

Martini's Visual
Anatomy and Physiology
First Edition

Martini ♦ Ober

Chapter 18
The Heart and Cardiovascular Function
Lecture 2

1

Lecture Overview

- Location of the heart
- Structure of the heart
- Blood flow through the heart
- Angina Pectoris and Myocardial Infarction
- Cardiac Conduction System

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Overview of the Cardiovascular System (CVS)

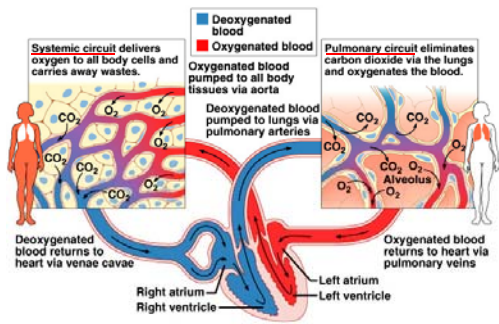


Figure from: Hole's Human A&P, 12th edition, 2010

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Introduction to the Heart

Average Size of Heart

- 14 cm long
- 9 cm wide
- about 300 g

• Cardiology is the study of the heart and the diseases associated with it

• Heart pumps enough blood in one day to fill 40, 55-gallon drums!!

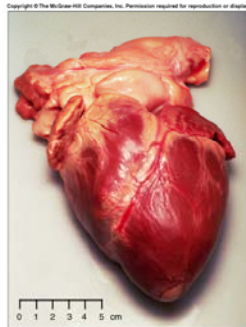


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Location of Heart

- posterior to sternum
- medial to lungs (in middle mediastinum)
- anterior to vertebral column

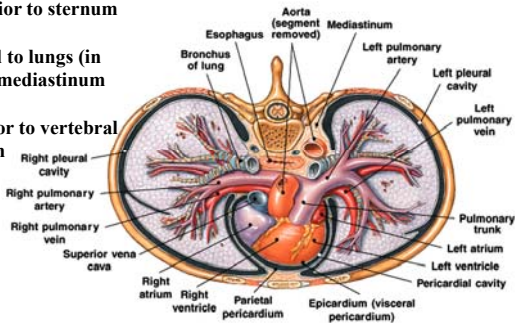


Figure from: Martini, *Anatomy & Physiology*, Prentice Hall, 2001

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Location of Heart

- base lies beneath 2nd rib
- apex at 5th intercostal space
- lies upon (and attached to) diaphragm

Notice that:

- Center of base lies slightly to the left of midline
- Long axis of heart points slightly left
- heart is rotated around long axis to left (more of right side is anterior)

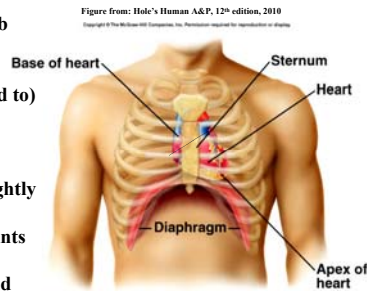


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Position of heart changes with height/weight

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Coverings of Heart

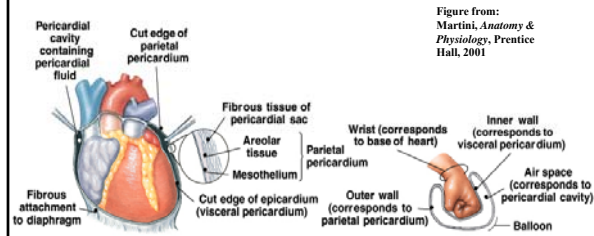


Figure from:
Martini, *Anatomy & Physiology*, Prentice Hall, 2001

Fibrous pericardium = pericardial sac – outermost layer

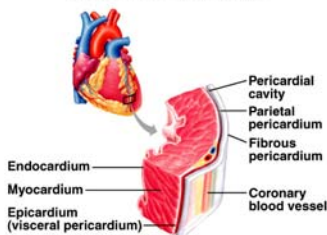
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Wall of Heart

Three layers

- **endocardium**
 - forms protective inner lining
 - membrane of epithelial and connective tissues
- **myocardium**
 - cardiac muscle
 - contracts to pump blood
- **epicardium**
 - serous membrane (visceral pericardium)
 - protective covering
 - contains capillaries and nerve fibers

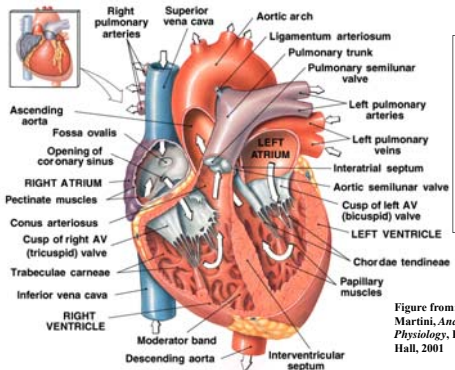
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Know all the layers depicted in the diagram, and know their correct order.

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Chambers of Heart



Atria are thin-walled chambers that receive blood passively from large veins

Figure from:
Martini, *Anatomy & Physiology*, Prentice Hall, 2001

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Heart Valves

Heart valves ensure one-way flow of blood through the heart

Atrioventricular (AV) valves	
<p>Tricuspid Valve</p> <ul style="list-style-type: none"> • right A-V valve • between right atrium and right ventricle • Attached to chordae tendineae 	<p>Bicuspid (Mitral) Valve</p> <ul style="list-style-type: none"> • left A-V valve • between left atrium and left ventricle • Attached to chordae tendineae
Semilunar valves	
<p>Pulmonary Valve</p> <ul style="list-style-type: none"> • <u>semilunar valve</u> • between right ventricle and pulmonary trunk 	<p>Aortic Valve</p> <ul style="list-style-type: none"> • <u>semilunar valve</u> • between left ventricle and aorta

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Heart Valves

FRONTAL SECTION THROUGH LEFT ATRIUM AND VENTRICLE

Figure from:
Martini, *Anatomy & Physiology*, Prentice Hall, 2001

About 70% of blood will flow passively into the ventricles before the atria contract

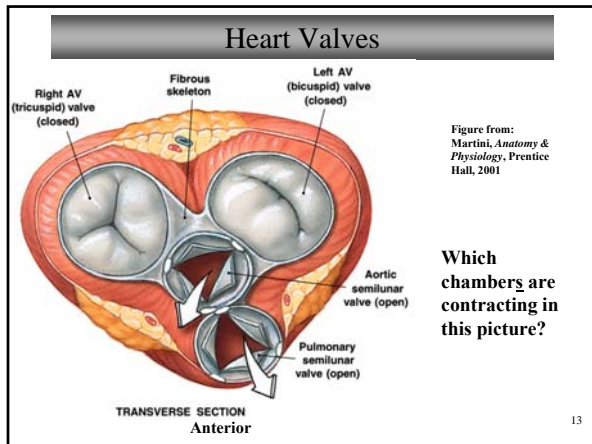
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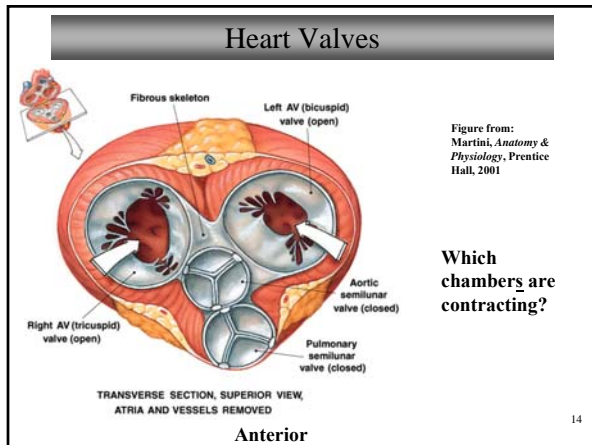
Heart Valves

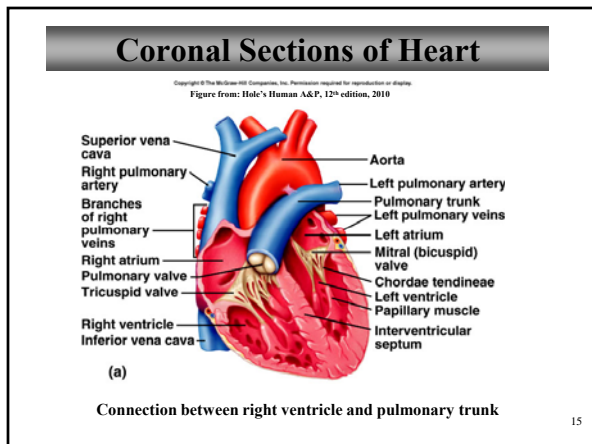
FRONTAL SECTION

Figure from:
Martini, *Anatomy & Physiology*, Prentice Hall, 2001

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Coronal Sections of Heart

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(b)
Connection between left ventricle and aorta

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Heart Valves

Tricuspid Valve

Figures from: Hole's Human A&P, 12th edition, 2010

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Skeleton of Heart

- fibrous rings to which the heart valves are attached
- masses of dense CT in interventricular septum

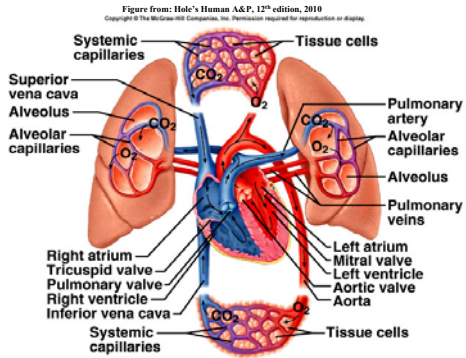
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Skeleton of heart:

1. Holds valves/vessels in place
2. Electrically separates the atria from the ventricles

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Path of Blood Through the Heart



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Pathway of Blood Through Heart

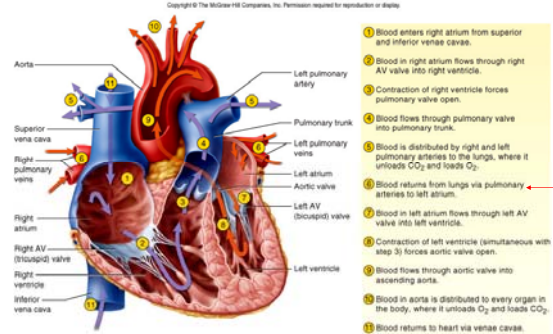


Figure from: Saladin, *Anatomy & Physiology*, McGraw Hill, 2007

Know This! (after correcting the one mistake... ☺)

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Blood Supply to Heart (Coronary circulation)

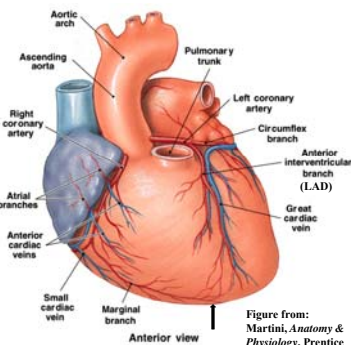


Figure from: Martini, *Anatomy & Physiology*, Prentice Hall, 2001

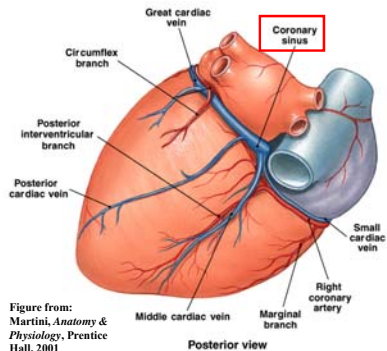
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Anastomoses = connections between 2 or more branches of arteries that supply the same region with blood.

Give rise to collateral circulation

Blood flow through coronary arteries takes place mainly during relaxation of the ventricles (ventricular diastole)

Blood Supply to Heart



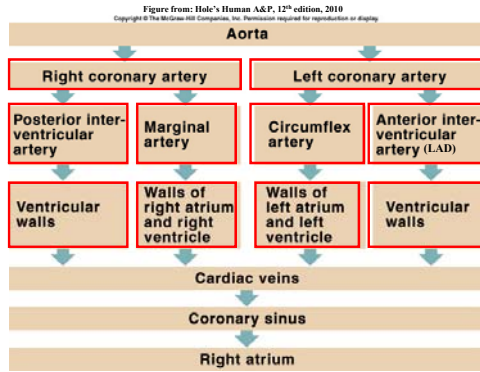
Cardiac veins join at an enlargement called the coronary sinus that drains into the right atrium

Figure from: Martini, *Anatomy & Physiology*, Prentice Hall, 2001

Posterior view

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Coronary Circulation



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Angina Pectoris and Myocardial Infarction

- **Ischemia** = reduction of blood flow
- **Hypoxia** = reduced supply of O₂
- **Angina Pectoris** = severe pain that accompanies myocardial ischemia
- **Myocardial Infarction (MI)** = heart attack
- **Reperfusion Damage**
 - Previously hypoxic tissue is re-supplied with O₂
 - O₂ free radicals cause tissue damage
 - Anti-oxidants may defend against this

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Systole and Diastole

Systole = contraction; Diastole = relaxation

Atrial Systole/Ventricular Diastole

(a)

Atrial Diastole/Ventricular Systole

(b)

Figure from: Hole's Human A&P, 12th edition, 2010

Systole and Diastole

Atrial Systole/Ventricular Diastole (Contraction of both atria)

- before atrial systole, blood flows passively into ventricles (~ 70%)
- remaining 30% of blood pushed into ventricles during atrial systole
- A-V valves open/semilunar valves close
- ventricles are relaxed and are filling with blood
- ventricular pressure begins to increase

Ventricular Systole/Atrial Diastole (Contraction of both ventricles)

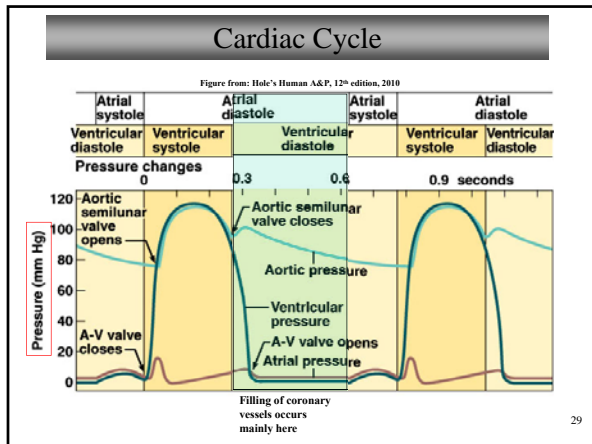
- A-V valves close
- chordae tendinae prevent cusps of valves from bulging too far into atria
- atria relaxed; low pressure allows blood return from veins
- blood flows into atria
- ventricular pressure increases and opens both semilunar valves
- blood flows into pulmonary trunk and aorta

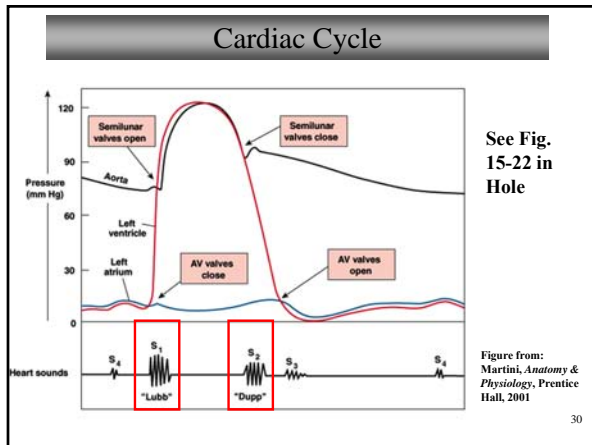
Cardiac Cycle - Overview

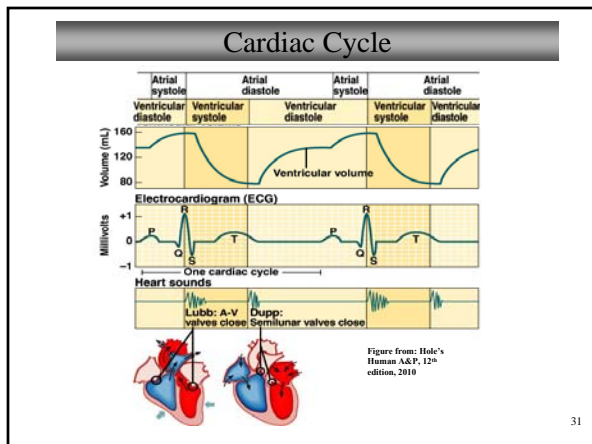
Figure from: Saladin, *Anatomy & Physiology*, McGraw Hill, 2007

Pressure ∝ $\frac{\text{Quantity of fluid}}{\text{Volume of container}}$

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Heart Sounds

Lubb

- first heart sound
- occurs during ventricular contraction (systole)
- A-V valves closing

Dupp

- second heart sound
- occurs at the end of ventricular contraction (diastole)
- semilunar valves closing

Murmur – abnormal heart sound

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Cardiac Muscle Fibers

Cardiac muscle fibers form functional **syncytium**
- group of cells that function as a unit

- atrial syncytium
- ventricular syncytium

}

Separate units that are:

- 1) separated by the cardiac skeleton
- 2) connected by fibers of the cardiac conduction system

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Muscle Fibers in Ventricular Walls

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Figure from: Hole's Human A&P, 12th edition, 2010

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Cardiac Conduction System

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S-A node = Pacemaker

Specialized myocardial cells. Instead of contracting, they initiate and distribute impulses throughout the heart.

Pacemaker firing rates:
SA Node – 80-100 bpm
AV Node – 40-60 bpm
Purkinje – 30-40 bpm

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Cardiac Conduction Pathway

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Know the sequence of this pathway

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Review

- The heart is located in the mediastinum
 - Anterior to the vertebral column
 - Posterior to the sternum
 - Between the lungs
 - Between the level of the 2nd (base) and 5th (apex) ribs
 - More prominent on the left side of the sternum
- The heart is covered by

<ul style="list-style-type: none"> – Fibrous pericardium (tough, dense CT) – Parietal pericardium – Visceral pericardium 	}	Pericardial cavity
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Review

- The **heart wall** is composed of **three layers**
 - **Epicardium** (= visceral pericardium)
 - **Myocardium** (muscle)
 - **Endocardium** (continuous with endothelium of blood vessels)
- The heart has **four chambers**
 - 2 atria (thin-walled, low pressure)
 - 2 ventricles (thicker-walled, higher pressure)
 - Atria and ventricles have valves between them
 - Ensure one-way flow of blood through the heart
 - AV valves = tricuspid and bicuspid (mitral)
 - Semilunar valves = pulmonary and aortic

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Review

- **Arteries** carry blood **away** from heart
 - Pulmonary arteries (low O₂, high CO₂)
 - Aorta
 - Coronary arteries
- **Veins** carry blood **to** the heart
 - Superior and inferior vena cava
 - Pulmonary veins (high O₂, low CO₂)
 - Coronary veins/sinus

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Review

- Recall **pathway of blood** (need to know!)
 - Pulmonary circuit
 - Systemic circulation
 - Coronary circulation
- Consequences of **compromised coronary blood flow**
 - **Ischemia**
 - **Hypoxia**
 - **Angina Pectoris**
 - Myocardial infarction
 - Reperfusion damage
- ****Prior to next lecture, STUDY Fig 18-8.2 in Martini or Fig. 15.22 in Hole.**

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Review

- Cardiac conduction system
 - Specialized myocardial cells
 - Conduct rather than contract
 - Autorhythmic (self-exciting)
 - S-A node is pacemaker of heart (80 - 100 bpm)
 - A-V node (40 - 60 bpm)
 - Delays impulse to allow ventricular filling
 - Located in interventricular septum
 - A-V Bundle (Bundle of His)
 - Only electrical connection between atria and ventricles
 - Give rise to right and left bundle branches
 - Purkinje fibers
 - Large diameter, rapid conduction for ventricles
 - Causes apex to contract first, then toward base

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