You Gotta Have Heart:
Congenital Heart Defects and Heart Surgery

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In collaboration with the Centers for Disease Control and Prevention's
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Congenital heart defects are one of the most prevalent types of birth defect and the largest contributor to infant mortality in the United States (Centers for Disease Control and Prevention, 1998). In this lesson students will A) learn heart anatomy by doing an on-line investigation, B) dissect a sheep heart and learn about congenital heart defects, and C) perform "cardiac surgery" to correct a septal defect on a sheep heart. The target age group for this lesson plan is students in the 11th or 12th grade.

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Summary
Congenital heart defects are one of the most prevalent types of birth defect and the largest contributor to infant mortality in the United States (Centers for Disease Control and Prevention, 1998). In this lesson students will A) learn heart anatomy by doing an on-line investigation, B) dissect a sheep heart and learn about congenital heart defects, and C) perform "cardiac surgery" to correct a septal defect on a sheep heart. The target age group for this lesson plan is students in the 11th or 12th grade.

Learning Outcomes
- Students will be able to identify internal and external anatomy of a heart.
- Students will dissect a heart and be able to model the techniques of a heart surgeon.
- Students will be able to discuss common heart defects, describe how they occur, and name risk factors and possible preventative measures.

Materials
1. Sheep or cow hearts
2. Dissecting equipment - trays, pins, forceps, scalpels, blunt and sharp probes, scissors
3. Masking tape
4. Sharpie marker
5. Curved surgical needles
6. Dental floss or fishing line
7. Gloves
8. Goggles
9. Plastic aprons

Total Duration
2 hours and 15 minutes, or 3 hours with optional step

Procedures

Teacher Preparation
Order sheep or cow hearts from a biological supply company, or obtain hearts from a local butcher. To prepare for dissection, put the following items next to each dissecting tray: several pins, 1 pair of forceps, 1 scalpel, 1 sharp probe, 1 blunt probe, 1 pair of scissors, 1 roll of masking tape, 1 sharpie marker, 1 curved needle, and a supply of fishing line or dental floss (for repairing heart defects). Rinse the hearts to remove excess chemicals and place one heart on each dissecting tray. If a teacher is unfamiliar with heart dissection, a good web-site to consult is "Human Anatomy and Physiology Laboratory Component" (see Web Resources). Also, be sure to have computers with Internet access, and print off the following hand-outs (see Supplementary Documents):
1. Heart Anatomy Pretest and Heart Anatomy Pretest Key (Introduction)
2. Getting to Know Your Pump and Getting to Know Your Pump Key (Introduction)
3. Heart Posttest and Heart Posttest Key (Conclusion)

Web Resource

Title: Human Anatomy and Physiology Laboratory Component
URL: http://www.gen.umn.edu/courses/1135/lab/heartlab/heartlab.html
Description: This Web site from the University of Minnesota describes how to dissect a sheep heart and is a good source for additional information on dissection protocol.

Introduction **Duration: 45 minutes**

To introduce the lesson, inform the students that they will be learning about heart anatomy, congenital heart defects, and heart surgery.

1. Pass out the "Heart Anatomy Pretest" to assess students' knowledge of basic heart anatomy and congenital heart defects.

2. Have the students visit "Your Healthy Heart and How it Works" and "The Heart of Discovery" to learn about heart anatomy (see Web Resources). While at these sites, students should complete the "Getting to Know Your Pump" worksheet.

3. Go over the answers to "Getting to Know Your Pump" worksheet. Once students have a good understanding of basic heart anatomy, proceed to Step Two.

Web Resources

Title: Your Healthy Heart and How it Works
URL: http://www.ynhh.org/cardiac/heart/#heart_anatomy
Description: This Web site from Yale-New Haven Hospital shows heart anatomy and is used on the "Getting to Know Your Pump" worksheet.

Title: The Heart of Discovery
URL: http://www.tmc.edu/thi/anatomy.html
Description: This Web site from the Texas Heart Institute gives the functions of heart structures and is used on the "Getting to Know Your Pump" worksheet.

Title: CyberHeart CardioTutorials
URL: http://www.gwc.maricopa.edu/class/bio202/cyberheart/cardio.htm
Description: This Web site from Arizona's Gate Way Community College includes tutorials and self-tests about the anatomy of the interior and exterior of the heart. This Web site can be used as an additional anatomy resource.

Supplemental Documents

Title: Heart Anatomy Pretest
Description: This Word document contains a true-and-false 10 question quiz and key to assess students' prior knowledge of heart anatomy and congenital heart defects.

Title: Heart Anatomy Pretest Key
Description: This Word document contains the answer key to the heart anatomy pretest.

Title: Getting to Know Your Pump
Description: This Word document contains a worksheet with questions about the anatomy and function of the heart.

Title: Getting to Know Your Pump Key
Description: This Word document contains the answer key to the "Getting to Know Your Pump" worksheet.

Step 2 **Duration: 45 minutes**

Now that the students have identified heart anatomy on-line and completed a worksheet, it is time to learn to identify the structures on a real sheep heart.

1. Divide students into groups of 2-3 and have them put on gloves, goggles, and plastic aprons.

2. Provide each group with a dissecting tray, pre-washed sheep heart, pins, forceps, scalpel, blunt probe, sharp probe, scissors, masking tape, and a sharpie marker.

3. Have each group create a set of 14 pins with masking tape flags on them. Using a sharpie marker, students should number the flags 1 thru 14.

4. Have the students place the pins with flags at the correct locations on the outside of the sheep heart. In order to identify the regions correctly, students should refer to the "Getting to Know Your Pump" worksheet they completed before. For example, pin #1 should be placed in the superior vena cava; pin #2 should be placed in the inferior vena cava, etc. Be sure to inform the students that not all structures will be visible from the exterior of the heart. The "Circulatory System-Sheep Heart" (Web Resources) is helpful for determining which structures will be visible to the students on the exterior of the sheep heart.

5. Once students have placed pins on the outside of the heart, teachers should check to make sure each group correctly identifies the regions, then have the students remove the pins.

6. Have the students place the heart on one end in the dissecting tray and cutting downward with a scalpel, carefully cut the heart open like a book.

7. Once again, using the "Getting to Know Your Pump" worksheet and the "Circulatory System-Sheep Heart" Web resource, students should identify the regions inside the heart by placing the pins at the correct locations.

8. As before, teachers should check to make sure the students correctly identify each region.

9. When students are done, have them remove all pins and leave their hearts on the trays. Do not throw them away or allow students to mutilate them. Students should proceed to clean up their desks with disinfectant and wash their tools as instructed.

10. If there is time, assign students to read the article on "Congenital Heart Disease" from the Texas Heart Institute Web site (see Web Resources). Students should describe in their notes A) the causes of congenital heart defects, and B) possible preventative measures, as well as provide brief descriptions of the 15 heart defects from the article. Inform the students that tomorrow in class they will be cardiologists who need to diagnose a congenital heart defect in a newborn baby. The only notes they can use to determine the defect are the ones they take from this article. Alternatively, if the students do not have time to read the article in class, it can be assigned as homework:

    Web Resources
    Title: Circulatory System-Sheep Heart
    URL: http://www.bio.psu.edu/faculty/strauss/anatomy/circ/circulat.htm

Description: This Web site from Philadelphia College includes labeled images of dissected sheep hearts and can be used to help students identify structures during dissection.

Title: Anatomy and Physiology 2 Lab Help-Cardiovascular-Heart Dissection Photos
URL: http://science.nhmccd.edu/biol/ap2lab.htm
Description: This Web site from North Harris College Biology Department provides photos of real sheep hearts, as well as cow hearts, and can be used as an additional resource to help students identify structures during dissection

Title: Congenital Heart Disease
URL: http://www.tmc.edu/thi/congenit.html
Description: This Web site from the Texas Heart Institute describes causes and types of birth defects and will be important in the next step, determining what is wrong with the defective hearts.

Title: Teaching Resources for Pediatric Cardiology
URL: http://www.kumc.edu/kumcpeds/cardiology/pedcardiodiagrams.html
Description: This Web site from University of Kansas Medical Center has a list of defect diagrams that are in color to show mixing of blue/red blood. It also has a normal heart for comparison next to the defect.

Step 3 **Duration: 30 minutes**

Using only their notes from the congenital heart disease Web site, students are to assume the roles of cardiologists and determine what the defect is and then perform surgical repair of the abnormalities. The teacher could mention that before the advent of cardiac surgery, most children could not survive very long with these defects and were often very ill. Cardiac surgery significantly improved the lives of children born with congenital heart disease. Children's hearts can now can be fully repaired and they can live to adulthood.

1. Before the students arrive for class, the teacher should create "congenital heart defects" in the sheep hearts. Septal heart defects (holes in the heart) account for the majority of heart defects and are easy to create in the sheep hearts by using a sharp probe. For this reason, two types of septal defects will be created – atrial and ventricular septal defects. The atrial hole should be made in the muscle that separates the left and right atria. The ventricular hole should be made in the muscle that separates the right and left ventricles.

2. If teachers would like to simulate other defects, they could also create "stenotic" defects by placing a string or tie around the aorta (coarctation of the aorta) or near the pulmonary or aortic valves. This defect would be for simulation purposes only because students could not do much for surgery.

3. When the students arrive for class, have them put on their gloves, goggles, and aprons.

4. Pass out the sheep hearts with the "birth defects" randomly to each group.

5. Working as a group, they are to diagnose the heart abnormality using only their notes and report what is wrong to their instructor. Teachers should award points to groups who correctly diagnose the disorder.

6. Once all disorders are correctly identified, the students will repair the holes by suturing the defects. To do this, students will use curved needles and either fishing line or dental floss to sew up the septal defects.

7. To clean up, put the sheep hearts in a biohazard bag and dispose of properly. Students should clean their tools, dissecting trays, and lab stations with disinfectant.

Step 4 (optional) **Duration: 45 minutes**

Following the heart dissection and heart surgery, the teacher can give students a chance to explore congenital heart defects. Allow students to discuss some of the implications a heart defect might have for a child. Discuss the implication of "holes" or "blockages/stenosis".

The septum functions to keep deoxygenated and oxygenated blood separate. If blood flows through a hole in the septum, then there is mixing of low and high oxygen blood. Thus the average blood oxygen content is low, which means not enough oxygen gets to all the cells in the body. In blockages or stenosis, blood isn't allowed to flow where it should and can "back up" into chambers where it originates, causing enlargement.

Discuss some of the things that could possibly cause such defects. Following the discussion, students can do some independent Web research using the 'March of Dimes: Congenital Heart Defects' Web site to find the answers to some of these questions. Have students write a 3-5 paragraph short essay on a) how prevalent congenital heart defects are in the United States, b) some of the possible causes of congenital heart defects, c) populations at risk for congenital heart defects, and d) treatment and prevention options available. Teachers can refer to the 'March of Dimes: Congenital Heart Defects' Web site as a means to assess whether students have gathered accurate data. For more scientific information on the role genetics might play in congenital heart defects or to challenge students further, the teacher and the students can refer to the paper entitled, 'A population-based study of the 22q11.2 deletion: phenotype, incidence, and contribution to major birth defects in the population'.

Web Resources

Title: March of Dimes: Congenital Heart Defects
URL: http://www.marchofdimes.com/professionals/681_1212.asp
Description: This Web site from the March of Dimes provides easy to understand information on congenital heart defects.

Title: A population-based study of the 22q11.2 deletion: phenotype, incidence, and contribution to major birth defects in the population
URL: http://pediatrics.aappublications.org/cgi/content/full/112/1/101
Description: This is a scientific paper published in Pediatrics on the genetic factors related to congenital heart defects in the population. This paper might be difficult for high school students to understand.

Conclusion **Duration: 15 minutes**

To reinforce what the students have learned about heart anatomy and congenital birth defects, administer the "Heart Posttest".

Supplemental Documents

Title: Heart Posttest and Heart Posttest Key
Description: This Word file contains a post-assessment for the heart anatomy and congenital defects lessons.

Title: Heart Posttest Key
Description: This Word file contains the answer key for the post-assessment for the heart anatomy and congenital defects lessons.

Assessment

In the Conclusion, students take a "Heart Posttest" to assess their knowledge of heart anatomy and congenital heart defects. An alternative posttest would be to have a lab practical with stations around the room where the students identify numbered regions on sheep hearts.

Modifications

Extension(s)
1. Teachers can arrange to have a guest heart surgeon come in to teach the students proper surgery techniques and describe their career as a cardiologist.

2. Teachers can have students create models of the heart using Model Magic or clay.

3. There are numerous scientific journal papers available on congenital heart defects that students could use to further their understanding. New findings and publications on birth defects, including congenital heart defects, are listed on the National Center on Birth Defects and Developmental Disabilities Web site at http://www.cdc.gov/ncbddd/bd/keyfind.htm. This would be a good way for teachers to introduce students to using and understanding scientific journal articles. This skill will be increasingly important as they progress in their education.

Other Modifications
While this lesson plan is written for 11th and 12th graders, it can be modified to a younger target group. One modification would be to teach only the principle structures of the heart. For example, the four chambers, aorta, and vena cava. A second modification is that teachers can perform the dissection if they are concerned that younger students might injure themselves. This would still allow the students to suture the septal defects.

Education Standards

National Science Education Standards

SCIENCE AS INQUIRY, CONTENT STANDARD A:
As a result of activities in grades 9-12, all students should develop
- **Abilities necessary to do scientific inquiry**
- Understanding about scientific inquiry

SCIENCE IN PERSONAL AND SOCIAL PERSPECTIVES, CONTENT STANDARD F:
As a result of activities in grades 9-12, all students should develop understanding of
- **Personal and community health**
- Population growth
- Natural Resources
- Environmental quality

- Natural and human-induced hazards
- Science and technology in local, national, and global challenges

Heart Anatomy Pretest

You Gotta Have Heart: Congenital Heart Defects and Heart Surgery
Rebecca Johns, CDC's 2005 Science Ambassador Program

Directions: Please indicate if the statements below are true or false by circling the correct letter (T or F) for each sentence.

1. T or F The atria are located on the bottom of the heart.

2. T or F The pulmonary arteries take blood from the heart to the lungs.

3. T or F The semi-lunar valves separate the atria from the ventricles.

4. T or F The aorta is the main artery of the heart taking deoxygenated blood to the systems of the body.

5. T or F A septal heart defect is a hole in the heart located between the right and left chambers.

6. T or F The cause of most congenital heart defects is smoking during pregnancy.

7. T or F The first sign of a heart defect is usually a heart murmur or blue skin coloring.

8. T or F Congenital heart defects are the second largest contributor to infant mortality in the United States.

9. T or F Poorly controlled diabetes or German measles (rubella) in the mother increases the risk for congenital heart defects.

10. T or F All congenital heart defects require surgery for treatment.

Heart Anatomy Pretest Key

You Gotta Have Heart: Congenital Heart Defects and Heart Surgery
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Directions: Please indicate if the statements below are true or false by circling the correct letter (T or F) for each sentence.

1. T or F The atria are located on the bottom of the heart. (False, the atria are located on the top of the heart)

2. T or F The pulmonary arteries take blood from the heart to the lungs.

3. T or F The semi-lunar valves separate the atria from the ventricles. (False, the A-V valves separate the atria from the ventricles)

4. T or F The aorta is the main artery of the heart taking deoxygenated blood to the systems of the body. (False, the aorta is the main artery of the heart taking oxygenated blood to the systems of the body)

5. T or F A septal heart defect is a hole in the heart located between the right and left chambers.

6. T or F The cause of most congenital heart defects is smoking during pregnancy. (False, the cause of most congenital heart defects is unknown)

7. T or F The first sign of a heart defect is usually a heart murmur or blue skin coloring.

8. T or F Congenital heart defects are the second largest contributor to infant mortality in the United States. (False, congenital heart defects are the largest contributor to infant mortality in the United States)

9. T or F Poorly-controlled diabetes or German measles (rubella) in the mother increase the risk for congenital heart defects.

10. T or F All congenital heart defects require surgery for treatment. (False, some small septal heart defects will close on their own, without any treatment, and some defects can be treated by inserting a catheter (tiny tube) through a vein in the leg, up into the heart, and using tiny instruments passed through the catheter into the heart to correct holes or blockages in the heart or blood vessels)

Getting to Know Your Pump

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Answer the questions below regarding heart anatomy by visiting the following Web sites: Part A: http://www.ynhh.org/cardiac/heart/#heart_anatomy
Part B: http://www.tmc.edu/thi/anatomy.html

Part A

1. How big is the heart?

2. What is the heart's role in the human body?

3. How many times does the average heart beat per day?

4. What are the 7 components of the circulatory system?

5. In the space below, draw, color, and label the exterior structures of the heart.

6. In the space below, draw, color, and label the interior structures of the heart.

7. Click on the link "Map of the Human Heart" to describe the 6 steps of the path that blood takes through the heart.
    1.

2.

3.

4.

5.

6.

Part B

1. Place your cursor over the diagram of the heart. Then fill in the functions of each heart structure in the chart below.

Heart Structure	Function
1. Superior Vena Cava	
2. Inferior Vena Cava	
3. Right Atrium	
4. Tricuspid Valve	
5. Right Ventricle	
6. Ventricular Septum	
7. Pulmonary Valve	
8. Pulmonary Arteries	
9. Pulmonary Veins	
10. Left Atrium	
11. Mitral Valve	
12. Left Ventricle	
13. Aortic Valve	
14. Aorta	

Getting to Know Your Pump Key

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Answer the questions below regarding heart anatomy by visiting the following Web sites: Part A: http://www.ynhh.org/cardiac/heart/#heart_anatomy
Part B: http://www.tmc.edu/thi/anatomy.html

Part A

1. How big is the heart?
   A little larger than a clenched fist.

2. What is the heart's role in the body?
   To pump the blood that delivers life-sustaining oxygen and nutrients to 300 trillion cells.

3. How many times does the average heart beat per day?
   100,000 times.

4. What are the 7 components of the circulatory system?
   Heart, lungs, arteries, arterioles, capillaries, venules, and veins.

5. In the space below, draw, color, and label the exterior structures of the heart.
   Please refer to http://www.ynhh.org/cardiac/heart/#heart_anatomy for a diagram of the exterior structures of the heart.

6. In the space below, draw, color, and label the interior structures of the heart.
   Please refer to http://www.ynhh.org/cardiac/heart/#heart_anatomy for a diagram of the interior structures of the heart.

7. Click on the link "Map of the Human Heart" to describe the 6 steps of the path that blood takes through the heart.
   1. Oxygen-poor blood flows from the body into the right atrium.

2. Blood flows through the right atrium into the right ventricle.

3. The right ventricle pumps the blood to the lungs, where the blood releases carbon dioxide and picks up oxygen.

4. The newly oxygen-rich blood returns to the heart and enters the left atrium.

5. Blood flows through the left atrium into the left ventricle.

6. The left ventricle pumps the oxygen-rich blood to all parts of the body.

Part B

1. Place your cursor over the diagram of the heart. Then fill in the functions of each heart structure in the chart below.

Heart Structure	Function
1. Superior Vena Cava	Oxygen-poor blood from the upper parts of the body returns to the heart through the superior vena cava.
2. Inferior Vena Cava	Oxygen-poor blood from the lower parts of the body returns to the heart through the inferior vena cava.
3. Right Atrium	Collects oxygen-poor blood returning from the body and then forces it through the tricuspid valve and into the right ventricle.
4. Tricuspid Valve	Controls blood flow from the right atrium into the right ventricle.
5.Right Ventricle	Collects oxygen-poor blood from the right atrium and then forces it through the pulmonary valve and into the lungs.
6. Ventricular Septum	A wall of muscle called the septum separates the left and right ventricles.
7. Pulmonary Valve	Controls the blood flow from the right ventricle into the pulmonary arteries.
8. Pulmonary Arteries	Carry blood from the heart to the lungs to pick up oxygen.
9. Pulmonary Veins	Carry oxygen-rich blood from the lungs back to the heart.
10. Left Atrium	Collects oxygen-rich blood returning from the lungs and then forces it through the mitral valve into the left ventricles.
11. Mitral Valve	Controls blood flow from the left atrium into the left ventricle.
12. Left Ventricle	Largest and strongest chamber, the walls are only about a ½" thick, but they have enough force to push blood through the aortic valve and into your body.
13. Aortic Valve	Controls blood flow from the left ventricles into the aorta.
14. Aorta	The largest artery. It carries oxygen-rich blood from the heart and distributes it to the rest of the body.

Heart Posttest

You Gotta Have Heart: Congenital Heart Defects and Heart Surgery
Rebecca Johns, CDC's 2005 Science Ambassador Program

1. Starting with deoxygenated blood coming from the head, describe the cycle that blood will take to return to the head. Be sure to note if it is oxygenated (O) or deoxygenated (D).
    1. Head (D), 2.

2. Match the heart structure with its function.

_____1. Right Ventricle	A. Largest and strongest chamber, the walls are only about a ½" thick, but they have enough force to push blood through the aortic valve and into your body.
_____2. Inferior Vena Cava	B. A wall of muscle called the septum separates the left and right atria and the left and right ventricles.
_____3. Tricuspid Valve	C. Controls blood flow from the right atrium into the right ventricle.
_____4. Left Atrium	D. Oxygen-poor blood from the lower parts of the body returns to the heart through it.
_____5. Superior Vena Cava	E. The largest artery. It carries oxygen-rich blood from the heart and distributes it to the rest of the body.
_____6. Left Ventricle	F. Controls blood flow from the left atrium into the left ventricle.
_____7. Pulmonary Veins	G. Controls blood flow from the left ventricles into the aorta.
_____8. Ventricular Septum	H. Carry oxygen-rich blood from the lungs back to the heart.
_____9. Aorta	I. Collects oxygen-poor blood returning from the body and then forces it through the tricuspid valve and into the right ventricle.
_____10. Pulmonary Valve	J. Controls the blood flow from the right ventricle into the pulmonary arteries.
_____11. Aortic Valve	K. Collects oxygen-poor blood from the right atrium and then forces it through the pulmonary valve and into the lungs.
_____12. Right Atrium	L. Oxygen-poor blood from the upper parts of the body returns to the heart through it.
_____13. Pulmonary Arteries	M. Collects oxygen-rich blood returning from the lungs and then forces it through the mitral valve into the left ventricles.
_____14. Mitral Valve	N. Carry blood from the heart to the lungs to pick up oxygen.

3. What is the most common congenital heart defect?

4. What are some possible contributors to congenital heart defects?

Heart Posttest Key

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1. Starting with deoxygenated blood coming from the head, describe the cycle that blood will take to return to the head. Be sure to note if it is oxygenated (O) or deoxygenated (D).

1. Head (D), 2. Superior Vena Cava (D), 3. Right Atrium (D), 4. Right Ventricle (D), 5. Pulmonary Arteries (D), 6. Pulmonary Veins (O), 7. Left Atrium (O), 8. Left Ventricle (O), 9. Aorta (O), 10. Head (O), 11. Head (D)

*Note: students may include more detail, such as arterioles, capillaries, venules, and the names of the heart valves.

2. Match the heart structure with its function.

__K___1. Right Ventricle	A. Largest and strongest chamber, the walls are only about a ½" thick, but they have enough force to push blood through the aortic valve and into your body.
__D___2. Inferior Vena Cava	B. A wall of muscle that separates the left and right ventricles.
__C___3. Tricuspid Valve	C. Controls blood flow from the right atrium into the right ventricle.
__M___4. Left Atrium	D. Oxygen-poor blood from the lower parts of the body returns to the heart through it.
__L___5. Superior Vena Cava	E. The largest artery. It carries oxygen-rich blood from the heart and distributes it to the rest of the body.
__A___6. Left Ventricle	F. Controls blood flow from the left atrium into the left ventricle.
__H___7. Pulmonary Veins	G. Controls blood flow from the left ventricles into the aorta.
__B___8. Ventricular Septum	H. Carry oxygen-rich blood from the lungs back to the heart.
__E___9. Aorta	I. Collects oxygen-poor blood returning from the body and then forces it through the tricuspid valve and into the right ventricle.
__J___10. Pulmonary Valve	J. Controls the blood flow from the right ventricle into the pulmonary arteries.
__G___11. Aortic Valve	K. Collects oxygen-poor blood from the right atrium and then forces it through the pulmonary valve and into the lungs.
__I___12. Right Atrium	L. Oxygen-poor blood from the upper parts of the body returns to the heart through it.
__N___13. Pulmonary Arteries	M. Collects oxygen-rich blood returning from the lungs and then forces it through the mitral valve into the left ventricles.
__F___14. Mitral Valve	N. Carry blood from the heart to the lungs to pick up oxygen.

3. What is the most common congenital heart defect?
Septal defects (atrial and ventricular).

4. What are some possible contributors to congenital heart defects?
Poorly-controlled diabetes or German measles (rubella) in the mother; use of alcohol, drugs, or some prescription medications during pregnancy; genetics.