# Chapter 20: Cardiovascular System: The Heart

## I. Functions of the Heart

A. List and describe the four functions of the heart:

1. _____
   _____
   _____
2. _____
   _____
   _____
3. _____
   _____
   _____
4. _____
   _____
   _____

## II. Size, Shape, and Location of the Heart

A. Size and Shape

1. The adult heart is shaped like a _____
2. The adult heart is approximately the size of _____
3. What is the apex? _____
4. What is the base? _____

B. Location

1. The heart is located in the _____ cavity between _____
2. The midline partition containing the heart is called the _____
3. The heart lies _____ in the _____
   a. The base is directed _____
   b. The apex is directed _____
4. The apex is directed to the _____ and approximately _____ of the heart lies to the _____
5. The base lies deep to _____ and extends to _____



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6. The apex is approximately _____ of the sternum and is _____

## III. Anatomy of the Heart

A. Pericardium or Pericardial Sac
   1. Structurally is described as a _____
   2. What is the fibrous pericardium? _____
   3. What is the serous pericardium? _____
   4. Functionally the fibrous pericardium prevents _____ & _____ within the _____
   5. Where is the parietal pericardium? _____
   6. Where is the visceral pericardium? _____
      a. The visceral pericardium is also called _____
   7. The space between the two layers of serous pericardium is called _____
      a. The space is filled with a _____
      b. Functionally this fluid _____

B. Heart Wall
   1. The epicardium is a _____
      a. This layer of the heart wall is also called _____
   2. The myocardium is the _____ of the heart
      a. It is composed of _____
      b. The myocardium is responsible for _____
   3. The endocardium is _____ of the heart chambers
      a. It is composed of _____
      b. Functionally the smooth surface _____
      c. The heart valves are formed _____
         1. Therefore a valve has a double layer of _____ with _____ between
   4. What are the musculi pectinati? _____
   5. What are the trabeculae carnae? _____


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C. External Anatomy and Coronary Circulation

1. Chambers
    a. How many chambers does the heart have? _____
        1. There are _____ and _____
    b. Describe the atria and their location _____

        _____
    c. Describe the ventricles and their location _____

        _____
    d. What are the auricles? _____
2. Blood Vessels
    a. What veins empty blood into the right atrium?
        1. _____
        2. _____
        3. _____
    b. What veins empty blood into the left atrium? _____
    c. What artery carries blood from the left ventricle to the body? _____
    d. What artery carries blood from the right ventricle to the lungs?

        _____
3. External Landmarks
    a. What is a sulcus? _____
    b. Where is the coronary sulcus? _____

        _____
    c. Extending inferiorly from the coronary sulcus:
        1. On the anterior surface of the heart is _____
        2. On the posterior surface of the heart is _____
            a. These indicate the division between _____
    d. These sulci are normally covered by _____
4. Coronary Circulation
    a. The two major arteries supplying the heart are called:
        1. _____
        2. _____



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b. These arteries branch off _____ just _____
c. Branches of the Left Coronary Artery:
    1. Anterior interventricular artery or also called _____
        a. It is located _____
        b. It supplies blood to _____
    2. Left marginal artery
        a. Supplies blood to _____
    3. Circumflex artery
        a. Extends _____
        b. It supplies blood to _____
d. Right Coronary Artery and its Branches:
    1. Right coronary artery
        a. Lies within _____ and extends from _____ around to _____
    2. Right marginal artery
        a. Supplies blood to _____
    3. Posterior interventricular artery
        a. It is located _____
        b. It supplies blood to _____
e. Most of the myocardium receives blood from _____
f. What is an anastomoses? _____
g. What effect does aerobic exercise have on coronary blood vessels?
    _____
h. Most of the left side of the heart is drained by _____
i. Most of the right side of the heart is drained by _____
j. These two veins join together forming the _____

D. Heart Chambers and Valves
    1. Right and Left Atria
        a. The right atrium receives blood through three major openings from the:
            1. _____
            2. _____


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3. _____

b. The left atrium receives blood through four openings from the:
   1. _____
c. What is the interatrial septum? _____
d. What is the fossa ovalis? _____
e. What is the foramen ovale? _____

2. Right and Left Ventricles
   a. The atria are connected to the ventricles through _____
   b. The right ventricle opens into the _____
   c. The left ventricle opens into the _____
   d. What is the interventricular septum? _____

3. Atrioventricular Valves
   a. One is located in each _____
   b. The valve is composed of _____ or _____
   c. The atrioventricular valves:
      1. Allow blood _____
      2. Prevent blood _____
   d. Where is the tricuspid valve? _____
      1. Why is it called tricuspid? _____
   e. Where is the bicuspid valve? _____
      1. Why is it called bicuspid? _____
      2. The bicuspid is also called the _____ valve
   f. Describe papillary muscles _____
      1. Where are the papillary muscles located? _____
   g. Papillary muscles are connected to cusps by _____
   h. Functionally papillary muscles _____
   i. Blood flowing from the atria to ventricles _____
   j. When the ventricle contracts _____
      1. The atrioventricular canal is closed _____


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4. Semilunar Valves
    a. The semilunar valves are located:
        1. In the _____ and is called _____
        2. In the _____ and is called _____
    b. Each semilunar valve consists of _____
    c. Blood flow is blocked when _____
    d. Blood flowing from the ventricles _____
    e. Blood flowing toward the ventricles _____

## IV. Route of Blood Flow Through the Heart

A. Blood from systemic circulation enters the _____
B. The blood is then passed through the tricuspid valve to _____
C. Contraction of the right ventricle:
    1. Closes the _____
    2. Opens the _____
    3. This allows blood to flow into _____ and eventually to the _____ where gas exchange occurs
D. Blood returns to the _____ through the four _____
E. The blood is then passed through the mitral valve to _____
F. Contraction of the left ventricle:
    1. Closes the _____
    2. Opens the _____
    3. This allows blood to enter the _____ and be distributed to _____

## V. Histology

A. Heart Skeleton
    1. Consists of a _____
    2. Fibrous rings are formed around _____
        a. Provides _____ for valves


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3. Functionally the heart skeleton:
    a. Serves as _____
    b. Provides _____

B. Cardiac Muscle
1. Describe cardiac muscle cells _____
2. Cardiac muscle cells contain _____ & _____ arranged to form _____ that join end to end to form _____
3. What causes striations in cardiac muscle cells? _____
4. The smooth sarcoplasmic reticulum:
    a. Is not as _____ arranged
    b. Is not as _____ as in skeletal muscle
    c. No _____ are present
    d. Comes into close association _____ with _____
5. T-tubules are _____ than in skeletal muscle
    a. Found near the _____
6. Slow onset of contraction and prolonged contraction phase are caused by:
    a. Loose association _____
    b. Depolarizations of the plasma membrane are not _____ _____
    c. Calcium must _____
    d. A substantial number of _____
7. Energy for cardiac muscle cell contraction is provided by _____
8. Cardiac muscle cells are rich in _____ which make _____
9. The extensive capillary network _____
10. Cardiac muscle cells are organized in _____
11. What are intercalated disks? _____
12. What are desmosomes? _____
13. What is the function of gap junctions? _____ _____
14. Electrically the cardiac muscle cells _____


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C. Conducting System

1. Consists of _____
2. Where is the sinoatrial (SA) node? _____
3. Where is the atrioventricular (AV) node? _____
4. The atrioventricular bundle arises from the _____
5. At the top of the interventricular septum the bundle divides to form:
   a. _____
   b. _____
      1. These extend inferiorly to the _____
6. The bundle branches form terminal branches called _____
   a. These are large-diameter _____
7. Why do action potentials travel faster in Purkinje fibers? _____

   _____
8. Why is the SA node called the pacemaker? _____

   _____
9. The heart contracts _____ & _____
10. Once action potentials are produced:
    a. They spread from _____ to _____
    b. Preferential pathways conduct action potentials from _____ to the _____ at greater _____
    c. Within the AV node action potentials _____
    d. The total delay allows _____
    e. The action potential is passed from the AV node to the _____ through the _____ & _____ branches and finally reaches the _____ in the ventricular myocardium
11. The first part of the ventricular myocardium to be stimulated is the:

    _____
12. The spiral arrangement of muscle layers results in _____ that proceeds from the _____ toward _____



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## VI. Electrical Properties

A. Action Potentials

1. What is the plateau phase? _____
2. Depolarization Phase
    a. Results when _____ or _____ open
    b. This allows _____ causing rapid depolarization
    c. Depolarization causes _____ to close
        1. This decreases membrane permeability to _____
    d. Depolarization also causes _____ or _____ to begin to open
3. Early repolarization occurs when:
    a. Voltage-_____ close
        1. Movement of _____ into the cell stops
    b. A small number of _____ open
        1. _____ move out of the cell
4. Plateau phase occurs as:
    a. Voltage-_____ continue to open
        1. The movement of _____ into the cell counteracts the movement _____ out of the cell
5. Plateau phase ends and final repolarization begins as:
    a. Voltage-_____ close
        1. _____ stops diffusing into the cell
    b. Many more _____ open
        1. Tendency for _____ to diffuse out of the cell _____
6. This causes the membrane potential to _____

B. Autorhythmicity of Cardiac Muscle

1. The heart is said to be autorhythmic because it:
    a. _____
    b. _____
2. What is a prepotential? _____



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3. For a prepotential to reach threshold:
    a. $Na^+$ moves into the pacemaker cells through _____
    b. Fewer _____ move out of the pacemaker cells
    c. The depolarization opens _____
    d. When the prepotential reaches threshold many _____ open
    e. The movement of _____ into the cells is primarily responsible for depolarization
4. Repolarization occurs when:
    a. _____ close
    b. _____ open
5. After the resting membrane potential is reestablished _____
    _____
6. What is an ectopic focus? _____

C. Refractory Period of Cardiac Muscle
1. During the absolute refractory period _____
2. During the relative refractory period _____
3. The refractory period is prolonged because _____
    _____
4. This ensures that after contraction _____
    a. This prevents _____ in cardiac muscle

D. Electrocardiogram (ECG or EKG)
1. Electrodes placed on the skin detect _____
2. The ECG is not a direct measurement of _____
3. The ECG can not provide information about _____ or
    _____
4. Each deflection in the ECG indicates _____
    a. Correlates with a _____
5. The P wave is the result of _____
    a. Signals the onset of _____
6. The QRS complex results from _____
    a. Signals the onset of _____

7. The T wave represents _____
    a. Precedes _____
8. Why is there no wave representing atrial repolarization? _____

    _____
9. What is the PQ (PR) interval? _____
    a. What mechanical events occur during this time period? _____

        _____
10. At the end of the PR interval _____
11. What is the QT interval? _____
    a. What mechanical events occur during this time period? _____

        _____

**VII. Cardiac Cycle**

A. General

1. Functionally the atrial primer pumps _____
2. Functionally the ventricular power pumps _____
3. Cardiac cycle refers to _____
4. Define the following terms:
    a. Systole _____
    b. Diastole _____
    c. Atrial systole _____
    d. Atrial diastole _____
    e. Ventricular systole _____
    f. Ventricular diastole _____
5. Conditions just before ventricular systole begins include:
    a. Atria and ventricles are _____
    b. Ventricles are _____
    c. Semilunar valves are _____
    d. AV valves are _____
6. As ventricular systole begins:
    a. Ventricular pressure _____



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b. Causing blood to flow _____ & _____
c. Ventricular pressure continues to _____
1. Why is this called period of isovolumic contraction? _____
_____
d. When ventricular pressure is greater than the pressure in the pulmonary trunk and aorta the _____ are pushed open
1. Why is this called period of ejection? _____

7. As ventricular diastole begins:
a. The ventricles relax and ventricular pressure _____ below that in the _____ & _____
b. Blood begins to flow back toward the ventricles causing _____
_____
c. Ventricular pressure continues to _____
1. Why is this called period of isovolumic relaxation? _____
_____
8. During this entire time the atria are _____ and blood flows into them
9. When ventricular pressure falls below atrial pressure _____ open
a. Blood flows from _____
1. Why is this called passive filling? _____
2. How much ventricular filling is passive? _____
10. When the atria contract it causes _____ atrial pressure
a. Blood flows into the _____
1. Why is this called active filling? _____
11. What is end-diastolic volume? _____
12. What is end-systolic volume? _____

B. Heart Sounds
1. The first heart sound:
a. Is described as a _____
b. It is caused by _____
2. The second heart sound:
a. Is described as a _____

b. It is caused by _____

3. A third heart sound is caused by _____

C. Aortic Pressure Curve

1. During the period of ejection the _____
   a. Aortic pressure remains _____
2. As ventricular pressure drops below the pressure in the aorta:
   a. Blood flows _____ because of _____
      1. This causes the _____ to close
      2. Pressure within the aorta _____ producing a _____
         a. This is also called an _____
3. Aortic pressure then gradually _____ as _____

**VIII. Mean Arterial Blood Pressure**

A. Define mean arterial pressure (MAP): _____

_____

1. It is proportional to:
   a. _____ times _____
      1. What is cardiac output? _____
      2. What is peripheral resistance? _____
2. The formula for mean arterial pressure is: _____

B. Cardiac Output

1. Cardiac output is equal to _____ times _____
   a. What is heart rate? _____
   b. What is stroke volume? _____
2. Stroke volume is calculated as _____ minus _____
3. Stroke volume can be increased by:
   a. Increasing _____ OR
   b. Decreasing _____



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4. During exercise:
    a. End-diastolic volume _____ because of _____
    b. End-systolic volume _____ because the _____
5. What is cardiac reserve? _____

    _____
6. How is cardiac reserve effected by exercise? _____

    _____

**IX. Regulation of the Heart**

A. Intrinsic Regulation
1. What is venous return? _____
2. As venous return increases _____ increases
3. This results in _____ of the ventricular walls
    a. This is sometimes called _____
        1. Increased preload causes _____
        2. Decreased preload causes _____
4. Cardiac muscle exhibits a _____ similar to skeletal muscle
    a. Therefore an increased preload causes _____ stretch
    b. Causes the muscle fibers to _____
    c. Producing a _____
        1. This relationship is known as _____
5. What is afterload? _____
    a. Ventricles are very _____ to changes in afterload

B. Extrinsic Regulation
1. Parasympathetic Control
    a. Parasympathetic stimulation has an _____ on the heart
        1. Primarily by _____
    b. During resting conditions the heart receives _____ that inhibits the heart to a _____


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c. During exercise the heart rate _____ in part because of _____

d. Parasympathetic stimulation can decrease heart rate _____

e. Acetylcholine binds to _____

1. Makes the membrane more permeable to _____
2. This _____ the membrane
3. Heart rate decreases because _____ _____

2. Sympathetic Control

a. Sympathetic stimulation of the heart _____ both the:

1. _____ &
2. _____

b. The heart rate can increase to _____

c. The increased force of contraction causes _____

d. If the heart rate is too fast diastole is too short to _____

e. During resting conditions sympathetic stimulation is important for _____

f. Norepinephrine binds to _____ receptors

1. Makes the membrane more permeable to _____ by _____

3. Hormonal Control

a. Result of the adrenal medulla releasing _____ & _____

b. Both increase the _____ & _____

c. Adrenal medulla secretes epinephrine and norepinephrine in response to:

1. Physical _____
2. Emotional _____
3. Stressful _____

d. Epinephrine takes a longer time to act on the heart but _____



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## X. Heart and Homeostasis

A. Effect of Blood Pressure

1. Baroreceptor reflexes detect _____ and _____
2. The sensory receptors of baroreceptors are _____
   a. They are found in large arteries like the:
      1. _____
      2. _____
3. They are innervated by cranial nerves:
   a. IX _____
   b. X _____
4. Nerves from the baroreceptors go to the _____ that is located in the _____
   a. Functionally the cardioacceleratory center _____
   b. Functionally the cardioinhibitory center _____
5. At normal blood pressure the medulla receives action potentials at _____
6. When blood pressure increases:
   a. The arterial walls are _____
   b. Afferent action potential _____
   c. In response the baroreceptor reflex:
      1. _____ sympathetic & _____ parasympathetic stimulation
         a. Causing the heart rate to _____
7. When blood pressure decreases:
   a. The arterial walls are _____
   b. Afferent action potential _____
   c. In response the baroreceptor reflex:
      1. _____ parasympathetic & _____ sympathetic stimulation
         a. Causing the heart rate to _____
         b. Causing the force of contraction to _____



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B. Effect of pH, Carbon Dioxide, and Oxygen
    1. Chemoreceptors sensitive to changes in pH and carbon dioxide exist _____
    2. A drop in pH and a rise in carbon dioxide:
        a. _____ parasympathetic stimulation of the heart &
        b. _____ sympathetic stimulation of the heart
            1. Resulting in:
                a. _____ &
                b. _____
        c. The increased blood flow through the lungs:
            1. Eliminates _____
            2. Helps to _____
    3. In the aorta and carotid bodies are chemoreceptors sensitive to _____
    4. The chemoreceptors are activated by a _____
    5. In isolated experiments it is shown that these chemoreceptors cause:
        a. Decrease in _____
        b. Increase in _____
            1. This would promote blood _____
    6. When all regulatory mechanisms function together, the effect of a large, prolonged decrease in oxygen is to _____
    7. Low oxygen levels increase inflation of the lungs:
        a. Stimulates _____ in the lungs
        b. Influence the cardioregulatory center and causes _____

C. Effect of Extracellular Ion Concentration
    1. Potassium
        a. Excess $K^+$ in cardiac muscle tissue:
            1. _____
            2. _____
        b. What is heart block? _____
            1. It can be caused by _____
        c. A decrease in extracellular $K^+$ results in _____


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1. Because the _____

2. Calcium
   a. An increase in extracellular $Ca^{2+}$ produces:
      1. Increase _____
         a. Because of a greater _____
   b. Elevated blood $Ca^{2+}$ levels have an indirect effect on heart rate because:
      1. Reduce _____
      2. Generally _____
   c. Significantly low blood $Ca^{2+}$ levels _____
      1. This is because _____ open resulting in _____
      2. Why do low $Ca^{2+}$ levels usually not effect heart rate? _____ _____

D. Effect of Body Temperature
   1. Small increases in cardiac muscle temperature _____
   2. Decreases in temperature _____

## XI. Effects of Aging on the Heart

A. Hypertrophy of the Left Ventricle
   1. Gradual increase in pressure in the aorta as a result of:
      a. Decrease in _____ resulting in an _____
   2. Cardiac muscle tissue becomes stiffer and less compliant due to:
      a. Accumulation of _____
      b. Increase in _____

B. Heart Rate
   1. There is a decrease in the maximum heart rate related to:
      a. Increase in the rate _____
      b. Decrease in the rate of _____
      c. Decrease in the maximum rate _____
      d. Epinephrine and norepinephrine _____


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C. Heart Valves
    1. Connective tissue of valves _____
    2. $Ca^{2+}$ deposits on valves _____
D. Conduction System
    1. Altered by:
        a. _____ & _____ of the left bundle branch
        b. _____ of SA node cells
    2. Lead to a higher rate of _____


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