

1. Origin of Heartbeat and Electrical Activity.

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4:05 PM

Sequence

Contraction of Atria $\rightarrow$ Contraction of Ventricle $\rightarrow$ Diastole of all
(Atrial systole) (Ventricular systole)

- This is triggered by Cardiac Conduction system and spreads via the system to all parts of myocardium.

- SA Node $\xrightarrow[\text{Atrial pathways.}]{\text{Internodal}}$ AV node $\rightarrow$ Bundle of His
(cardiac pacemaker) $\downarrow$ via Purkinje system $\downarrow$ Ventricular muscle.

Anatomy

SA Node: At the junction of superior vena cava with the right atrium.

AV Node: At the posterior portion of interatrial septum.

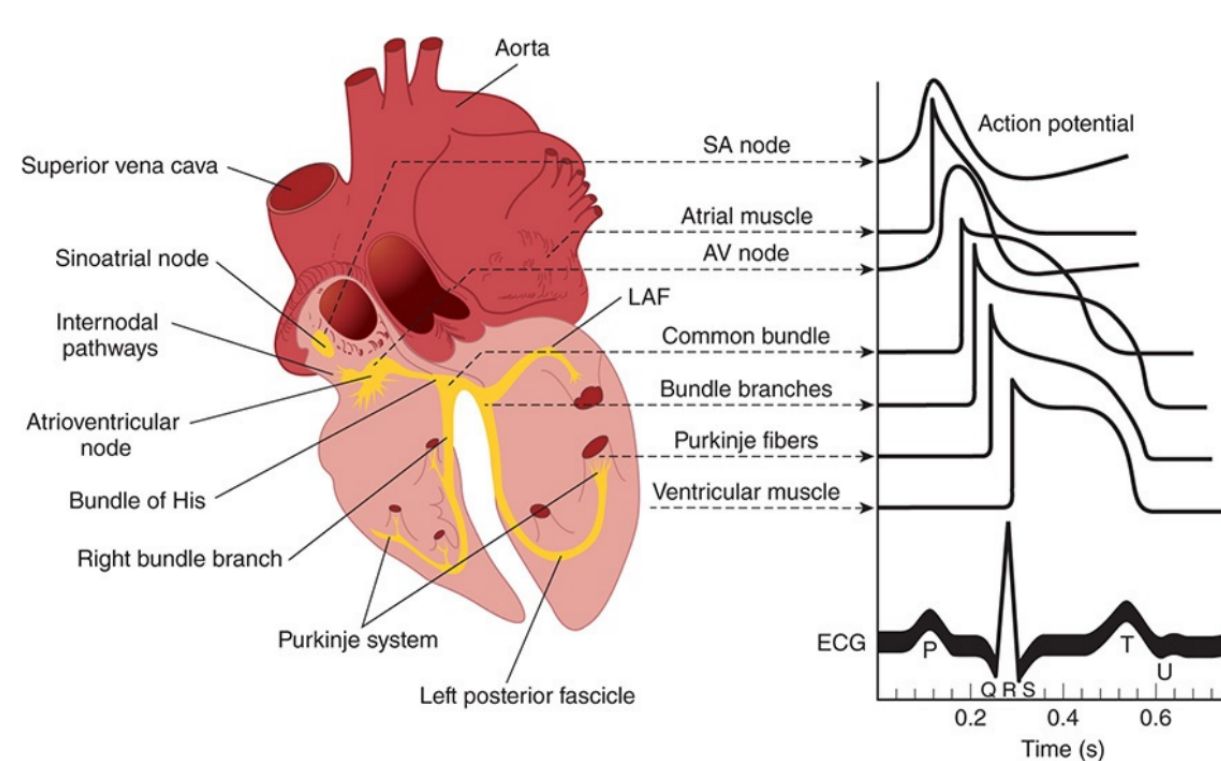
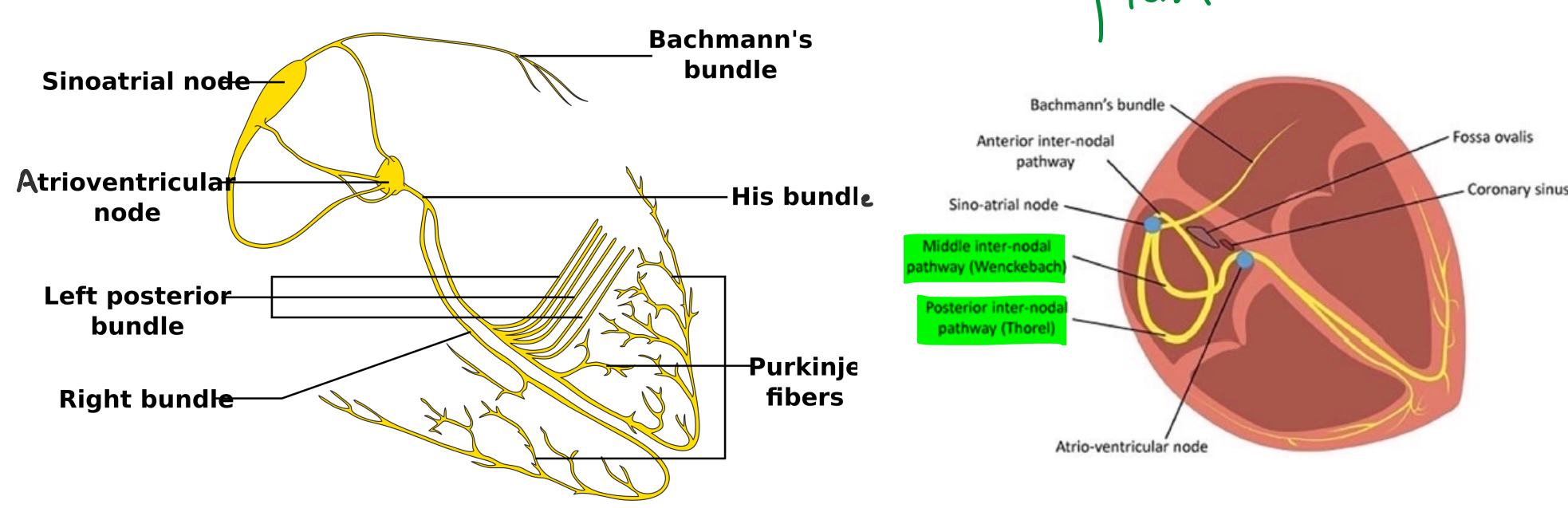


FIGURE 29-1 Conducting system of the heart. Left: Anatomic depiction of the human heart with additional focus on areas of the conduction system. Right: Typical transmembrane action potentials for the SA and AV nodes, other parts of the conduction system, and the atrial and ventricular muscles are shown along with the correlation to the extracellularly recorded electrical activity, that is, the electrocardiogram (ECG). The action potentials and ECG are plotted on the same time axis but with different zero points on the vertical scale for comparison. AV, atrioventricular; LAF, left anterior fascicle; SA, sinoatrial.

Properties of Cardiac Muscle :-

- Myocardial fibres have a RMP of -90 mV.
- Phase 0** : The initial rapid depolarisation and the overshoot are due to opening of voltage-gated Na^+ channels.
- Phase 1** : The initial rapid repolarisation is due to closure of Na^+ channels and opening of one type of K^+ channel.
- Phase 2** : The subsequent prolonged plateau is due to a slower but prolonged opening of voltage-gated Ca^{2+} channels.
- Phase 3 & Phase 4** : Final repolarisation to the resting membrane potential is due to closure of Ca^{2+} channels and a slow, delayed increase of K^+ efflux through various types of K^+ channels.

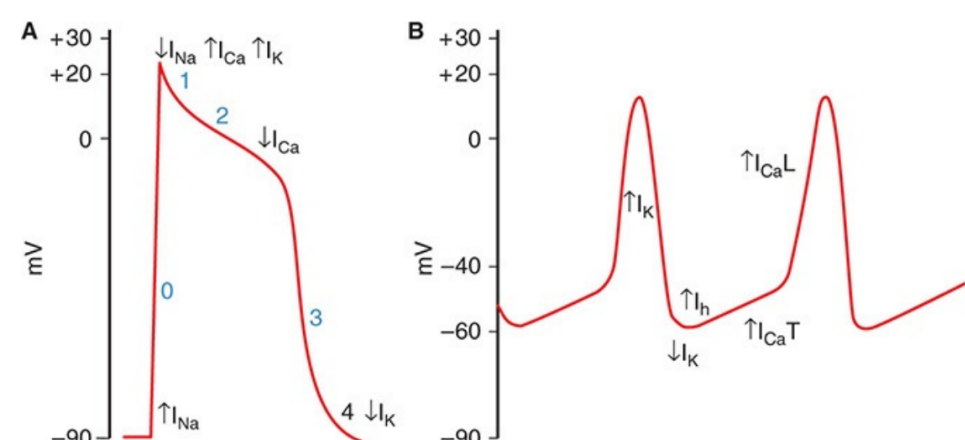


FIGURE 29-2 Comparison of action potentials in ventricular muscle and diagram of the membrane potential of pacemaker tissue. A) Phases of action potential in ventricular myocyte (0-4, see text for details) are superimposed with principal changes in current that contribute to changes in membrane potential. B) The principal current responsible for each part of the potential of pacemaker tissue is shown under or beside the component. L, long-lasting; T, transient. Other ion channels contribute to the electrical response. Note that the resting membrane potential of pacemaker tissue is somewhat lower than that of atrial and ventricular muscle.

CLINICAL BOX 29-1

Use of Digitalis

Digitalis, or its clinically useful preparations (digoxin and digitoxin), has been described in medical literature for over 200 years. It was originally derived from the foxglove plant. (*Digitalis purpurea* is the name of the common foxglove.) Correct administration can strengthen cardiac contractions through digitalis inhibitory effects on the Na, K ATPase, resulting in greater amounts of Ca^{2+} release and subsequent changes in contraction forces. Digitalis can also have an electrical effect in decreasing AV nodal conduction velocity and thus altering AV transmission to the ventricles.

Spread of Cardiac Excitation :-

- Atrial depolarisation is complete in 0.1 s
- As conduction in AV node is slow, a delay of about 0.1 s (AV nodal delay) occurs before excitation spreads to the ventricles.
- Depolarisation spreads in Purkinje fibres to all parts of the ventricles in 0.08 - 0.1 s.

TABLE 29-1 Conduction speeds in cardiac tissue.

Tissue	Conduction Rate (m/s)
SA node	0.05
Atrial pathways	1
AV node	0.05
Bundle of His	1
Purkinje system	4
Ventricular muscle	1

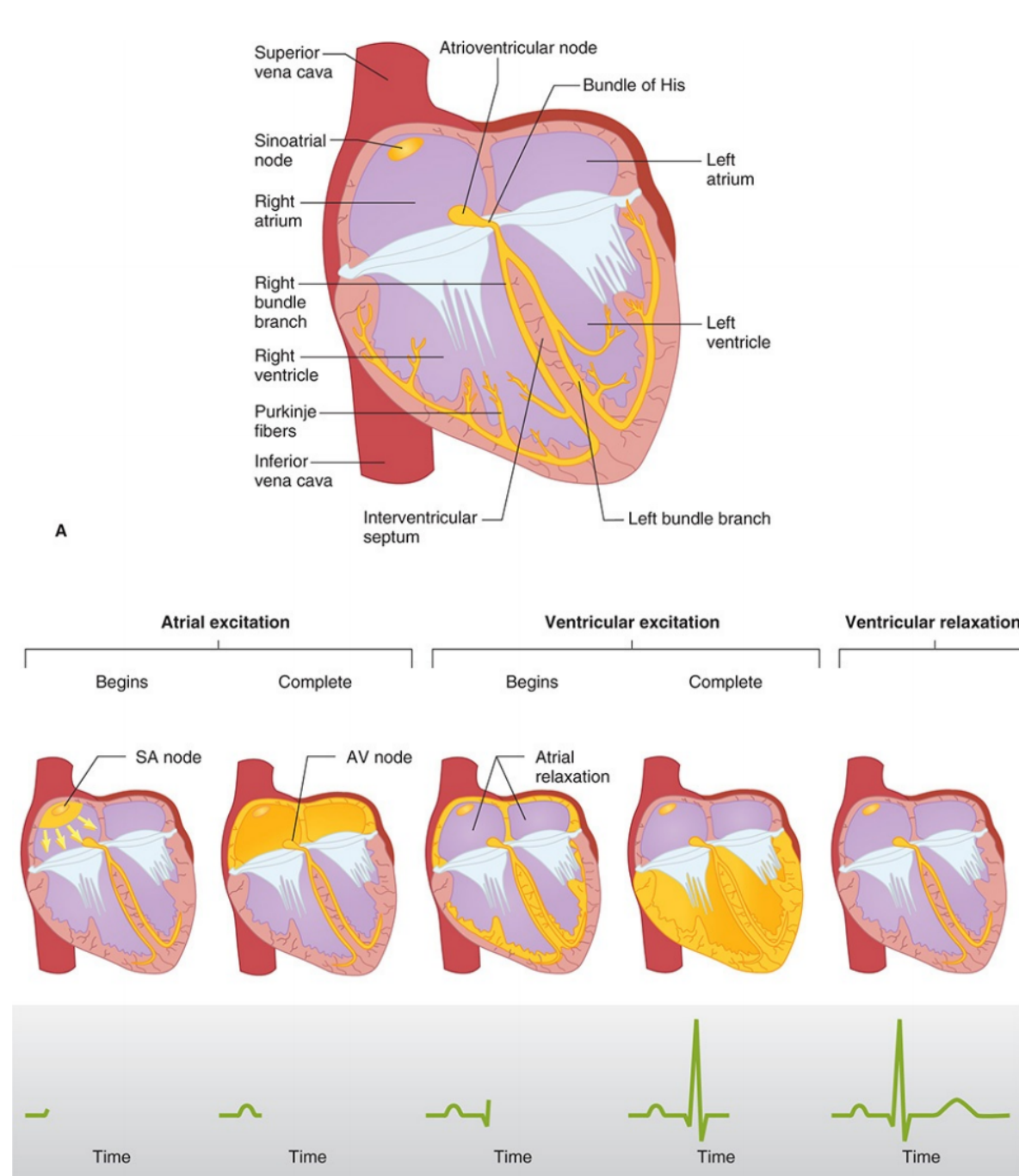


FIGURE 29-4 Normal spread of electrical activity in the heart. A) Conducting system of the heart. B) Sequence of cardiac excitation. Top: Anatomic position of electrical activity. Bottom: Corresponding electrocardiogram. The yellow color denotes areas that are depolarized. AV, atrioventricular; SA, sinoatrial. (Reproduced with permission from Goldman MJ: