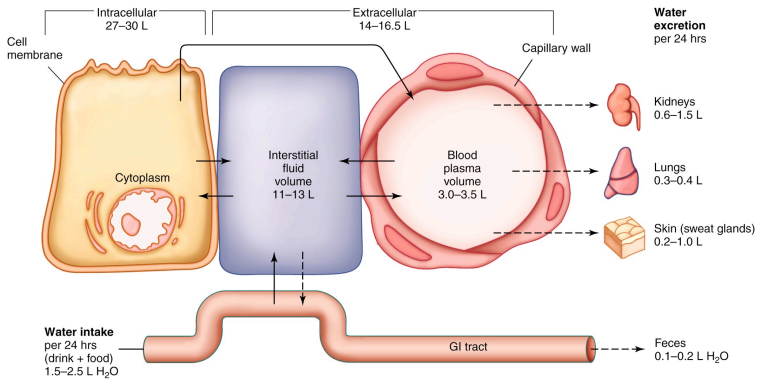
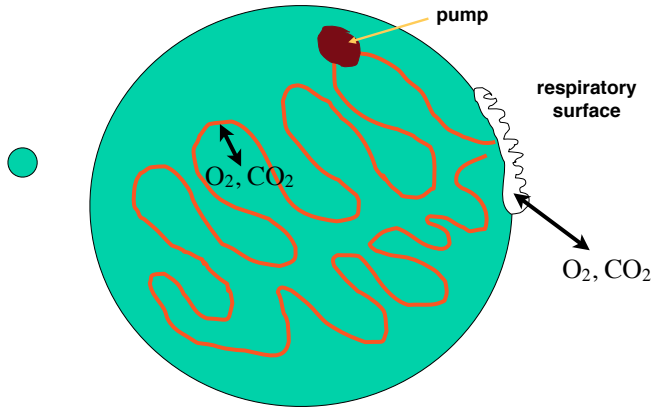
Vert Phys PCB3743

Heart 1
Fox Chapter 13 part 1
(Chapter 12.6 Cardiac Muscle)

Figure 14.8



Circulatory System: Active Pumping
to transport gases from respiratory surface to tissues



Atrium
receives incoming blood, passes it to ventricle

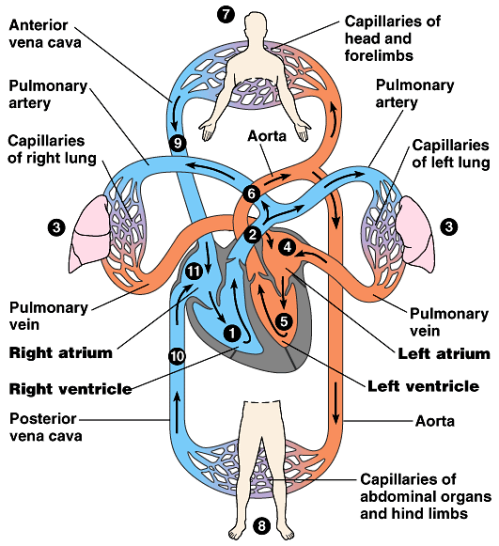
Ventricle
more muscular pump sending blood to a separate circulation (either pulmonary circulation (lungs) or systemic circulation).

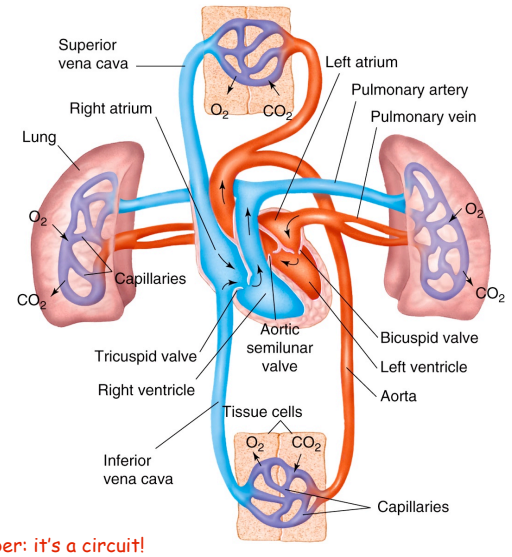
Arteries (arterial blood)
vessels carrying blood from heart towards the capillaries.
Thick muscular walls to keep pressure up.
High in oxygen (except for pulmonary arteries).

Veins (venous blood)
vessels carrying blood from capillaries back to heart. Very thin flabby walls with low pressure, but have one-way valves to prevent blood from backing up. Low in oxygen (except for pulmonary veins).

Capillaries
very small vessels (one blood cell wide) that perfuse all the tissues.

Figure 42.4 The mammalian cardiovascular system: an overview





remember: it's a circuit!

Figure 13.10

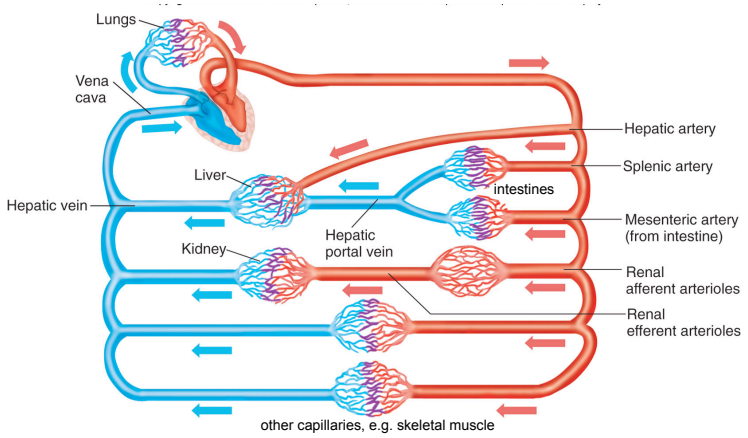


Figure 14.17

7

William Harvey, MD

1578-1657

Physician to Kings James I and Charles I

Author of ***de Motu Cordis et Sanguinis*** (An Anatomical Exercise on the Motion of the Heart and Blood in Living Beings), 1628

"This book is important both for the discovery of the complete circulation and for the experimental, quantitive and mechanistic methodology which Harvey introduced. He looked upon the heart, not as a mystical seat of the spirit and faculties, but as a pump analyzable along **mechanical lines.**

He observed that with each beat two ounces of blood leave the heart; so that with 72 heart beats per minute, the heart throws into the system 540 pounds of blood every hour. Where could all this blood come from? The answer seems to be that it is the same blood that is always returning. Moreover, the one-way valves in the heart, like those in the veins, indicate that ... the blood goes out to all parts of the body through the arteries and returns by way of the veins. The blood thus makes a **complete closed circuit**."

described pulmonary vs. systemic circulation, cardiac cycle, pacemaker cells, arteries vs. veins...(but couldn't see capillaries)

8

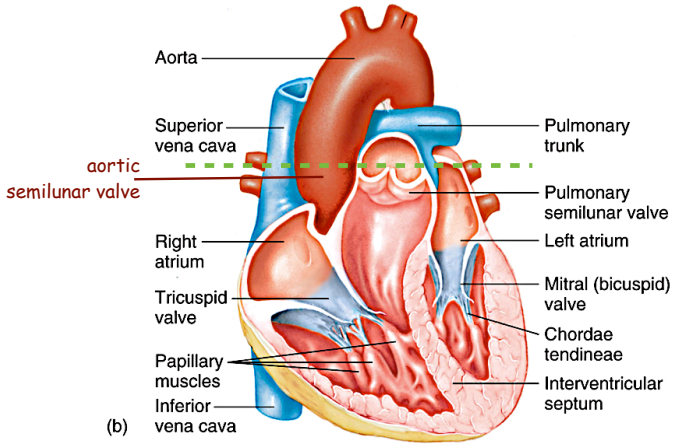
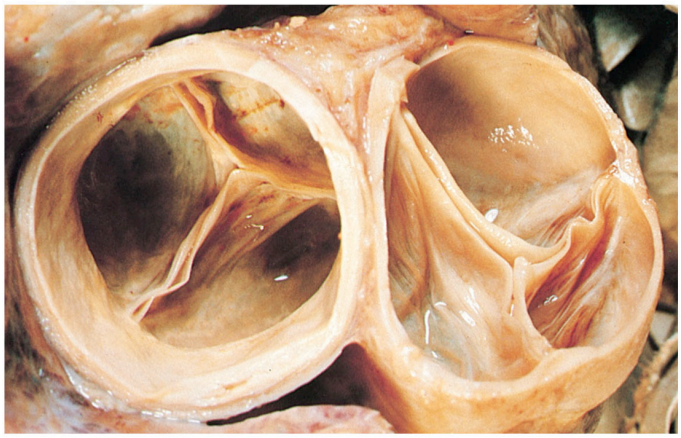


Figure 13.11

9

aortic semilunar valves pulmonary semilunar valves

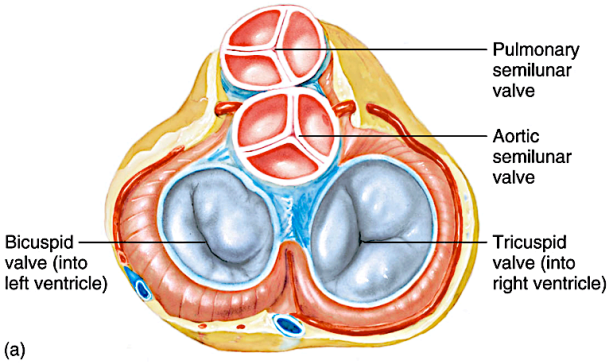


Igaku-Shoin, Ltd., Tokyo, Japan

Figure 13.12

10

"dub" = closing of semilunar valves = S2



"lub" = closing of AV valves = S1

Figure 13.11

11

The Cardiac Cycle

Diastole
chambers are relaxed, blood can flow in

Atrial Systole
atria contract, pushing blood into ventricles

Ventricular Systole
ventricles contract with high pressure, pushing blood into the lungs and systemic circulation

Diastolic pressure (bottom number)
arterial pressure when ventricle is relaxed

Systolic pressure (top number)
arterial pressure when ventricle contracts and pumps

12

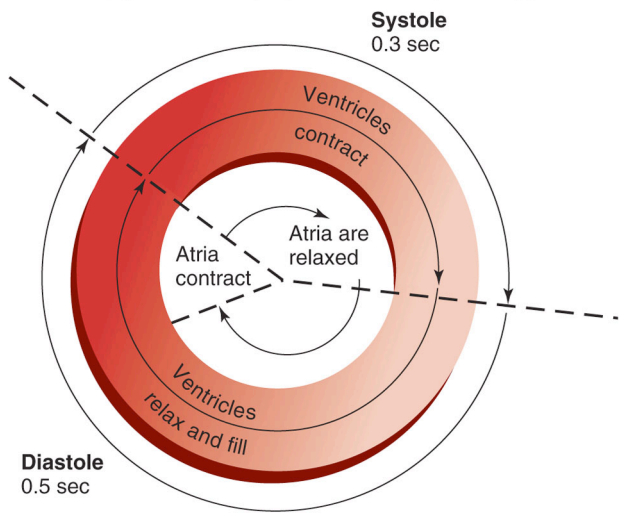
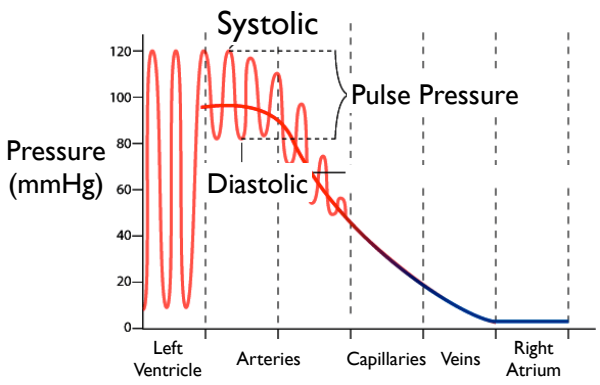


Figure 13.16

13

Blood Pressure:
Arterial Pressure > Venous Pressure



http://www.adinstruments.com

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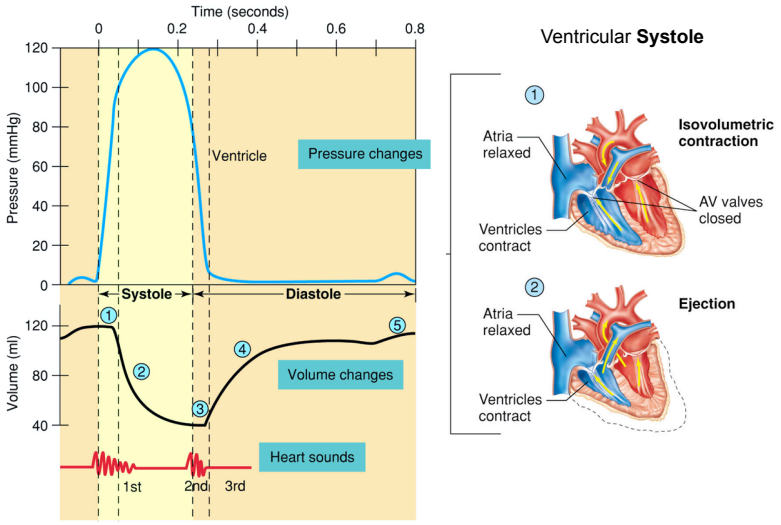

Figure 13.17

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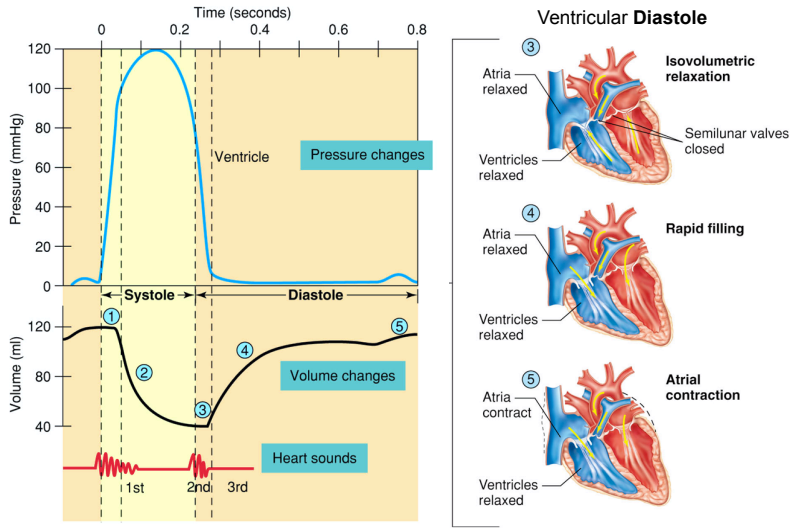


Figure 13.17

16

Events of the Cardiac Cycle

Atria	AV Valves	Ventricles	Semi-Lunar Valves	Blood Flow
diastole	open	**diastrole**	closed	into atria (from vena cava, lungs)
systole	open	**diastole**	closed	into ventricles
	"lub" ↓			
diastole	closed	**systole**	open	into lungs, aorta
			"dub" ↓	
diastole	open	**diastrole**	closed	into atria (from vena cava, lungs)

diastole = relaxed, systole = contracting

17

Heart Beat

1. Generate rhythmic stimulation to start cardiac action potential

2. Action potential will cause contraction of cardiac muscle

3. Allow action potential to spread across the heart; introduce delay between atria and ventricles so they don't contract at the same time

18

Contraction of Cardiac Muscle (Myocardium)

Action Potential starts from pacemaker cells in **sinoatrial node** (SA node)
HCN channels open when hyperpolarized (**H**yperpolarization-activated **C**yclic **N**ucleotide-gated channels)
-> spontaneous depolarization of pacemaker cells to -40 mV
-> opening of voltage-gated Ca++ channels
-> + 20 mV -> action potential across myocardium

Myocardial Action Potential is longer than neural action potential:
fast Na+ channels -> fast depolarization
slow Ca++ channels -> plateau phase
voltage-gated K+ channels cause repolarization

Myocardium forms a functional **syncitium**, via **gap junctions**

Myocardial Contraction
Voltage-gated Na+ channels open, causing depolarization
Voltage-gated Ca++ channels open in transverse tubules
Influx of Ca++ causes release of Ca++ from sarcoplasmic reticulum
Ca++ binds to troponin to allow contraction
Ca++ ATPase pump returns Ca++ into sarcoplasmic reticulum
Na+/Ca++ exchanger pumps Ca++ from cytoplasm into extracellular fluid

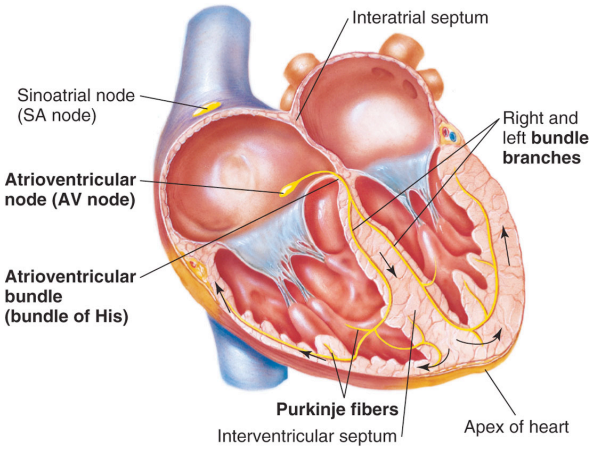


Figure 13.20

Spontaneous Depolarization of Pacemaker Cells

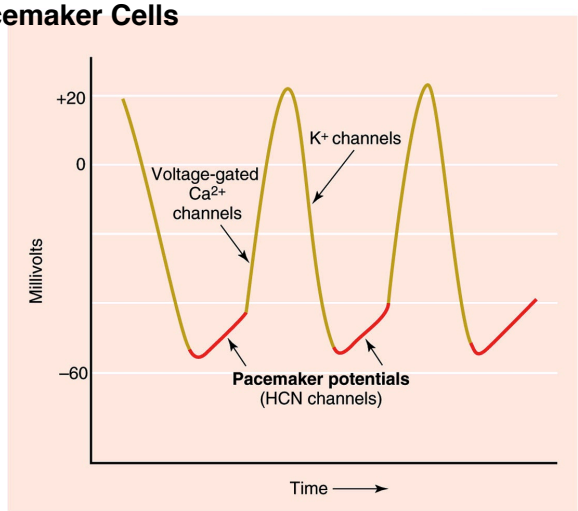
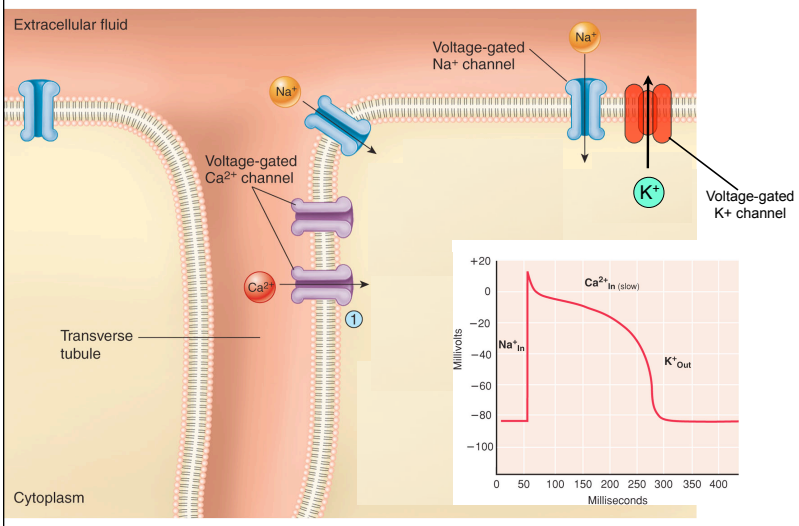


Figure 13.18



frog heart does not beat in Ca++ free buffer

22

Comparison of Skeletal Muscle and Cardiac Muscle

Skeletal Muscle	Cardiac Muscle
Striated; actin and myosin arranged in sarcomeres	Striated; actin and myosin arranged in sarcomeres
Well-developed sarcoplasmic reticulum and transverse tubules	Moderately developed sarcoplasmic reticulum and transverse tubules
Contains troponin in the thin filaments	Contains troponin in the thin filaments
Ca^{2+} released into cytoplasm from sarcoplasmic reticulum	Ca^{2+} enters cytoplasm from sarcoplasmic reticulum and extracellular fluid
Cannot contract without nerve stimulation; denervation results in muscle atrophy	Can contract without nerve stimulation; action potentials originate in pacemaker cells of heart
Muscle fibers stimulated independently; no gap junctions	Gap junctions present as intercalated discs

Table 12.8

myocardial infarction (tissue damage due to lack of oxygen)
-> cardiac troponin in the blood

23

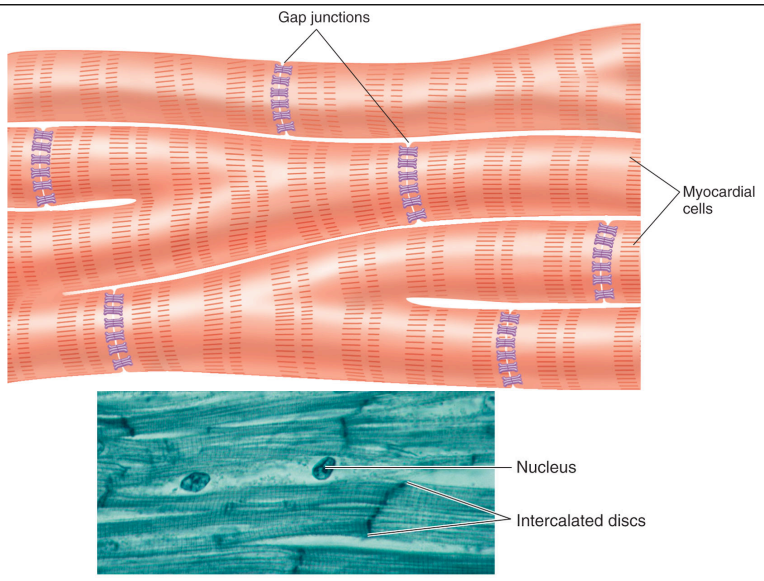


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Figure 12.32

24

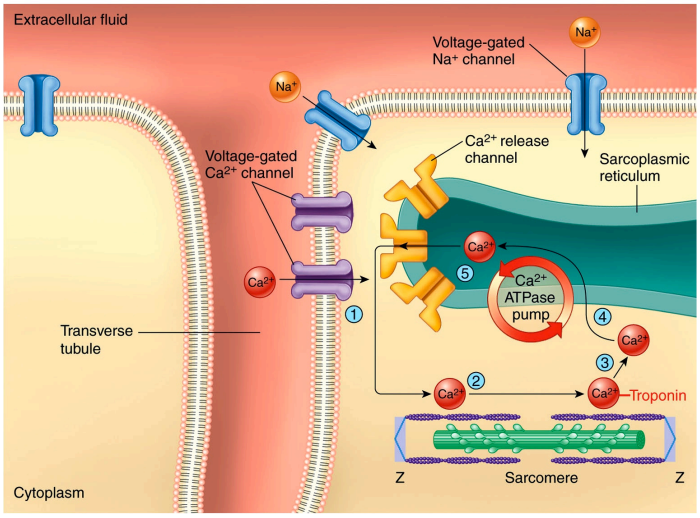

Figure 12.34

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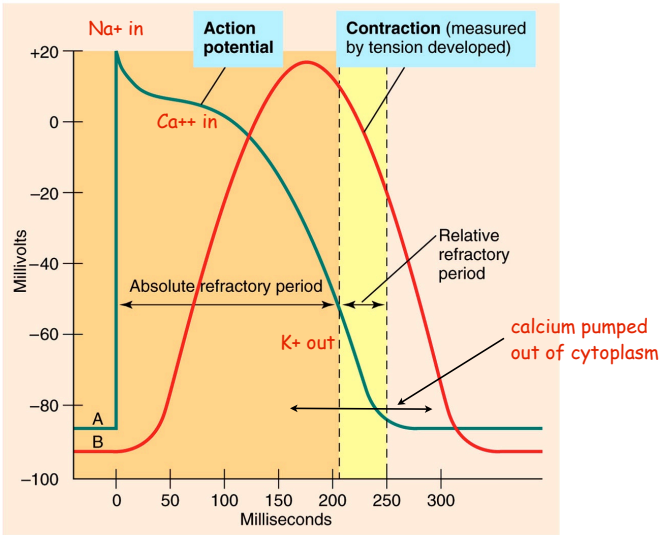

Figure 13.21

26

Conduction of action potential across heart and Electrocardiogram (ECG)

Action Potential (AP) spreads from pacemaker cells in **SA node**.

Myocardium forms a functional **syncitium**, via **gap junctions**

AP spreads rapidly across atria to cause depolarization and atrial systole (contraction). **[P wave]**

AP cannot cross directly to ventricles: must pass through **atrioventricular node** (AV node).

Slow conduction through AV node causes delay between atrial and ventricular contraction.

AP spreads from AV node through bundle of His and along Purkinje fibers in the walls of the ventricles. [Atria repolarize.]

Ventricles depolarize and contract. **[QRS wave]**

Ventricles repolarize. **[T wave]**

27

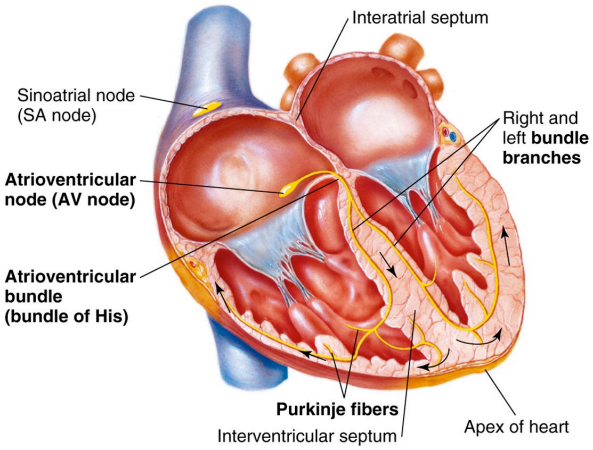

Figure 13.20

28

Figure 42.7 The control of heart rhythm

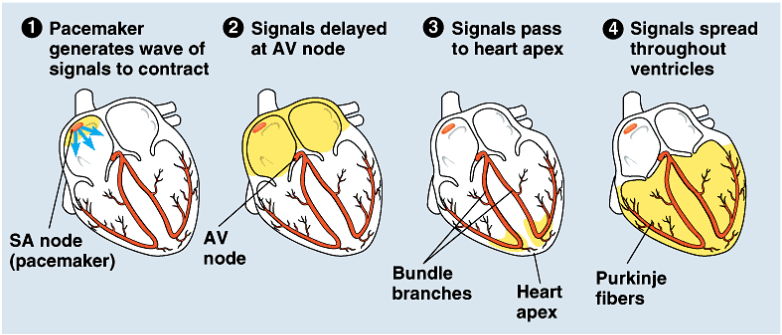

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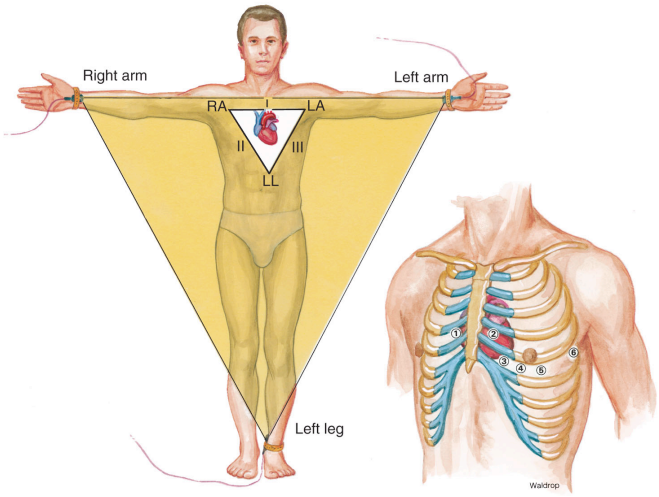
Figure 13.24



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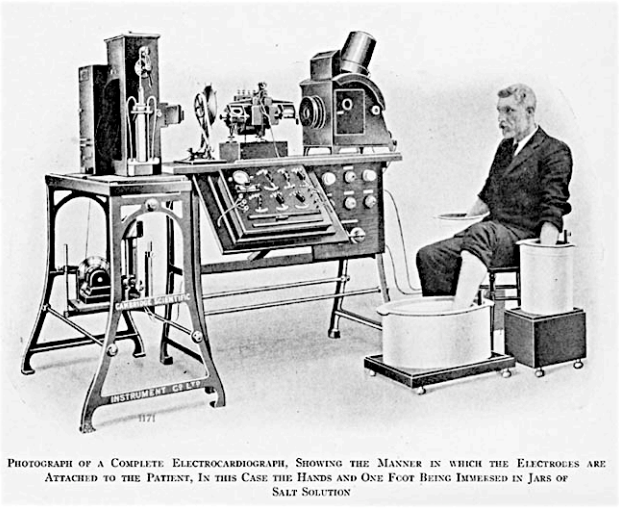
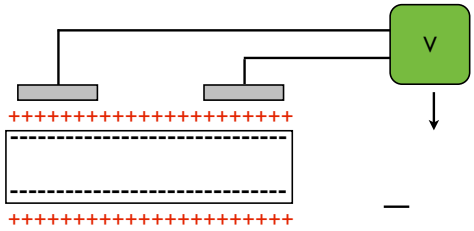


Photograph of a Complete Electrocardiograph, Showing the Manner in which the Electrodes are Attached to the Patient, In this Case the Hands and One Foot Being Immersed in Jars of Salt Solution

1911

http://en.wikipedia.org/wiki/Image:Willem_Einthoven_ECG.jpg

31



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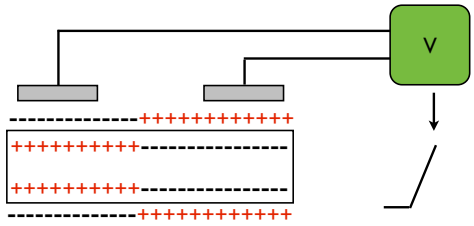

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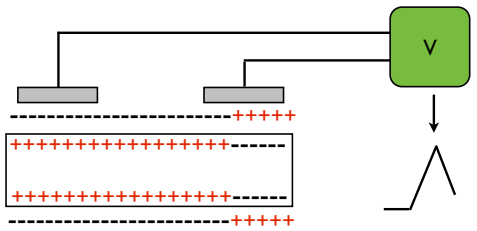

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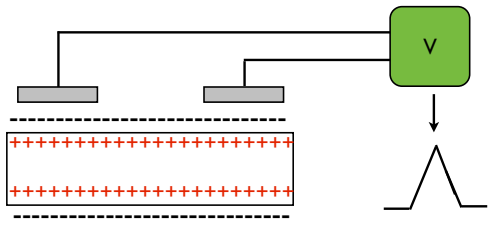

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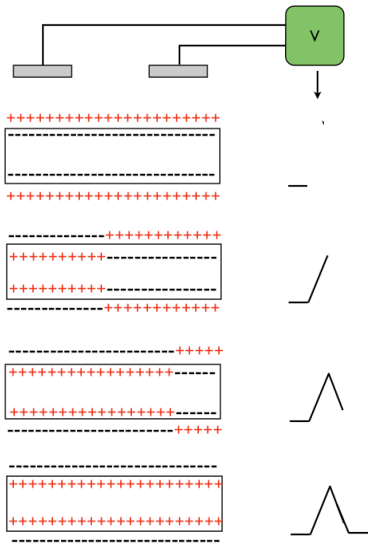

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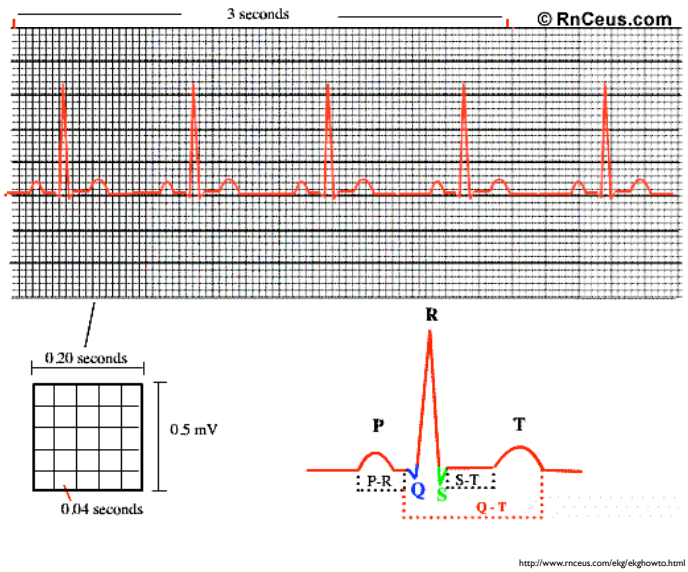

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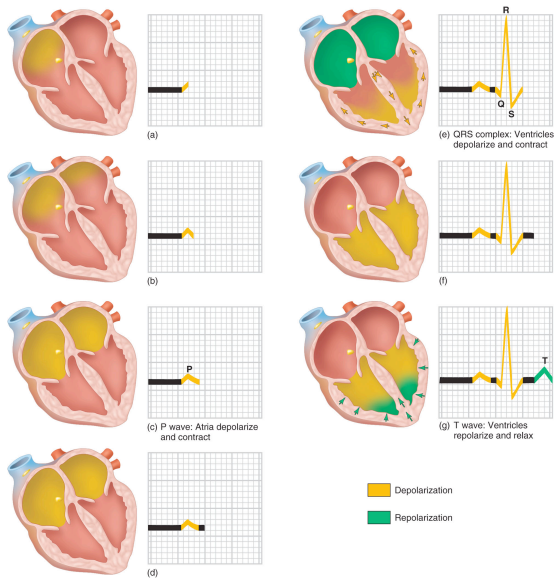

Figure 13.23

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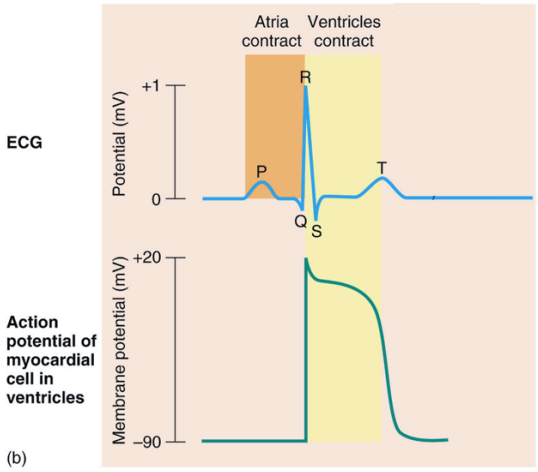

Figure 13.22

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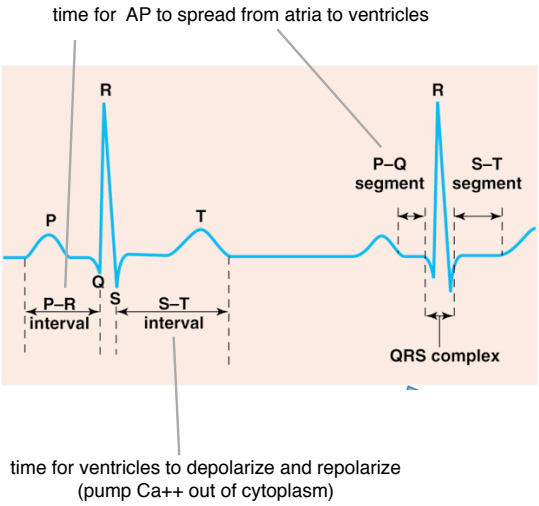

Figure 13.22

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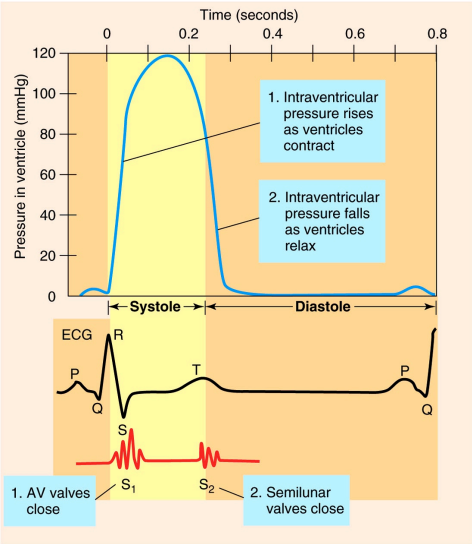
Figure 13.25



41

Events of the Cardiac Cycle

Electrical	ECG	Atria	AV Valves	Ventricles	Semi-Lunar Valves	Blood Flow
between beats		diastole	open	diastrole	closed	into atria (from vena cava, lungs)
SA node fires, spreads to AV node	P	systole	open	diastole	closed	into ventricles
spreads down bundle of His to Apex		systole	open	diastole	closed	
			"lub"			
spreads thru Purkinje fibers	QRS	diastole	closed	systole	open	into lungs, aorta
					"dub"	
between beats	T	diastole	open	diastrole	closed	into atria (from vena cava, lungs)

diastole = relaxed, systole = contracting

42