

# CARDIOVASCULAR SYSTEM

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## OBJECTIVES/RATIONALE

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To pursue a career in health care, proficiency in anatomy and physiology is vital. The student will describe biological and chemical processes that maintain homeostasis; analyze forces and the effects of movement, torque, tension, and elasticity on the human body; associate the disease process with changes in homeostasis; identify changes in structure and function due to trauma and disease; and identify normal and abnormal anatomy and physiology.

TEKS: 121.3 (c)(1)(F)(H),  
121.4 (c)(1)(G)(H)(I),  
121.5 (c)(1)(E)(F)(G)

TAKS: ELA 1, 4  
Mathematics 1, 2, 8, 10  
Science 1, 2, 5

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## KEY POINTS

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### Powerpoint

- I. Introduction
  - A. Fully formed by the 4<sup>th</sup> week of embryonic development
  - B. Hollow Muscular Organ That Acts as a Double Pump
  - C. Continuous pump - once pulsations begin, heart pumps endlessly until death
- II. Heart Anatomy
  - A. General
    1. Size: approximately the size of a person's fist
    2. Location: in the mediastinum
  - B. Coverings: Pericardium
    1. Double layered sac
    2. Contains 10 – 20 cc. Of pericardial fluid to reduce the friction of the beating heart
    3. Parietal layer: fibrous membrane; outer layer
    4. Visceral layer: serous membrane; also called the epicardium; attached to myocardium
  - C. Heart Wall
    1. Myocardium: heart muscle; thicker on left side of the heart
    2. Endocardium: lining of heart chambers; endothelial tissue continuous with the lining of the blood vessels
  - D. Chambers
    1. Atria
      - a. 2 upper chambers of heart
      - b. Thin walls, smooth inner surface
      - c. Foramen ovale: passageway between the 2 atria so that the lungs are bypassed in the developing fetus

- d. Fossa ovale: scar tissue where the foramen ovale existed until it closed up shortly after birth
  - e. Responsible for receiving blood
  - f. Right atrium receives deoxygenated (oxygen poor) blood from the body through the superior and inferior vena cava
  - g. Left atrium receives oxygenated (oxygen rich) blood from the lungs through the pulmonary veins
2. Ventricles
- a. 2 lower chambers of the heart
  - b. Thicker walls, irregular inner surface
  - c. Contain papillary muscles and chordae tendineae (prevent heart valves from turning inside out when ventricles contract)
  - d. Left wall 3 times as thick as right wall; forms apex of heart
  - e. Responsible for pumping blood away from the heart
  - f. Right ventricle sends deoxygenated blood to the lungs via the pulmonary arteries
  - g. Left ventricle sends oxygenated blood to all parts of the body via the aorta
3. Accessory Structures
- a. Septum: muscular wall dividing the heart into right and left halves
  - b. Heart valves – prevents the backflow of blood
  - c. Papillary muscles
  - d. Chordae tendineae

#### E. Great Vessels

1. Superior and inferior vena cava: receive deoxygenated blood from all parts of the body
2. Coronary sinus
3. Pulmonary arteries: carry deoxygenated blood to the lungs from the right ventricle
4. Pulmonary veins: carry oxygenated blood to the left atrium from the lungs
5. Aorta: carries oxygenated blood to distribute to all parts of the body

#### F. Pathway of Blood Through the Heart and All Body Tissues

1. Superior and inferior vena cava
2. Right atrium
3. Tricuspid valve
4. Right ventricle
5. Pulmonary semilunar valve
6. Pulmonary arteries
7. Lungs ( O<sub>2</sub> and CO<sub>2</sub> exchange = external respiration)
8. Pulmonary veins
9. Left atrium
10. Bicuspid/Mitral valve

11. Left ventricle
12. Aortic semilunar valve
13. Aorta - all parts of body via arteries
14. Arterioles
15. Capillaries of individual tissues (O<sub>2</sub> and CO<sub>2</sub> exchange = internal respiration)
16. Venules
17. Veins
18. Superior and inferior vena cava

#### G. Cardiovascular Circuits

1. Pulmonary circuit: transport of blood from the right side of the heart to the lungs and then back to the left side of the heart
2. Systemic circuit: transport of blood from the left side of the heart to all parts of the body and then back to the right side of the heart
3. Coronary circuit: transport blood from the left side of the heart to the heart tissues and back to the right side of the heart

#### H. Valves

1. Tough fibrous tissue between the heart chambers and major blood vessels of the heart
2. Gate-like structures to keep the blood flowing in one direction and to prevent regurgitation or backflow of blood
3. Atrioventricular valves: when ventricles contract, blood is forced upward and the valves close; attached by papillary muscles and chordae tendineae
  - a. Tricuspid valve: between the right atrium and the right ventricle
  - b. Bicuspid/mitral valve: between the left atrium and the left ventricle
4. Semilunar Valves: 3 half moon pockets that catch blood and balloon out to close the opening
  - a. Pulmonary semilunar valve: between the right ventricle and the pulmonary arteries
  - b. Aortic semilunar valve: between the left ventricle and the aortic arch/aorta
5. Heart Sounds
  - a. When the AV (atrioventricular) and semilunar valves close, they make the sound heard as “lub-dub” (auscultated with stethoscope)
  - b. First sound = S1 - ventricles are contracting and forcing blood to the lungs and entire body (AV valves closing)
  - c. Second sound = S2 - atria are contracting and the semilunar valves are closing
  - d. Abnormal heart sounds = murmur; valve pathology (M1, M2)

#### I. Cardiac Circulation (Blood Supply to the Heart)

1. Aorta - coronary arteries - capillaries in myocardium → coronary veins - coronary sinus - right atrium
2. Blood in chambers nourishes endocardium
3. Coronary circuit open ONLY during relaxation phase of cardiac cycle
4. Occlusion of coronary artery - myocardial infarction (heart attack) if collateral circulation is inadequate

### III. Heart Physiology

#### A. Nerve Supply to Heart

1. Alters rate and force of cardiac contraction
2. Vagus nerve (parasympathetic nervous system): slows heart rate
3. Sympathetic nerves: increase heart rate
4. Epinephrine/norepinephrine: increase heart rate
5. Sensory (afferent) nerves: detect atria being stretched and lack of oxygen (changes rate of contractions)
6. Angina: chest pain due to lack of oxygen in coronary circulation

#### B. Intrinsic Conduction System: Automaticity

1. Enables heart to contract rhythmically and continuously without motor nerve impulses
2. Arrhythmia: myocardial cells leak sodium faster than the SA node - irregular heart beat
3. SA (sinoatrial) node: pacemaker located where the superior and inferior vena cava enter the right atrium
4. AV (atrioventricular) node: sends impulses to ventricles
5. Bundle of His/bundle branches: in septum
6. Purkinje fibers: in heart wall to distribute nerve impulses

#### C. Cardiac Cycle: Generated in the Heart Muscle Itself

1. One (1) contraction (systole = 0.3 seconds) + one (1) relaxation (diastole = 0.5 seconds) at 75 beats per minute
2. Initiation of contraction - SA node (group of nerve cells); impulse spreads out over both atria causing them to contract together to force blood into both ventricles
3. Impulse from SA node sent to AV node (between atria in septum)
4. Impulse from AV node sent to nerve fibers in septum (bundle of His) which transmit the impulse via the right and left bundle branches to the Purkinje fibers - cause ventricles to contract together and force blood out of the aorta and pulmonary arteries to the body and the lungs
5. Shift of ions along the conduction system = action potential
6. Periods of rest = polarization
7. Periods of activity = depolarization - when impulse is transmitted and repolarization → when slow shift back to polarization occurs

#### D. EKG

1. Electrical changes during cardiac cycle recorded as an EKG

2. To estimate heart rate using EKG strip, count the number of QRS complexes in a 6 – second strip and multiply by 10
3. P wave
  - a. Impulse received by SA node
  - b. Atria depolarized (contract)
  - c. Enlarged P wave = enlarged atrium or stenosed AV valve
4. QRS complex
  - a. Impulse passing through ventricles (systole)
  - b. Ventricles depolarize (contract)
  - c. Atria repolarize (relax)
  - d. Enlarged Q = myocardial infarction
  - e. Enlarged R = enlarged ventricles
5. T wave
  - a. Repolarization of ventricles (diastole)
  - b. Elevated = K<sup>+</sup> level too high
6. PR interval
  - a. 0.12 – 0.2 seconds
  - b. Too long = rheumatic heart disease or hardening of the arteries; conduction problem or delay at the AV node
7. ST segment
  - a. Elevated = acute myocardial infarction
  - b. Depressed = insufficient oxygen to the heart

#### E. Stroke Volume and Cardiac Output

1. Weak hearts have low stroke volume - must pump faster to move adequate amount of blood
2. Well trained athletes have good stroke volume - can pump slower to move adequate amount of blood

### IV. Overview of Blood Vessels

#### A. General Composition and Function

1. Allow for circulation of blood and other body fluids to all body cells
2. Three layers
  - a. Tunica adventitia: outer layer of tough fibrous tissue
  - b. Tunica media: smooth muscle which allows vessels to constrict/dilate
  - c. Tunica intima: smooth, inner elastic layer (lumen = internal diameter)

#### B. Arteries

1. Carry blood AWAY from the heart
2. All BUT pulmonary arteries carry oxygenated blood
3. Aorta: largest artery; 1 inch in diameter
4. Arterioles: smallest arteries
5. Coronary arteries: most important; supply blood to the heart muscle
  - a. Left and right main coronary artery

- b. Left coronary artery - left anterior descending → left circumflex branch
- c. Right coronary artery - right atrium and right ventricle

#### C. Veins

1. Carry blood TOWARD the heart
2. All BUT pulmonary veins carry deoxygenated blood
3. Layers much thinner, less elastic
4. Series of internal valves that work against the flow of gravity to prevent reflux
5. Superior and inferior vena cava: largest veins
6. Venules: smallest veins

#### D. Capillaries

1. Tiny, microscopic vessels
2. Walls one cell layer thick
3. Function: to transport and diffuse essential materials to and from the body's cells and the blood

#### V. Blood Pressure

- A. Systole: maximum pressure formed during a ventricular contraction
- B. Diastole: minimum pressure during ventricular relaxation (atrial contraction)
- C. Measured in mm of Hg
- D.  $BP = CO \times PR$  (blood pressure = cardiac output x peripheral resistance)
- E. Normals
  1. Systolic = 100 – 140
  2. Diastolic = 60 – 90
- F. Hypotension: Systolic < 90
- G. Hypertension: Systolic > 150 and/or Diastolic > 90
- H. Must be lower in pulmonary circuit to prevent fluid from filtering out into the alveoli
- I. Factors Affecting BP
  1. Cardiac output
  2. Peripheral resistance
  3. Blood volume
- J. Circulatory Shock
  1. Hypovolemic shock
  2. Vascular shock
  3. Cardiogenic shock

#### VI. Diagnostic Procedures for the Cardiovascular System

- A. History and Physical
  1. Checking for symptoms of disease
  2. Chest pain, Shortness of Breath (SOB), awareness of heartbeat (palpitation), fatigue, dizziness or loss of consciousness, edema, pain in legs when walking (claudication)
- B. Electrocardiogram: tracing of the electrical activity of the heart
- C. Phonocardiogram: EKG with heart sounds

- D. Echocardiogram: ultrasound measures size and movement of heart structures
  - E. Doppler Ultrasound: measures blood flow
  - F. Arteriography: radiopaque dye injected and x-ray series taken of blood flow
  - G. Cardiac Catheterization
    - 1. Right side of heart: catheter threaded into vein then into the vena cava then into the heart then into the pulmonary artery
    - 2. Left side of heart: catheter threaded into artery then into left ventricle, then into aorta then into coronary vessels
    - 3. X-rays taken during the procedure
    - 4. Dye is also injected
- VII. Diseases of the Cardiovascular System
- A. Arteriosclerosis: hardening of the arteries
  - B. Atherosclerosis
    - 1. Fatty deposits on the walls of the arteries
    - 2. Factors: increased blood lipids, high blood pressure, smoking, obesity, physical inactivity, tension
  - C. Hypertension
    - 1. 90% = essential hypertension - no specific cause
    - 2. 10% = symptom of another disease i.e. adrenal tumor, kidney disease
    - 3. Increases workload of the heart
    - 4. Leads to hypertrophy of left ventricle then heart failure
    - 5. Accelerates development of atherosclerosis
  - D. Ischemic Heart Disease
    - 1. Oxygen supply to heart inadequate
    - 2. Atherosclerosis is major cause
    - 3. Can lead to
      - a. Angina pectoris: condition in which coronary arteries are temporarily blocked - reduced blood supply to heart muscle - chest pain
      - b. Heart attack: cessation of normal cardiac contraction (cardiac arrest)
      - c. Myocardial infarction: necrosis (death) of heart muscle due to severe prolonged ischemia
      - d. Sudden death: heart stops of ventricular fibrillation occurs
  - E. Cardiac Arrhythmias
    - 1. Abnormality in rate, rhythm, or conduction of heart beat
  - F. Bacterial Endocarditis
    - 1. Inflammation of the internal lining of the heart
    - 2. Also involves the heart valves
  - G. Valvular Heart Disease
    - 1. Involves abnormalities of the heart valves
    - 2. Especially mitral and aortic valves

3. Leading cause = rheumatic fever with hypersensitivity reaction to streptococcus antigens
  4. Heart valves are scarred
  5. Treatment - valve replacement
- H. Congenital Heart Disease
1. Defects in the heart that occurred during embryologic and fetal development
  2. Involves defective communication between the chambers, malformation of valves, and malformation of septa
  3. Cyanotic: inability of individual to get adequate blood oxygenation due to extensive cardiac abnormalities that cause blood to be shunted away from lungs
  4. Example: “Blue Babies”; failure of foramen ovale to close or transposition of great arteries or patent ductus arteriosus
  5. Some association with pregnant mother having German measles (rubella)
- I. Congestive Heart Failure (CHF)
1. Pumping action of heart diminished
  2. Fluid accumulates and is retained in tissues
  3. Compensations
    - a. Increased heart rate, greater force of contraction
    - b. Retention of fluid by kidneys
    - c. Enlargement of heart
- J. Cor Pulmonale
1. Hypertrophy of right ventricle due to hypertension in pulmonary circulation
  2. Increased bp in lungs - reduction in blood flow and increased resistance in lungs - pulmonary hypertension - increased pressure in pulmonary arteries - blood backs up into right ventricle - hypertrophy
- K. Peripheral Arterial Disease - Decreased blood flow to peripheral vessels
- L. Varicose Veins: enlarged veins which can be inflamed
- M. Hemorrhoids: varicose veins of rectal and anal area
- N. Aneurysm: weak section in wall of artery - ballooning out - rupture
- O. Phlebitis: inflammation of a vein
- P. Thrombus: blood clot that stays where it is formed
- Q. Stroke (CVA): brain infarct; caused by decreased oxygen supply to brain due to blood clot or hemorrhage
- R. Raynaud’s Disease
- S. Esophageal Varices
- T. Tetralogy of Fallot

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## ACTIVITIES

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- I. Complete Heart Dissection.
- II. Complete [Interpreting Pulse and Respiration Strips Activity](#).

III. Participate in Circulation Derby Game.

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**MATERIALS NEEDED**

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**Cardiovascular System Terminology**

Cow or sheep hearts  
Dissecting trays, kits

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**ASSESSMENT**

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Completed labs

**Cardiovascular System Test**

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**ACCOMMODATIONS**

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For reinforcement, the student will color code a diagram of the heart and label the anatomical parts and/or design a poster depicting the pathway of blood through the heart and all body tissues.

For enrichment, the student will research and report on advancements in cardiology treatments.

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**REFLECTIONS**

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# Circulation Derby

Developed by Dr. J. Stephen Robinson

## Objective

Learn the correct order of transit through the vessels, heart chambers and valves in a single round of the circulatory system.

## Materials

1. Satin or Sateen cloth (4' x 8') of dark color (Sticky Cloth)
2. White board or display board large enough for the cloth
3. Can of Dry Mount spray
4. Paper sheets (cut photocopy sheet in half) with names of vessels, heart chambers and valves
5. Small table

## Preparation

1. Hang the sateen cloth on whiteboard or on wall.
2. Spray the cloth with Dry Mount spray in needed (preferably the night before).
3. Cut 8 ½ x 11" sheets of paper in half (width-wise) for as many cardiovascular items as are being studied.
4. Write the number of an item (vessel, valve, or chamber) on each sheet. Make a set in black and another in red using clearly legible lettering.
5. Stack the sheets in two separate piles (red and black) in random order
6. Suspend a string dividing the cloth into left and right halves.
7. Place the table standing beneath the Sticky Cloth
8. Place the two stacks of circulatory items face down on the table.

## Competition

1. Divide the class into two equally skilled teams and have them choose team names and a color (red or black).
2. Draw a grid on the whiteboard to tally the points.
3. Line up the teams at one end of the room opposite the Sticky Cloth. Clear the area between the teams and the Sticky Cloth.
4. The instructor explains the rules and places one sheet (e.g. RIGHT ATRIUM) on each side of the Sticky Cloth as the starting point in the circulation.
5. Each team sends one player at a time in rotation to the table to find in the stack of circulatory terms the next landmark encountered in the circulation. In the case of the RIGHT ATRIUM, the student would search for the TRICUSPID VALVE as the next item.
6. The student returns to the team area and tags off the next student who must search for the next ensuing circulatory landmark.
7. This continues until all the landmarks have been used.
8. The winner is the first team to complete the circulatory system with the fewest mistakes and in the least time.

9. The instructor reviews the order with the opposing team critiquing.
10. Scoring is by time with each error adding 15 seconds to the team time.

### **Additional Rules**

1. Other players are not allowed to communicate with the player who is at the Sticky Cloth searching for and putting up a sheet. The team is penalized one point (or 15 seconds) for violating this rule.
2. Players may only put one sheet up on the board or take one down, not both. If a player has made an incorrect choice, it may be corrected by a following player, but only by removing the incorrect sheet. The correct sheet must be put up by a following player.

### **Comments**

Teams will quickly realize the importance of working together as a team. Teams cannot shout out instructions to a player at the board, so if a player goes to the board without a clear idea of which is the next landmark on the circuit, it will cost the team two turns to correct it. They may deliberate together and make a clear decision before their player goes to the board. They will also discover that it is faster to spread the sheets out on the table to locate the proper landmark. I let the teams draw out the circuitry the first time it is played. The second time no pencils or crib sheets are allowed. In a third variation, the players are not allowed to speak at all. Speaking incurs a penalty point.

## TEST - CARDIOVASCULAR SYSTEM

### Multiple Choice.

1. Normal heart sounds are caused by which of the following events?
  - a. closure of the heart valves
  - b. excitation of the SA node
  - c. friction of blood against the chamber walls
  - d. contraction of ventricular muscle
  
2. Hemorrhage with a large loss of blood causes:
  - a. a lowering of blood pressure due to change in cardiac output
  - b. a rise in blood pressure due to change in cardiac output
  - c. no change in blood pressure but a slower heart rate
  - d. no change in blood pressure but a change in respiration
  
3. The left ventricular wall of the heart is thicker than the right wall in order to
  - a. accommodate a greater volume of blood
  - b. expand the thoracic cage during diastole
  - c. pump blood with greater pressure
  - d. pump blood through a smaller valve
  
4. Damage to the \_\_\_\_\_ is referred to as heart block.
  - a. SA node
  - b. AV node
  - c. AV bundle
  - d. AV valves
  
5. The P wave of a normal electrocardiogram indicates:
  - a. atrial depolarization
  - b. ventricular depolarization
  - c. atrial repolarization
  - d. ventricular repolarization
  
6. Blood within the pulmonary veins returns to the:
  - a. right atrium
  - b. left atrium
  - c. right ventricle
  - d. left ventricle

7. Blood enters which of these vessels during ventricular systole?
- a.aorta
  - b.pulmonary arteries
  - c.pulmonary vein
  - d.Both a and b
8. Small muscle masses attached to the chordae tendineae are the:
- a.trabeculae carneae
  - b.papillary muscles
  - c.pectinate muscles
  - d.vena cavae
9. The term for pain associated with deficient blood delivery to the heart that may be caused by the transient spasm of coronary arteries is:
- a.ischemia
  - b.angina pectoris
  - c.myocardial infarction
  - d.pericarditis
10. Stenosis of the mitral valve may initially cause a pressure increase in the:
- a.venae cavae
  - b.pulmonary circulation
  - c.left ventricle
  - d.coronary circulation
11. Which of the following is not part of the conduction system of the heart?
- a.AV node
  - b.bundle of His
  - c.AV valve
  - d.SA node
12. Blood is carried to capillaries in the myocardium by way of:
- a.the coronary sinus
  - b.the fossa ovalis
  - c.coronary arteries
  - d.coronary veins

13. The tricuspid valve is closed:
- a. while the ventricle is in diastole
  - b. by the movement of blood from atrium to ventricle
  - c. while the atrium is contracting
  - d. when the ventricle is in systole
14. Which of the following factors does not influence heart rate?
- a. skin color
  - b. age
  - c. gender
  - d. body temperature
15. Which of the following is not an age-related change affecting the heart?
- a. thinning of the valve flaps
  - b. decline in cardiac reserve
  - c. fibrosis of cardiac muscle
  - d. atherosclerosis
16. Select the correct statement about the heart valves.
- a. The mitral valve separates the right atrium from the right ventricle.
  - b. The tricuspid valve divides the left atrium from the left ventricle.
  - c. Semilunar valves control the flow of blood into the heart.
  - d. The AV valves are supported by chordae tendinae so that they do not blow back up into the atria during ventricular contraction.
17. Select the correct statement about the function of myocardial cells.
- a. The all-or-none law as applied to cardiac muscle means that the entire heart contracts as a unit or it does not contract at all.
  - b. Cardiac muscle cells each are innervated by a sympathetic nerve ending so that the nervous system can increase heart rate.
  - c. The refractory period in skeletal muscle is much longer than that in cardiac muscle.
  - d. The influx of potassium ions from extracellular sources is the initiating event in cardiac muscle contraction.
18. The pericardial cavity:
- a. is another name for the chambers of the heart.
  - b. is a space between the fibrous pericardium and the serous pericardium.
  - c. contains a lubricating fluid called serous fluid.
  - d. is the region of the thoracic cavity that contains the heart.

19. Norepinephrine acts on heart muscle cells by:
- a. decreasing heart contractility
  - b. causing a decrease in stroke volume
  - c. causing threshold to be reached more quickly
  - d. blocking the action of calcium
20. The effect of endurance-type athletic training may be to lower the heart rate. This phenomenon:
- a. is a sign of dangerous overexertion
  - b. is caused by hypertrophy of the heart muscle
  - c. results in decreased cardiac output
  - d. does not occur in aerobic training
21. Foramen ovale:
- a. connects the two atria in the fetal heart
  - b. is a connection between the pulmonary trunk and the aorta in the fetus
  - c. is a shallow depression in the interventricular septum
  - d. is a condition in which the heart valves do not completely close
22. A man enters the hospital complaining of chest pain. His history includes smoking, a stress-related job, a diet heavy in saturated fats, lack of exercise, and high blood pressure. Although he is not suffering a heart attack, his doctor explains to him that a heart attack is quite possible. What did the chest pain indicate?
- a. myocardial infarction
  - b. atherosclerosis
  - c. angina pectoris
  - d. murmur
23. In the above clinical case study, why is this man a prime candidate for a heart attack i.e. what has probably caused his chest pain?
- a. atherosclerosis
  - b. murmur
  - c. vascular spasm
  - d. angina pectoris
24. An older woman complains of shortness of breath and intermittent fainting spells. Her doctor runs various tests and finds that the AV node is not functioning properly. What is the suggested treatment?
- a. blood transfusion
  - b. valve replacement surgery
  - c. defibrillation
  - d. implantation of an artificial pacemaker

Matching.

- a. Myocardium
- b. Epicardium
- c. Endocardium
- d. Parietal pericardium

25. The outermost layer of the serous pericardium

26. The lining of the heart

27. Heart muscle

28. Serous layer covering the heart muscle

- a. AV node
- b. AV bundle
- c. Purkinje fibers
- d. SA node

29. The pacemaker of the heart

30. Network found in the ventricular myocardium

31. The point in the conduction system of the heart where the impulse is temporarily delayed

32. Found in the interventricular septum

- a. Pulmonary semilunar valve
- b. Aortic semilunar valve
- c. Mitral valve
- d. Tricuspid valve

33. Prevent backflow into the left ventricle

34. Prevents backflow into the right atrium

35. Prevents backflow into the left atrium

36. Prevents backflow into the right ventricle

37. AV valve with two flaps

38. AV valve with three flaps