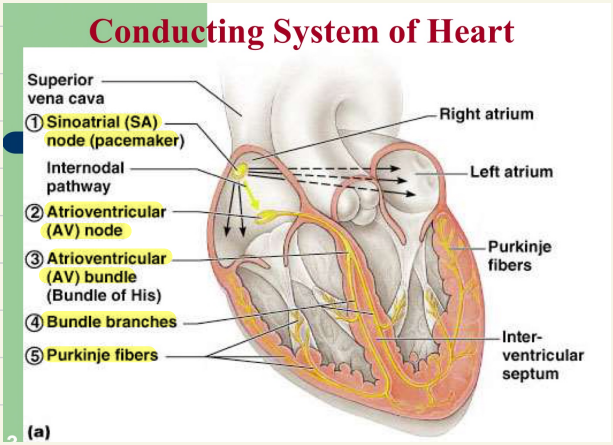
⇒ Remember that all the cells in our body exibit a resting membrane potential, some of these membranes are excitable and some aren't

1/ of cardiac muscle cells are not contractile, they lack actin and myosin Why are they there then? for other purpouses like

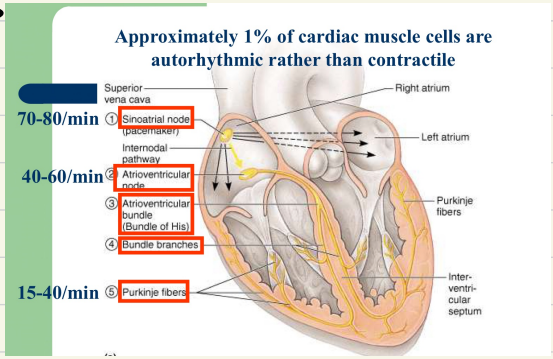


① initiating the action potential (SA node)

② transmit the impulse from the atrium to the ventricul and delay the impulse (AV node)

③ making the conduction velocity inside the ventricul very high

Pacemaker what produces the electrical impulses that cause the heart to beat



the SA node is the heart's natural pacemker, it causes the heart to beat 70-80 beats/min

if the SA node does not work the AV node will take its place and produce 40-60 beats/min

if we have a block between the atrium and the ventricle the perkinje cells become the pacemaker causing 15-40 beats/min which is not enough and an artificial pacemaker will be needed then

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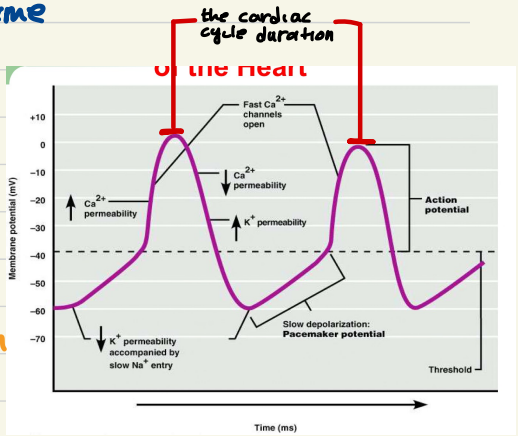
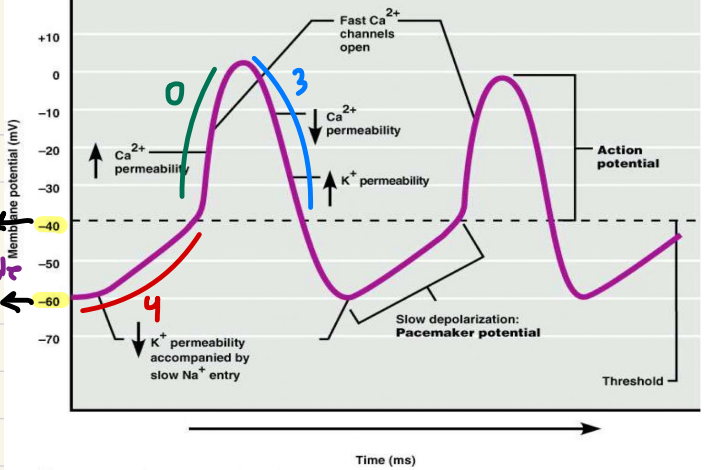
the cardiac cycle duration the time between two peaks (R-R) in this graph This time is usually 0.8 s

to calculate how many beats per minute $\frac{60\,s}{0.8\,s} = 75$ beats



⇒ sympathetic stimulation increases the heart rate by decreasing the cardiac cycle duration (making the peaks closer)

for example it makes it 0.6 ⇒ $\frac{60\,s}{0.6\,s} = 100$ beats/min

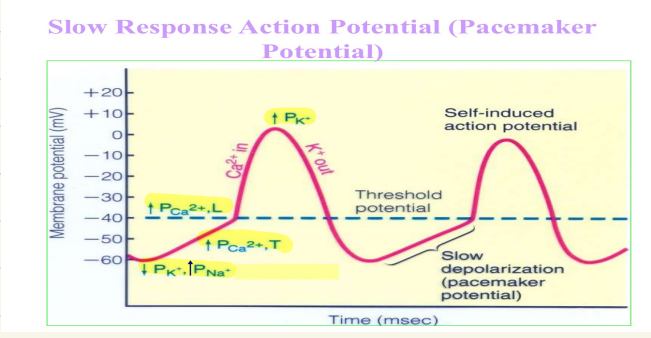


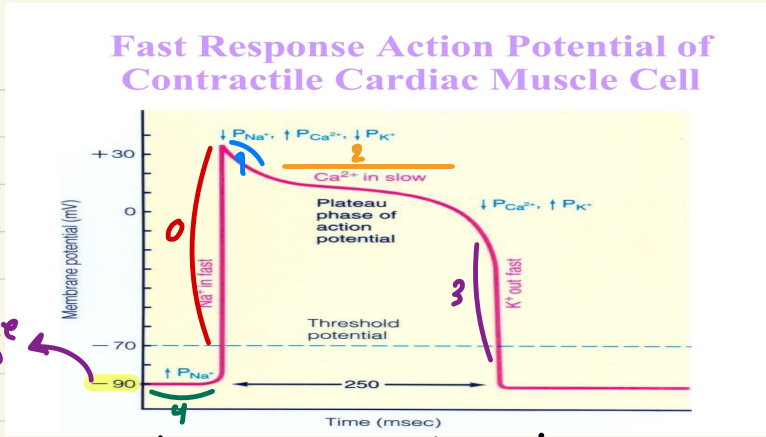
this graph shows the pacemaker action potential of the heart, it includes 3 phases

phase 4 slow depolyrization where leaky Na^+ channels are open and the membrane potential will slowly reach threshold this phase acounts for the automaticity of pacemaker activity (unstable, accending RMP)

phase 0 after reaching threshold Ca^{2+} channels will open and calcium will enter the cell causing full depolyrization (it's called the upstroke of action potential)

phase 3 conductance for K^+ increases and repolyrization happens after the entry of K^+





this graph shows the contractile muscle cell (ventricular) action potential

phase 4 resting membran potential at −90 mV (stable RMP)

phase 0 an increase in Na^+ conductance → an inward Na^+ current (very fast) → depolyrization happens in no time

phase 1 K^+ channels open causing a transient out current (TO current) → initial repolyrization happens

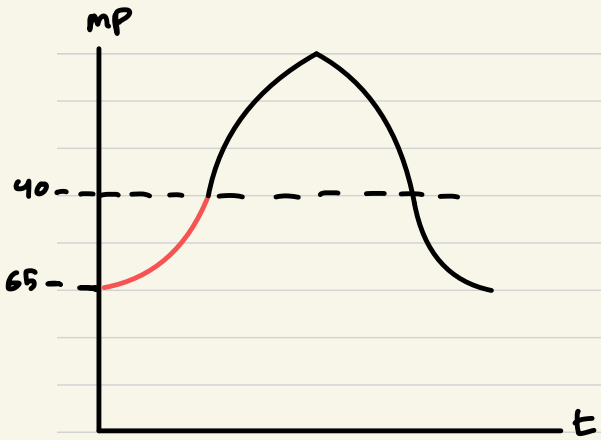
phase 2 plateau phase → Ca^{2+} conductance increases causing an inward current of Ca^{2+} → membrane potential stays stable for some time

Plateau happens because the inward current of Ca^{2+} is equal to the outward current of K^+ (1 Ca^{2+} in and 1 K^+ out)

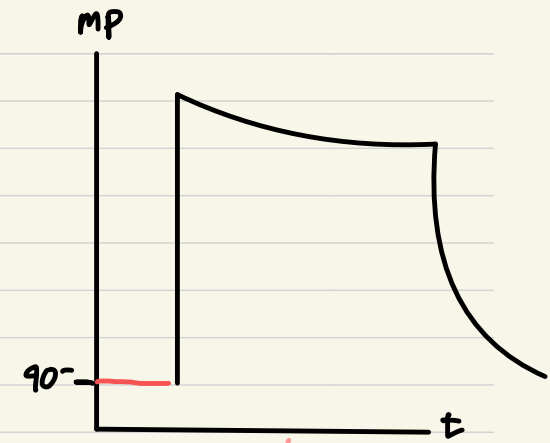
phase 3 conductance for Ca^{2+} decreases and conductance for K^+ stays stable causing full repolyrization because of the inward K^+ current

stable RMP (in ventricular cells)	unstable RMP (SA node)
* current for both Na^+ and K^+ is zero	* current for K^+ is zero but there is small current of Na^+ causing the slow depolyrization

the doctor asked a question what is so special about the SA node that makes it the pacemaker? Ans its membane is the most leaky to sodium making it the ~~fastest~~ pacemaker, so it covers the activity of the AV node



SA node



ventricle

why did the depolyrization in the ventricle happen in no time while in the SA node it happened slowly?
because in the ventricle Na^+ channels are closed but ready to open so once we reach threshold all of them will open very fast by positive feedback causing the sharp depolyrization

while in the SA node fast Na^+ channels are closed and incapable of opening, but slow leaky Na^+ channels are open till threshold is reached, at threshold they close and Ca^{+2} completes the depolyrization

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why do we have a plateau phase in the ventricle?
it represents a prolonged refractory period that gives the heart the chance to relax before another action potential happens and this is very important to prevent heart tetanisation (تشنج)

So why is heart tetanisation impossible? because of plateau phase (phase 2)

> skeletal muscle tetanisation is possible because we don't have the plateau phase in skeletal muscle action potential

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Autonomic stimulation of SA node

Sympathetic	parasympathetic
* increses heart rate * decreases cardiac cycle duration * increases Ca^{+2} and Na^{+} inward current * decreases K^{+} current	* decreases heart rate * increases cardiac cycle duration * decrease Ca^{2+} and Na^{+} inward current * increase K^{+} outward current