries* (and *arterioles*) – carry blood away from the heart
- *Capillaries* – where nutrient and gas exchange occur
- *Veins* (and *venules*) – carry blood toward the heart.

Blood vessels



The Heart

- The *heart* is a cone-shaped, muscular organ located between the lungs behind the sternum.
- The heart muscle forms the *myocardium*, with tightly interconnect cells of *cardiac muscle* tissue.
- The *pericardium* is the outer membranous sac with lubricating fluid.

Consists of three layers- epicardium, myocardium and endocardium

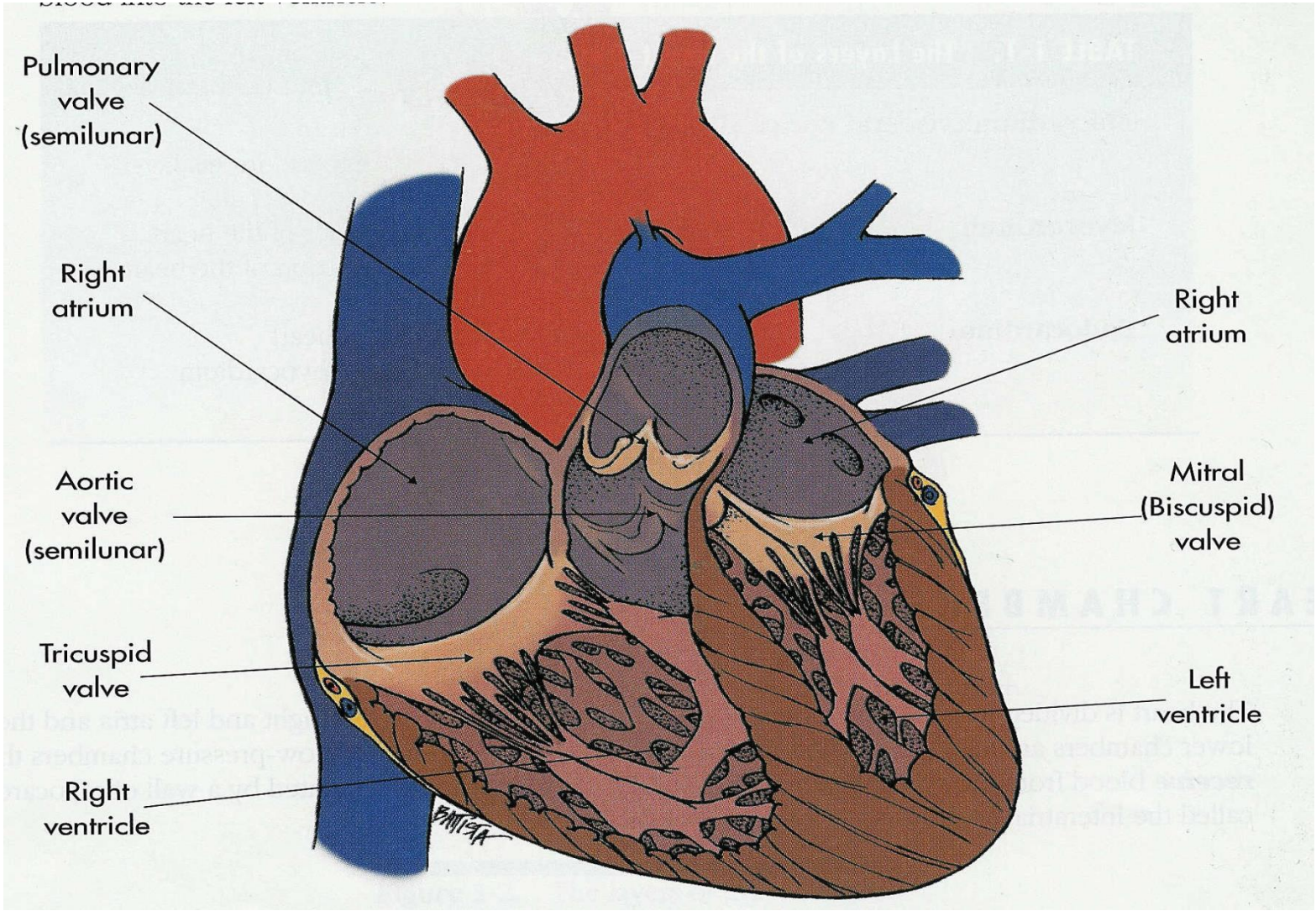
- The epicardium covers the outer surface of the heart
- The myocardium is the middle muscular layer of the heart
- The endocardium lines the chambers and the valves

Functions:

- Pumps blood throughout the body
- Routes blood
- Ensures one-way blood flow
- Regulates blood supply

- The heart has four chambers: two upper, thin-walled *atria*, and two lower, thick-walled *ventricles*.
- The *septum* is a wall dividing the right and left sides.
- *Atrioventricular valves* occur between the atria and ventricles – the *tricuspid valve* on the right and the *bicuspid valve* on the left; both valves are reinforced by *chordae tendinae* attached to muscular projections within the ventricles.

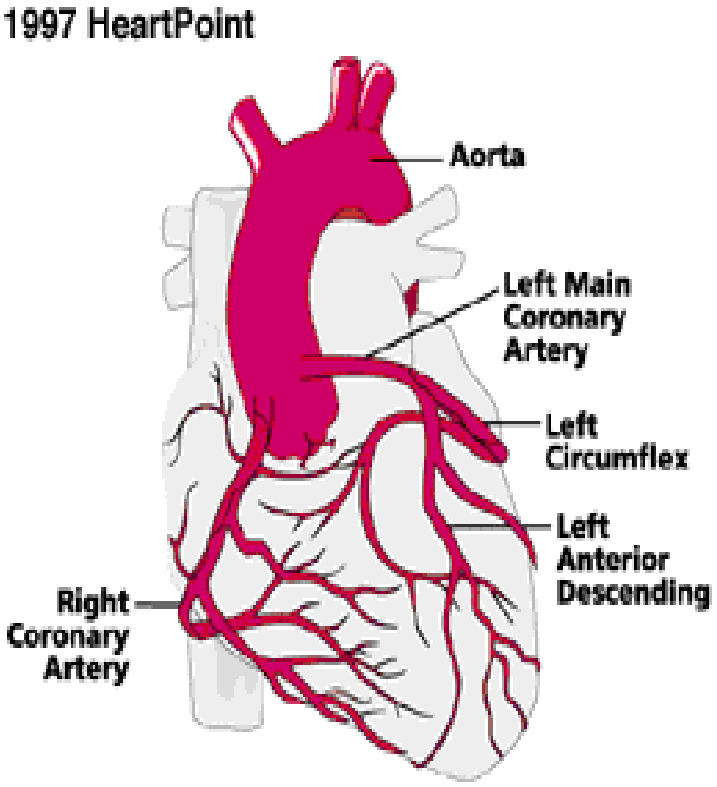
The Valves of the Heart		
Valve Type	**Name**	**Location**
Atrio-ventricular (AV)	Tricuspid	Separates right atrium and right ventricle
	Mitral (Bicuspid)	Separates left atrium and left ventricle
Semilunar	Pulmonic	Between right ventricle and pulmonary artery
	Aortic	Between left ventricle and aorta


Pulmonary valve (semilunar)
Right atrium
Aortic valve (semilunar)
Tricuspid valve
Right ventricle
Right atrium
Mitral (Biscuspid) valve
Left ventricle

The Blood supply of the heart comes from the Coronary arteries

- Right coronary artery
- Left coronary artery

- The heart itself must receive enough oxygenated blood.
- Blood is supplied to the heart through the coronary arteries, two main branches which originate just above the aortic valve.



The Coronary Arteries

Coronary Artery and its Branches	Portion of Myocardium Supplied	Portion of Conduction System Supplied
Right · Posterior descending · Right margin (AV nodal)	· Right atrium · Inferior wall of right ventricle · S anterior surface of left ventricle	· AV node (90% of population) · SA node (> 55%) Bundle of His · Posterior division of left bundle branch
Left · Anterior descending (LAD) · *Circumflex (LCX)*	· Anterior surface of left ventricle · Left atrium · Lateral wall of left ventricle · Part of right ventricle	· AV node (10%) · SA node (45%) · All bundle branches

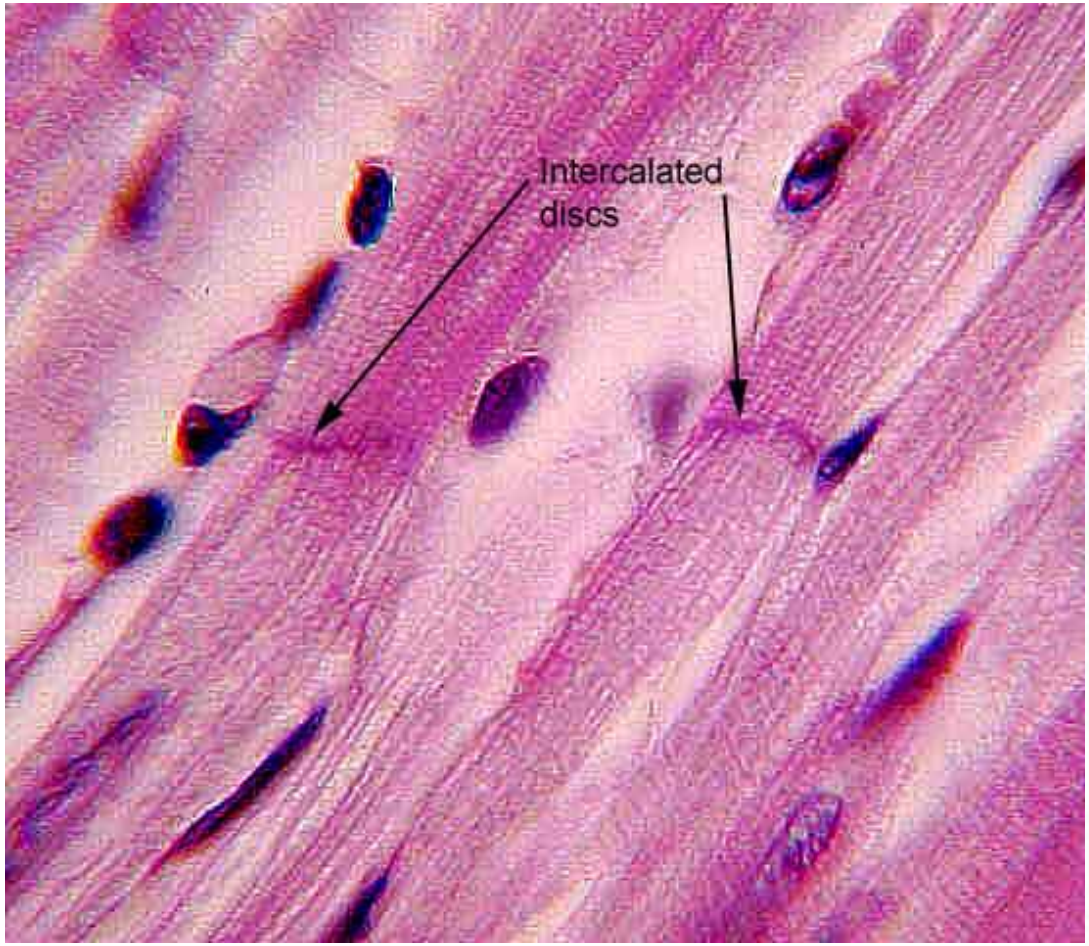
Passage of Blood Through the Heart

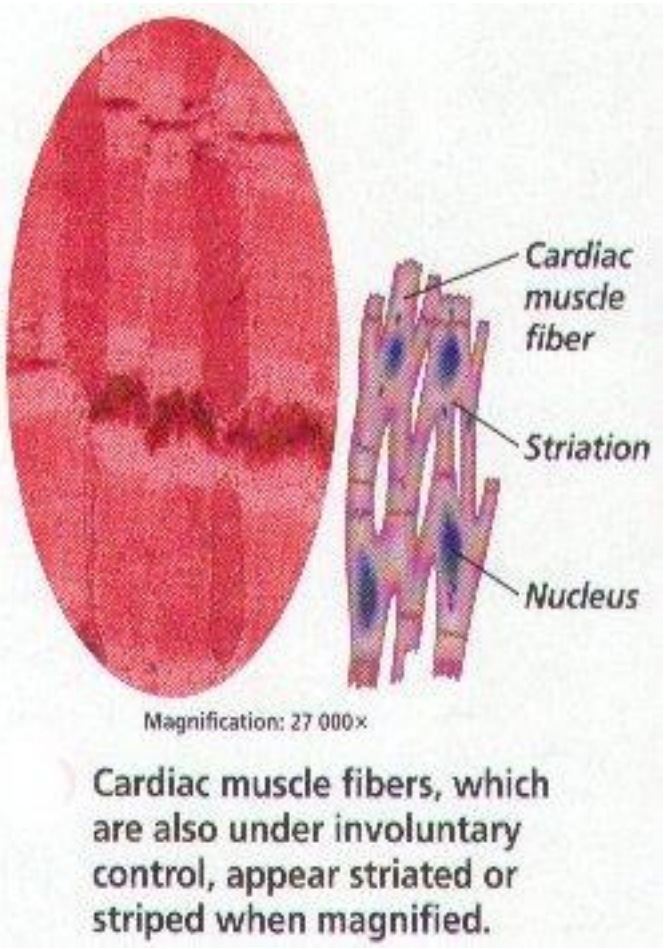
- Blood follows this sequence through the heart: superior and inferior vena cava → right atrium → tricuspid valve → right ventricle → pulmonary semilunar valve → pulmonary trunk and arteries to the lungs → pulmonary veins leaving the lungs → left atrium → bicuspid valve → left ventricle → aortic semilunar valve → aorta → to the body.

Cardiac muscle

- Small elongate tapered cells with a single nucleus
- Individual cells are connected to neighbors by gap junctions, mostly at intercalated disks
- Cells tightly bound together by desmosomes
- Contractile fibers are striated similar to skeletal muscle
- Conducting fibers which include pacemaker fibers are different

Cardiac muscle





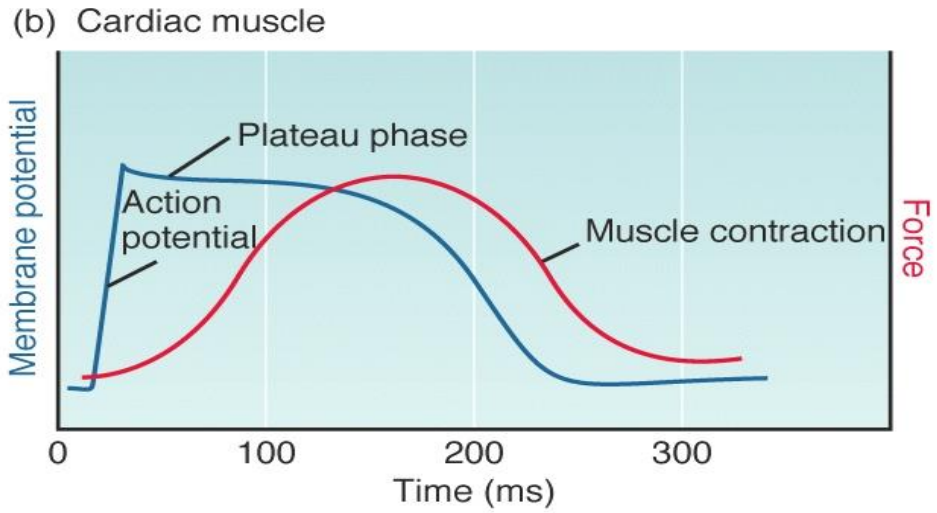
Cardiac muscle fibers, which are also under involuntary control, appear striated or striped when magnified.

Properties of Cardiac Muscle

- Contraction is myogenic
- Innervation from the sympathetic and parasympathetic nervous system serves a modulatory role without producing action potentials
- Sympathetic NS increases strength and rate and parasympathetic decreases strength and rate

AP's in Cardiac Muscle

- AP has a plateau phase the is 100's of milliseconds long
- This combined with a long refractory period prevents tetanic contraction
- This allows the muscle to function in a fashion suited to the function of a pump



Role of Calcium

- Calcium enters from the extracellular space as well as the SR
- Influx of calcium from extracellular sources triggers greater release from the SR
- Calcium removed rapidly by calcium pumps in the SR and sodium/calcium exchange pumps in the plasma membrane
- Role of SR and plasma membrane differs from species to species - frogs mostly PM, mammals mostly SR

Regulation of Calcium Levels

- Not all calcium regulation is from the AP
- Catecholamines bind to alpha and beta receptors and enhance cardiac contraction force
- Alpha receptors stimulate the inositol phospholipid system to increase SR release and Beta receptors activate adenylate cylcase to increase calcium flux across the plasma membrane

Myocardial Cells

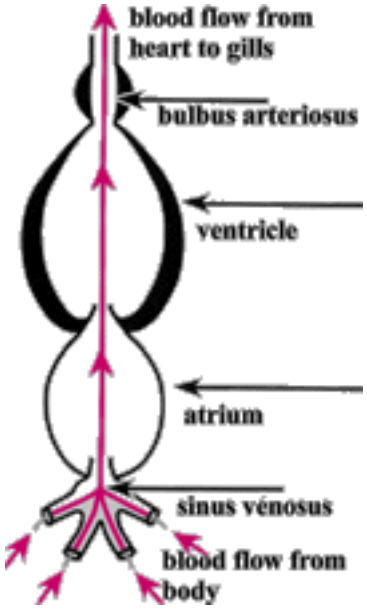
- Nodal cells are often smaller, autorhytmic and weakly contractile with slow electrical conduction
- Large ventricular cells are weakly contractile and show fast electrical conduction
- The bulk of the heart is made up of intermediate size cells that are strongly con-tactile

Electrical Properties

- Contraction is termed systole and relaxation is termed diastole
- Contraction is associated with an AP
- Diastole is associated with the time period between AP's

Pacemaker Locations

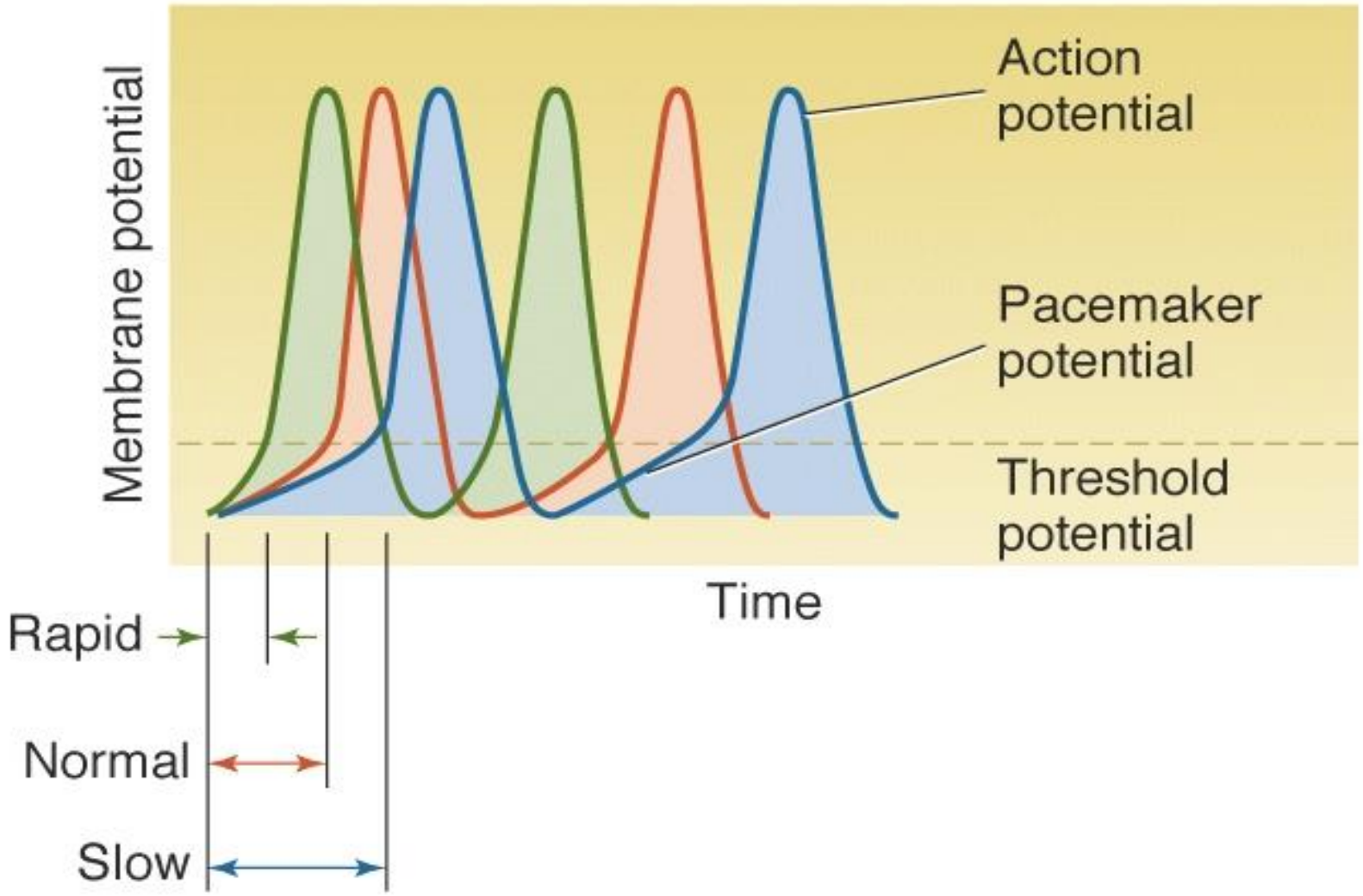
- In vertebrates this is incorporated into the wall of the atrium as the sinoatrial node
- The cardiac ganglion is innervated by both inhibitory and stimulatory neurons
- Normally one pacemaker determines the rate of the entire heart - if another is established it is called an ectopic pacemaker



Pacemaker Potentials

- Pacemaker cells have no stable resting potential
- This brings the cell to threshold in usually slightly less than a second
- Rate of depolarization determines the rate of cardiac contraction
- After AP - potassium conductance drops which ultimately activates sodium and calcium channels
- Cycle completed by the Hodgkin cycle
- High impedance cells needing very little voltage change to initiate an AP

Pacemaker Potentials



Ion Channels

- Several channel types (6 potassium-both time and voltage gated, several calcium and sodium, with some calcium and potassium channels also allowing sodium to pass)
- This provides a large margin of safety
- Acetylcholine and adenosine increase potassium conductance thus delaying depolarization
- Catecholamines bind to beta receptors and accelerate pacemaker function by increasing CAMP and activating cation channels