CHAPTER 20
CARDIOVASCULAR SYSTEM: The Heart

CHAPTER OVERVIEW: This chapter discusses the heart in detail. The location, structure, histology, cellular properties, and mechanism of contraction of the heart and cardiac muscle are discussed. The functions of the heart in relation to the entire cardiovascular system are considered. The events of the cardiac cycle, normal and abnormal heart sounds, and the regulation of the heart are described in detail. The role of the heart in homeostasis is discussed.

OUTLINE (four or five fifty-minute lectures):
Seeley, A&P, 5/e

Chapt. Object.	**Topic Outline, Chapter 20**	**Figures & Tables**	**Transparency Acetates**
1	I. Size, Form and Location of the Heart, p. 608	Fig. 20.1, p. 608	TA-380
		Fig. 20.2, pp.609	TA-381
	A. In the Thoracic Cavity		
	1. Size of a Closed Fist		
	2. Region of Mediastinum		
	B. Orientation		
	1. Apex Inferior		
	2. Base Superior		
	II. Anatomy of the Heart, p. 610		
	A. Four Chambers		
2	A. Pericardium	Fig. 20.3, p.610	TA-382
	1. Fibrous Pericardium		
	a. Holds Heart in Place		
	b. Continuous with CT of Great Vessels & Diaphragm		
	c. Outer Layer		
	2. Serous Pericardium		
	a. Reduces Friction		
	b. Components		
	1). Parietal Pericardium Lining Fibrous Pericardium		
	2). Visceral Pericardium Covering Heart Itself		
	3). Pericardial Cavity with Pericardial Fluid	Clinical Note, p.610	
	B. Heart Wall		
3	1. Layers	Fig. 20.4, p.611	TA-383
	a. Epicardium		
	b. Myocardium		
	c. Endocardium		
	2. Special Structures		
	a. Musculi Pectinati		
	b. Crista Terminalis		
	c. Trabeculae Carneae		
4	C. External Anatomy	Fig. 20.5a-c, p. 612-	TA-384-385

		613	
	1. Atrial Auricles		
	2. Great Veins		
	a. Superior and Inferior Venae Cavae - R. Atrium		
	b. Four Pulmonary Veins - L. Atrium		
	3. Great Arteries		
	a. Pulmonary Trunk - L. Atrium		
	b. Aorta - L. Ventricle		
	4. Coronary Blood Supply	Fig. 20.6, p.613 Clinical Focus, p.615	TA-386
	a. Landmarks		
	1). Coronary Sulcus - Separates Atria from Ventricles		
	2). Ant. & Post. Interventricular Grooves - Separate Ventricles		
	b. Coronary Arteries	Predict Quest. 1	
	1). Off Aorta to Supply Heart		
	2). Left Coronary Artery		
	a). Anterior Interventricular Artery		
	b). Marginal Branch		
	c). Circumflex Branch		
	3). Right Coronary Artery & Posterior Interven-tricular Artery		
4	D. Heart Chambers and Valves		
	1. Right and Left Atria	Fig. 20.7, p.614	TA-387
	a. Interatrial Septum		
	b. Fossa Ovalis		
	2. Right ant Left Ventricles		
	a. Interventricular Septum		
	b. Interventricular Grooves = Surface Landmark		
	3. Atrioventricular Valves		
	a. Tricuspid Valve - Separates R. Atrium from R. Ventricle		
	b. Bicuspid (or Mitral) Valve - Separates L. Atrium from L. Ventricle		
	c. Structure of Atrioventricular Valves	Fig. 20.7, p.614 Fig. 20.8, p. 615	TA-387
	1). Valve Flaps (2 or 3)		
	2). Chordae Tendineae		
	3). Papillary Muscles		
	4. Semilunar Valves	Fig. 20.7, p.614 Fig. 20.8, p. 616 Fig. 20.9, p. 616	 TA-388 TA-389
	a. Aortic Semilunar Valve		
	b. Pulmonary Semilunar Valve		
	c. Three Valve Flaps		

	III. Route of Blood Flow Through the Heart, p. 617	Fig. 20.10, p.617	TA-390
	A. Double Pump		
	B. Right Heart		
	1. Heart to Lungs		
	2. Through Pulmonary Trunk and Pulmonary Arteries	Fig. 20.5, p. 612	TA-384
	3. Returned to Left Heart		
	C. Left Heart		
	1. Heart to Body		
	2. Through Aorta		
	3. Returned to Right Heart		
	IV. Histology, p. 618		
	A. Heart Skeleton	Fig. 20.11, p.618	TA-391
	1. Fibrous CT Rings Support Heart Valves		
	2. Electrically Isolates Atria from Ventricles		
	3. Point of Attachment of Cardiac Muscle		
5	B. Cardiac Muscle	Fig. 20.12, p.619	TA-392
	1. Striated, Branched, Uninucleate Cells		
	2. Smooth Sarcoplasmic Reticulum		
	a. Less Organized than in Skeletal Muscle		
	b. T-tubule system Important		
	3. Slow Onset of contraction - Related to Ca^{2+} Diffusion		
	4. Primarily Aerobic Respiration - No O_2 Debt Possible	Predict Quest. 2	
	5. Functional Syncytium of Bundles or Sheets of Cells		
	a. Desmosomes		
	b. Gap Junctions		
6	C. Conducting System	Fig. 20.13, p.619	TA-393
	1. Structures		
	a. Sinoatrial Node (SA Node) - R. Atrium		
	b. Atrioventricular Node (AV Node) - R. Atrium		
	c. Atrioventricular Bundle		
	d. R & L Bundle Branches - Interventricular Septum		
7	e. Purkinje Fibers - Large Diameter Cardiac Muscle Fibers		
	2. Functions		
	a. SA Node with Spontaneous Action Potentials = Pacemaker		
	b. Depolarization Spreads from Node to Other Cardiac Cells		
	c. Atria Contract before Ventricles Depolarized		
	1). Preferred Depolariza-tion Path to AV Node (0.04 sec.)		

	2). 0.11 sec. Delay at AV Node		
	d. Action Potentials along Bundles to Purkinje Fibers and Ventricular Fibers		
	e. Ventricular Contractions		
	1). Apex to Base	Predict Quest. 3	
	2). Wringing Action		
	V. Electrical Properties, p.620		
	1. Resting Membrane Potentials (details Chapter 9)		
8	A. Action Potentials	Fig. 20.14, p.621 Clinical Note, p.622	TA-394
	1. Rapid Depolarization - Na^+ Fast Channels Open		
	2. Rapid Partial Repolarization		
	3. Prolonged Slow Repolarization (Plateau Phase) - Slow Ca^{2+} Channels		
	4. Final Rapid Depolarization - K^+ Channels Open and Ca^{2+} Channels Close		
9	B. Autorhythmicity of Cardiac Muscle	Fig. 20.15, p.622	TA-395
	1. Spontaneous Depolarizations		
	a. Fastest in SA Node 70-80 Beats per min.		
	b. Slow Channels		
	2. Ectopic Foci	Predict Quest. 4	
10	C. Refractory Period of Cardiac Muscle		
	1. Extended Due to Plateau Phase		
	2. Absolute Refractory Period Ensures Relaxation Nearly Complete Before Next Contraction		
	3. Summation and Tetany Impossible	Predict Quest. 5	
11	D. Electrocardiogram	Table 20.1, p. 624 Fig. 20.16, p.623 Clinical Note, p.623	 TA-396
	1. P Wave - Atrial Depolarization		
	2. QRS Complex - Ventricular Depolarization		
	3. T Wave - Ventricular Repolarization		
	4. PQ Interval (PR Interval)		
	a. Time Between Beginning of P Wave and Beginning of QRS Complex		
	b. 0.16 sec.		
	c. Time of Atrial Contraction		
	5. QT Interval		
	a. Time Between Beginning of QRS Complex and End of T Wave		
	b. 0.3 sec.		
	c. Time of Ventricular Contraction		
12	VI. Cardiac Cycle, p. 625	Fig. 20.17 p.626	TA-397
	1. Repetitive Pattern of Pumping Action	Fig. 20.18, p.627 Table 20.2, pp.628-	TA-398

		629	
	A. Systole and Diastole		
	1. Atrial Systole and Diastole	Fig. 20.17, p.628	TA-397
	2. Ventricular Systole and Diastole	Fig. 20.18, p.627	TA-398
	a. Period of Isovolumic Contraction		
	1). After AV Valves Have Closed	Predict Quest. 6	
	2). Before Semilunar Valves Have Opened		
	b. Ejection Phase		
	1). AV Valves Remain Closed		
	2). Semilunar Valves Forced Open		
	c. Early Diastole and Isovolumic Relaxation		
	1). After Semilunar Valves have Closed		
	2). Before Semilunar Valves have Opened		
	3. Cardiac Output or Minute Volume	Predict Quest. 7	
	a. End Diastolic Volume - End Systolic Volume = Stroke Volume		
	b. Stroke Volume X Heart Rate = Cardiac Output or Minute volume		
	c. Cardiac Reserve = Ability to Increase Cardiac Output		
	d. Major Determinant of Arterial Blood Pressure (MABP = CO X PR, where PR Stands for Peripheral Resistance to Blood Flow)	Predict Quest. 8	
13	B. Heart Sounds	Fig. 20.18, p. 627 Fig. 20.19, p. 631 Clinical Focus, p.626	TA-398 TA-399
	1. First Heart Sound (Lubb)		
	a. Vibrations Due to Closure of AV Valves		
	b. Beginning of Ventricular Systole		
	2. Second Heart Sound (Dupp)		
	a. Vibrations Due to Closure of Semilunar Valves		
	b. Near End of Ventricular Systole		
	3. Third Heart Sound		
	a. Normal, but Usually too Faint to be Heard		
	b. Turbulent Flow of Blood from Atria to Ventricles		
	c. Marks end of First Third of Ventricular Diastole		
14	C. Aortic Pressure Curve		
	1. Peak Pressure During Ventricular Contraction		
	2. Incisura or Dicrotic Notch	Fig 20.18, p. 627	TA-398

a. Follows Closure of Aortic Semilunar Valve
b. Pressure Increase Caused by Elastic Recoil of Aorta

VII Regulation of the Heart, p. 632

15 A. Intrinsic Regulation
1. Venous Return Determines End Diastolic Volume and Preload
2. Starling's Law of the Heart — Fig. 20.20, p.632
a. Stretch of Cardiac Muscle Produces Stronger Contractions
b. Increased Venous Return Leads to Greater Cardiac Output
3. Afterload = Pressure Needed to Move Blood into the Aorta

16, 17 B. Extrinsic Regulation — Fig. 20.21, p.633 — TA-400
1. Cardioregulatory Center and Chemoreceptors in Medulla Oblongata
2. Parasympathetic Control
a. Vagus Nerve
b. Decreases Heart Rate and (Small) Decrease in Force; up to 20% Decrease in Cardiac Output
c. Acetylcholine
1). Hyperpolarization
2). Opens Ligand Gated K^+ Channels
3. Sympathetic Control — Fig. 20.21, p. 634 — Predict Quest. 9 — TA-400
a. Cardiac Nerves
b. Increases Heart Rate and Contractility; up to 100% Increase in Cardiac Output
c. Norepinephrine
1). Hypopolarization
2). β -Adrenergic Activation of cAMP Second Messenger System
4. Hormonal Control — Fig. 20.20, p. 632
a. Epinephrine and Norepinephrine in Blood from Adrenal Medulla
b. Longer Lasting than Neural Stimulation
c. Increases Heart Rate and Force of Contraction

18 VIII. Heart and Homeostasis, 634

A. Effect of Blood Pressure — Fig. 20.21, p.633 — TA-400
1. Baroreceptor Reflex
a. Stretch Receptors in Internal Carotid Artery and Aorta
b. Sympathetic Fibers from

Cardioacceleratory Center
c. Parasympathetic Fibers from Cardioinhibitory Center
d. Increased BP Increases Parasympathetic Activity and Decreases Sympathetic Activity
e. Decreased BP Increases Sympathetic Activity and Decreases Parasympathetic Activity — Fig. 20.22, p.635

B. Effect of pH, Carbon Dioxide, and Oxygen — Fig. 20.23, p.636 — TA-401
1. Central Chemoreceptors Sensitive to Decreased pH and Increased CO_2 in Medulla Oblongata
2. Peripheral Chemoreceptors Sensitive to Decreased O_2 in Aorta and Carotid Bodies; More Important in Regulation of Respiration and Blood Vessel Constriction

C. Effect of Extracellular Ion Concentrations
1. K^+, Ca^{2+}, and Na^+ and Effects on Membrane Potentials
2. K^+ Heart Block

D. Effect of Body Temperature

IX. Systems Pathology, p. 640 — Systems Interactions, p. 641; Predict Quest. 10

IMPORTANT CONSIDERATIONS: Four major topic areas covered above are: basic anatomy of the heart, histology and electrical properties of cardiac muscle, the cardiac cycle, and the regulation of the heart and its relation to homeostasis. Being familiar with the pattern of circulation of blood through the heart and the cardiovascular system is of special importance to those students planning on careers in the health related professions. There are pharmacological implications for clinical practice in knowing where the blood goes after leaving the site of administration of therapeutic agents.

Autorhythmicity and the plateau of the action potential give trouble to students who did not get a solid grasp of the ideas associated with membrane potentials when they were presented in Chapter 9. Some backtracking may be necessary to ensure that students do get these concepts, since they are fundamental to understanding the control mechanisms regulating cardiac function.

The pressure relationships which are so important to a clear understanding of the cardiac cycle are not necessarily familiar to the student. Students may need to be helped to see that it is the pressure difference and not the cardiac muscle itself that maintains the flow of blood through the cardiovascular system. Another common misconception that students may have is that the heart contracts and immediately ejects blood. Be sure that they understand that initially both the atrioventricular valves and the semilunar valves are closed, until the pressure on the blood is sufficient to force the semilunar valves open and eject the blood.

Understanding of the extrinsic regulatory mechanisms require remembering the discussions on the parasympathetic and sympathetic divisions of the autonomic nervous system covered in Chapter 16. Students should be encouraged to review this material if they cannot remember it.

Students should be able to predict (and explain) changes in heart rate and/or force of contraction that follow changes in any of the following: blood pressure, pH, oxygen content of the blood, carbon dioxide content of the blood, body temperature, and/or extracellular concentrations of important ions (sodium, potassium, calcium, chloride).

SEE INSTRUCTOR'S MANUAL AND COURSE SOLUTIONS MANUAL FOR ADDITIONAL RESOURCES.