BIO-sect
Mammalian Heart (sheep)
Dissection Manual
Cat. No. 32W 2090
62W 2090 (Kit)

INTRODUCTION

BIO-sect is a learning system. Each study unit in this system is
designed so that the student, with your help and support, can ex-

cplore, understand, and integrate basic principles of anatomy and

physiology among representatives of the animal kingdom.

This Study Unit Contains

12 sheep hearts preserved in WARD-SAFE
12 disposable styrofoam dissection trays
12 plastic storage bags
1 teacher’s reference folder
4 student worksheet copy masters

Students Will Also Require

1 pair scissors
1 blunt probe
1 scalpel

Learning Objectives

1. Recognize and identify the major external and internal
features and structures of the mammalian heart.

2. Explain the function of these various structures.

3. Interpret how these organ features and structures involve
themselves with physiological events to the animal itself, to
other animals, and to the human condition.

4. Develop competency in the skills of dissection and the careful
following of instructions.

Special Instructions

Disposable dissection tray: this tray is designed to be a firm
moisture-proof surface on which the student can work. The dissec-
tion pins provided will hold the organ securely and can be used in
future work. At the conclusion of the laboratory exercise, the stu-
dent can simply discard the organ, thus reducing clean up time
and mess. The dissection tray may be reused at your option.

Copy masters: copy masters are acetate reproduction sheets

designed for photocopying. Two acetate reproduction sheets are
supplied for each copy master number — one details identified,
labelled structures for use by the educator; the other details only

the structures called out for students to label. Copy master sheets
may be reproduced and distributed as the educator deems
necessary.

Specimen Storage

All BIO-sect specimens are treated with WARD-SAFE, which greatly

minimizes student discomfort, especially eye irritation. Between
study periods, the specimen, pinned to the disposable dissection

tray, should be covered with a paper towel dampened in ethylene
glycol (7%) or WARD-SAFE and stored in one of the plastic bags
provided. Students should fold over the open end of the bag twice
and secure with staples or paper clips. The student’s name can be
written directly on the dissecting tray or the plastic bag with a felt-
tip marking pen.

Dissecting Tips

A false notion about dissecting is that all you do is cut and slice.
An animal or organ specimen is a marvelously assembled and in-
tricate set of structures held together by connective tissue. Dissec-
tion is making careful incisions to expose parts, then using a blunt
probe to separate structures from their coverings. In a sense,
one’s intent is to carefully unwrap the organ’s structures without
damage. Except for major incisions, don’t cut - dissect!

Note: Adequate precautions and supervision should be given to
students using scalpels. Never let them use a razor blade. As with
the handling of all biological specimens, use of protective rubber
gloves is suggested as is eye protection.

Anatomical Orientation Terminology

Dorsal - upper surface

Ventral - lower or underneath surface

Anterior - forward or front part

Posterior - hind or rear part

Median - toward the middle

Lateral - toward the side, away from the middle

Superior - higher, uppermost, above, or more elevated in position

Inferior - in a lower position; beneath or underneath

COMPARATIVE ANATOMICAL AND PHYSIOLOGICAL
FEATURES OF VERTEBRATE HEARTS

Diagrams of Vertebrate Circulatory Systems

Primitively, the vertebrate heart consisted of 4 linearly arranged
chambers: from posterior to anterior these are: sinus venosus,
avenue, ventricle, and conus arteriosus. This basic configuration is
found in most fishes today. The fish heart is generally arranged
such that the atrium and ventricle are sharply folded over each

other. One-way valves between each of the chambers prevents
the backflow of blood. Three out of four of these chambers are
muscular except for the thin-walled sinus venosus, which serves as
a collecting chamber - passing blood forward to the other

chambers. The sinus venosus contains tissue that initiates the
rhythmic heartbeat, thus serving as a "pacemaker," a function,
along with valves, that is maintained throughout the vertebrate

condition. The conus arteriosus, as its name implies, is mainly a

chamber that helps to distribute blood to various major vessels
once it has passed from the ventricle. Its function gradually
diminishes as one climbs the evolutionary ladder being replaced by
distinct vessel branches in mammals. In the fish, blood outflow
from the heart flows along a single circuit, passing through gill
capillaries for oxygenation, then on to the body, and back to the

heart. Refer to BIO-sect manual "The Perch" (32W 2020) for a
detailed discussion of the perch heart.
2. Oxygenated blood from the lungs then returns to the heart and subsequently out to the body.

3. Blood going to the body passes through one set of capillary beds - blood going to either the renal or hepatic portal* systems passes through two sets of capillary beds - before returning to the heart.

*Portal system: a vein with a capillary bed at each end.

Hearts of birds and mammals have abandoned the flexibility of "shunting." In favor of increased efficiency of complete separation of oxygenated and deoxygenated blood - presumably in association with the maintenance of a constant body temperature and "steady state" or homeostasis. The only time mammals exhibit "shunting" is during developmental stages. Refer to BIOD-sect manual "The Fetal Pig" (32W 2005) for a discussion of fetal circulation.

In the mammalian and bird heart the sinus venosus is lost as a distinct chamber. It is incorporated into the wall of the right atrium as the S.A (sino-atrial) node or pacemaker. The true "double-pump" is at work here - a complete septum divides the heart into distinct and complete right and left sides. The right atrium and ventricle receives deoxygenated blood from the body circuit and passes it to the segregated lung circuit for oxygenation. This oxygenated blood is then cycled through the left atrium and ventricle and then out to the rest of the body.

The adult human heart, weighing approximately 300 grams, is an extremely efficient muscular pump, designed to contract 42 million times per year and eject 700,000 gallons of blood during the same period. In contrast, a mouse's heart beats 315 million times in a year and ejects 1000th the blood volume! The sheep heart (Ovis aries) is usually selected for study since it is a large specimen whose anatomical structure approximates our own.

LABORATORY LESSON 1

EXTERNAL ANATOMY OF THE SHEEP HEART

Dissection Instructions

Using scissors and a scalpel, remove as much fatty and connective tissue from the heart and major vessels as possible. Place the heart on the styrofoam dissection tray so that its ventral surface faces toward you, the major blood vessels are on top, and the point (apex) of the heart is facing downward. Correct positioning can be verified by comparison to the illustration in Copy Master 1 (a). The heart is now in a position similar to that in the human body as you face the body. Do not pin or cut the heart at this time.

Locate and identify the external features of the heart by referring to figures and Terms For Recognition and Learning. It is suggested that students be given a list of terms prior to beginning the lesson and that they mark and label each of these on the reproduction copies made from the acetate copy master provided.

An additional suggestion is to have students label tags (with string) with the names of the structures to be identified. Once identification is made, these tags should be pinned to the structure. Such action will greatly facilitate understanding of associated structures from right to left sides of the heart as well as dorsally and ventrally.

Protective Tissues of the Heart

(Copy Master 1)

Two tissue types protect the heart: fibrous and serous. Fibrous tissue is tough, resilient, and thick. Serous membranes are extremely thin and appear "moist" or watery. Their function is more lubrication than physical protection.

Terms for recognition and learning

Epicardium (serous pericardium - visceral layer) - a second serous membrane that is tightly attached to the heart muscle itself and forms a smooth covering over it. These two moist membranes reduce friction during heartbeat movements. Expose the epicardium by carefully scraping the fatty tissue from the heart muscle. Remove a piece of the membrane to observe how thin it is. Fibrous pericardium (pear-in-car-deum) - a fibrous loose sac that surrounds the heart in life. It forms a protective chamber for the heart, isolating it and its major vessels from other body organs.
vessels. It is suggested that a demonstration heart, with pericardium (69W 7211), be supplied for study.

Serous pericardium (parietal layer) - a moist membrane that lines the inner surface (one facing the heart) of the pericardium.

Heart Tissue Layers
(Copy Master 1)

In addition to the epicardium, the following tissues can be observed;

Terms for recognition and learning

Myocardium (my'-oh-card'-de-um) - the middle layer of the heart consisting of cardiac tissue or heart muscle. Heart muscle will be observed in cross section when the organ is sectioned.

Endocardium - a thin, smooth layer of tissue that lines the inside of the heart chambers and blood vessels. It has a non-wettable surface which helps avoid blood clots. When this smooth layer is disturbed, platelets may attach to the area and a clot may develop. The endocardium will be observed during dissection.

External Structures on the Heart - Ventral View
(Copy Master 1)

Terms for recognition and learning

Anterior interventricular sulcus (sull' kuss) - also termed the ventral longitudinal sulcus. This groove (sulcus) lies over the intraventricular septum which is the wall between the ventricles. This fat-filled groove extends from the posterior part of the right side of the heart anteriorly and slightly to the left. The groove also contains the descending branch of the left coronary artery and the middle cardiac vein. These structures may not be readily visible. You may have to trim away some fat and membrane to locate them.

Apex - the point of the heart.

Atria (right and left) - the chambers of the heart which receive blood from the veins* and pump it to the ventricles.

Auricle (or 'in culf) (right and left) - a protruding portion of the atrium in the heart of mammals. Both auricles are plainly visible as "pouches" off each respective atrium. Each auricle provides extra storage volume for the atrium.

Coronary sulcus - a groove that separates the atria from the ventricles and encircles the heart. The right side contains the right coronary artery.

Ventricle (right and left) - a chamber in the heart which receives blood from the respective atrium and pumps it into arteries*. Squeeze each of the ventricle chambers with your fingers. Note that the left ventricular chamber feels thicker and firmer than the right. The left ventricle works at about five times the pressure, pumping blood out to the body (the right ventricle pumps blood to the lungs for oxygenation) thus requiring a much stronger wall.

Major Blood Vessels of the Heart
(Copy Master 1)

Dissection Instructions

Certain vessels are better observed on the dorsal aspect of the heart. The notation "dorsal aspect" will appear following those terms. Students are requested to turn the heart over at those points in study. Most specimens will have the major vessels cut close to the heart. However, the cut ends and openings to the heart will be able to be located.

Terms for recognition and learning

Aorta (a-ot'-ah) - in ventral aspect, a large artery near the right atrium, just behind the pulmonary artery. The aorta delivers blood from the left ventricle to the arteries of the body. The first part of this vessel is curved and is termed the aortic arch. Usually only the beginning of the arch can be observed in the specimen. The aortic arch in humans has three major branches: the innominate, the left carotid, and the left subclavian. Note how thick the wall of this vessel is. Its thickness is necessary to withstand the high pressures exerted by the heart in pumping blood to all parts of the body.

Coronary veins - parallel the position of coronary arteries. Coronary veins (three major ones) return blood from heart muscle tissue to the right atrium (at its meeting with the right postcava) in a region termed the coronary sinus.

NOTE: the anterior/posterior sinus and coronary sinus are difficult structures to observe unless care is taken in dissection of the respective anatomical areas covered in Lesson II. They are presented here for the understanding of blood flow pattern rather than for their anatomical consideration.

Left coronary artery (lower branch - also termed the descending branch) - is located in the anterior interventricular sulcus. You may have to trim away some fat and membrane to locate it. It arises from the left posterior sinus of the aorta.

Left coronary artery (upper branch - also termed the circumflex branch) - is another main (descending) branch of the left coronary artery. It passes over the left ventricle toward the dorsal aspect of the heart. The left coronary artery supplies oxygenated blood to the left side of the heart.

Ligamentum arteriosum (lig-a-men'-tum ar-tee-er'-e-um) - in ventral aspect, a small "band" of tissue connecting the aorta and pulmonary artery. This arterial ligament is a vestige of the ductus arteriosus (see BIO-Fed Fet Pig - 32W 2050) of the fetus. This fetal artery allows blood to flow from the pulmonary artery into the aorta thus bypassing the lungs. Since lungs are reduced in size and are nonfunctional in the fetal state, this artery helps maintain a good rate of blood flow in the fetus.

Pulmonary arteries - in the ventral aspect, a vessel that arises from the right ventricle. It delivers blood from the right ventricle to the lungs. It divides into right and left branches. In most specimens, this artery will have been cut off before it branches.

Pulmonary veins - in the dorsal aspect, four veins, two from each lung, that deliver blood from the lungs to the left atrium. Ideally these vessels are cut very close to the heart and may be difficult to observe as distinct vessels. Their openings should be able to be located in the wall of the left ventricle (dorsal aspect).

Right coronary artery - an artery located in the coronary sulcus between the right atrium and right ventricle. This vessel arises from the anterior sinus of the aorta and supplies oxygenated blood to the right side of the heart.

Right postcava (also termed the inferior vena cava) - a large vein that also enters the right atrium of the heart. It delivers blood from the lower body to the heart. Locate the lumen for this vein on the dorsal aspect of the right atrium just below that of the precava.

Right precava (also termed the superior vena cava) - a large vein that enters the right atrium of the heart. It delivers blood from the upper body (head region) to the heart. Locate the hole (lumen) of this vessel on the upper portion of the right atrium behind the right auricle (ventral aspect).

Great cardiac or left coronary vein - ascends the posterior interventricular sulcus tendon and turns backward in the coronary sulcus, in which it winds around the posterior border of the heart to the right side and joins the coronary sinus.

Middle cardiac or right coronary vein - ascends the anterior interventricular sulcus to join the coronary sinus.

Small cardiac veins - three in number; small vessels which return blood to the right ventricle and atrium.

*Artery - a vessel which conveys blood from the heart to body tissues. A common misconception is that veins carry deoxygenated blood and that arteries carry oxygenated blood.

Suggested Class Activity - Understanding Coronary Bypass Surgery

In certain instances of heart disease, the coronary arteries (one or more) become narrowed with deposits (mostly cholesterol) thus reducing blood flow to certain muscle areas of the heart. When this occlusive matter builds up to the point where it completely occludes (shuts off) the artery and prevents blood flow to a portion of heart muscle, that portion suffers an infarction - an attack - and dies. Sometimes the heart can survive such an attack and continue to perform its function, although the dead area turns gray in color and is termed "ischemic." In the 1970's, an operation was devised by cardiologists and surgeons in Cleveland and Minneapolis to "reroute" blood past such occlusions. The operation is termed the coronary bypass. In the procedure, a portion of a leg vein (the saphenous) is borrowed from the patient and attached to the coronary artery - bypassing the blockage - to restore blood flow to the heart.

Have students locate and dissect free a portion of the left common artery (descending or circumflex branch) as if that portion had an occlusion. Then have the students make two cuts in the
vessel (completely severing it) at points away from the "occlusion." Ask them how difficult it would be for them to reconnect another vessel to each of these cut areas to restore the blood flow circuit!

Suggested Articles:
Debakey, Dietrich, et al., "Surgical Treatment of Coronary Heart Disease." Department of Medical Illustration, Baylor College of Medicine, Houston (1970).

LABORATORY LESSON II
INTERNAL ANATOMY OF THE RIGHT SIDE OF THE HEART

Heart chambers are lined with a thin, smooth membrane termed the endocardium. Feel this smooth membrane in the right atrium.

Coronary sinus - an opening on the posterior surface of the right atrial wall which empties blood from heart muscle. This opening can be observed ventral to right postcava at its juncture with the right atrium. Insert a blunt probe into this orifice, noting that it penetrates the coronary vein.

Fossa ovalis - a small depression found on the right atrial wall of the interatrial septum. It is the vestige of the foramen ovale, present in fetal life, which is an opening for blood to pass from the right atrium to the left atrium. In about 20% of human hearts, it fails to close completely but causes few functional problems.

Intercostal septum - a wall that separates the right and left atria. The two ventricles are separated by a corresponding interventricular septum.

Right postcava - note the opening of this great vein into the right atrium below that of the precava. Insert a blunt probe into the vessel's lumen and follow it to its cut end. This vessel may be difficult to observe due to its being cut at the time of preservation.

Right precava - a great vein that drains the head, neck, and thoracic limbs. This vein attaches to the right atrium. Locate its lumen on the superior position of this chamber toward the center of the heart.

Right Ventricle
(Copy Master 2)

Function: a chamber that constitutes the right inferior portion of the apex of the heart. Leading from its superior surface and directed upward to the left is the pulmonary artery, which carries blood to the lungs. Its opening is guarded by three semilunar valves. The right ventricle receives blood from the right atrium and pumps it to the lungs for oxygenation.

Terms for recognition and learning

Right ventricle - note the thickness of the muscle wall of this chamber. The walls are thicker than that of the right atrium but has only one-third the thickness of the left ventricle. Observe the endocardium.

Moderator bands - muscular bands of tissue connecting the wall of the right ventricle to the wall of the interventricular septum. The bands are partly muscular, partly tendinous, and vary greatly in mammals. The moderator bands' purpose is to resist over distention of the right ventricle. It is reduced in the human heart because of our upright posture.

Trabeculae carnea (trah'-beck'-lee car'-knee-ee) - muscular ridges and bands of the inner layers of the walls of both ventricles. The heart muscle forms these muscle bundles which are subdivided into three groups:

Pulmonary artery - arises at the left side of the base of the right ventricle. It curves upward and divides into two main branches (which are not visible in some specimens), one to each lung. Compare the thickness of this vessel and the aorta, with either the precava or postcava and pulmonary veins. Observe that arteries are thicker than veins.

Valves of the Heart
(Copy Master 2)

Description and function: Two types of valves are found in the heart: atrioventricular and semilunar.

The atrioventricular valves are thin, leaf-like structures, or cusps, located at the junction of both atria and ventricles. The bases of these leaflets form a ring about the opening, so that blood readily passes between them. Their free edges project inferiorty into the respective ventricular chambers, and, from these edges of the valves, the chordae tendineae extend to the papillary muscles. The right atrioventricular or tricuspid valve consists of three cusps; the left atrioventricular valve or mitral valve has two cusps. Upon contraction of the atria, blood readily flows through the openings between the leaflets, spreading them apart. When the ventricles contract, blood is forced upward against the outer surfaces of the valves, causing them to approximate each other, thus closing the opening and preventing return of the blood to the atria.

Figure 2
Cutting Diagram - Ventral Surface to Expose Right Side

Dissection Instructions:

1. Place the heart on the dissection tray, ventral surface facing you with the apex of the heart pointing downward.
2. Using a scalpel or scissors, make a cut along the right precava, posterior, toward and into the walls of the right atrium and atrium. Refer to Figure 2, outline #1. Cut just deep enough to go through only the outer atrial wall. Continue the cut, posteriorly in an arc, into the right ventricle until you reach the interventricular septum at the region of the anterior interventricular sulcus. With your fingers, push open the heart at the cut to examine the internal structures of the right ventricle. If the chambers have dried blood, rinse out the blood with tap water in order to observe the structures.

Right Atrium
(Copy Master 2)

Function: a chamber that constitutes the right superior portion of the heart. It is thin-walled and into it empty the veins which bring blood from all body tissues, except the lungs.

Terms for recognition and learning

Right atrium - note the thin muscular wall of this chamber. Follow the cut along the right precava toward the right atrium and observe the lack of any valve at the junction of these two structures.

Right auricle - a blind pouch extending from the right atrium. Examine the pouch with a blunt probe. Note the parallel comb-like ridges of muscle bundles, pectinate muscles, that are found at the auricle opening. Each auricle provides extra storage volume for its corresponding atrium.
INTERNAL ANATOMY OF THE LEFT SIDE OF THE HEART

Dissection Instructions:

(Figure 3)

1. Initiate cut #4, beginning along the superior side of the left atrium, downward, toward the left ventricle. Cut just deep enough to penetrate the left ventricular wall. Terminate the cut at heart's apex.

2. Initiate cut #5 across the middle of the left ventricle, upward, towards the aorta. Leave approximately a ¼-inch thickness between this cut and cut #2 made previously. Extend the cut along the aorta about 1 inch to expose the underlying aortic semilunar valve.

3. Begin cut #6 at the area on the left atrium where cut #4 was initiated. Extend this cut around and through the pulmonary artery, upwards, on the aorta to the right of cut #5.

4. Carefully lift up the resultant flap to expose the structures underneath. Note: Complete removal of the flap will involve severance of some of the chordae tendineae to the bicuspid valve, damaging it.

5. With the chambers of the left side of the heart now fully exposed, review the internal structures listed below. If needed, rinse out any dried blood present to better observe structures.

Left Atrium

(Copy Master 3)

Function - This chamber constitutes the left superior portion of the heart. It is slightly smaller than the right atrium, and its walls are thicker. It receives blood from four pulmonary veins which bring blood from the lungs. It opens inferiorly to the left ventricle by means of the left atrioventricular opening, which is guarded by the left atrioventricular or bicuspid valve.

Terms for recognition and learning

Left atrium - as with the right atrium, note the thickness of the chamber, the lack of any valves between it and the pulmonary veins. Note the presence of the interatrial septum separating the two atria, right and left.

Left auricle - a blind pouch extending from the left atrium. Examine the pouch with a blunt probe. Note the parallel comb-like ridges of muscle bundles, pectinate muscles, that are found at the auricle opening.

Pulmonary veins (4) - four veins open into the atrium behind and on the right side. Both the sheep and human have four such veins, others like the horse possess seven or eight. Insert a blunt probe into each of the vessels from inside the atrium and note their exit.

Left Ventricle

(Copy Master 3)

Function: a chamber that constitutes the left inferior portion of the heart. Its walls are very thick, for by its contractions the blood is forced through the aorta to all parts of the body except the lungs. From its superior surface the aorta arises, its opening being guarded by three semilunar (aortic) valves.

Terms for recognition and learning

Left ventricle - note the thickness of the heart muscle wall of this chamber. Compare its thickness to that of the right ventricle. Observe the endocardium and the following structures:

chordeae tendineae - note that these cords support the edge of each cusp of each of the two valves that comprise the mitral valve and extend into the left ventricle. Compare the number of cords on each cusp of the mitral valve with that of the tricuspid valve.

moderator bands - note that these bands are more numerous and thicker than their counterparts in the right chamber.

papillary muscle - compare the size of these projections of the ventricle wall with counterparts in the right ventricle. Note these muscles are flatter and heavier due to increased chamber pressure.

Continuation of Right Atrium and Right Ventricle Dissection

Terms for recognition and learning

Pulmonary semilunar valve - located at the point where the pulmonary artery makes its exit from the right ventricle. Use a blunt probe to examine the three valve cusps. Note the absence of chordae tendineae. Also observe the direction of action of the valves.

Tricuspid valve (right atrioventricular valve) - note the location of this valve between the right atrium and ventricle. Use a blunt probe to examine each of its three (tricuspid) cusps (valves) and chordae tendineae ("wonderous cords") attaching each cusp to papillary muscle.

Figure 3

Cutting Diagram - Ventral Surface to Expose Left Side
Aortic semilunar valve - located at the point where the aorta makes its exit from the left ventricle. Use a blunt probe to examine the three valve cusps. Note the absence of chordae tendineae. Also observe the direction of action of the valves.

Bicuspid valve (left atrioluminal valve) - note the location of this valve between the left atrium and ventricle. Use a blunt probe to examine each of its two (bicuspid) cusps (valves) and chordae tendineae attaching each cusp to papillary muscles.

Heart arteries - look for two holes in the wall of the aorta just above the bicuspid valve. These are openings for the bronchial branches and left subclavian arteries. Generally, these vessels are cut at the time of trimming prior to preservation. Insert a blunt probe into each opening to follow the route of each artery.

**Figure 4**

Longitudinal Section of Sheep Heart Illustrating Interventricular Septum

**Dissection Instructions**

Rotate the heart 90° and make an incision along the interventricular septum. Continue this longitudinal cut superiorly to the level of the atria. See Figure 4.

Interventricular septum: Note the thickness of this muscle wall between ventricles. Most of the thickness is due to the muscles of the left ventricle.

Note: Copy Master 4 (Human Heart, ventral aspect) is provided as an adjunct to comparative study.

**CONGENITAL CARDIOVASCULAR ANOMALIES**

Occasionally, the heart or its associated blood vessels are malformed during fetal life; the defect is called a congenital anomaly. Basically, there are three major types of congenital anomalies of the heart and associated vessels: (1) stenosis (narrowing) of the channel of blood flow at some point in the heart or in a closely allied major vessel, (2) an abnormality that allows blood to flow directly from the left heart or aorta to the right heart or pulmonary artery, thus bypassing the systemic circulation - this is called a lestright shunt, and (3) an abnormality that allows blood to flow from the right heart or pulmonary artery directly into the left heart or aorta, thus bypassing the lungs - this is termed a right-to-left shunt.

One of the most common causes of congenital heart defects is a virus infection of the mother during the first trimester of pregnancy when the fetal heart is being formed. German measles is a known cause of such defects.

Specific anomalies of the heart include:

Pulmonary stenosis - Often a child is born with pulmonary stenosis (a narrowing of the pulmonary artery) but without other congenital anomalies. Such severe pulmonary stenosis occasionally occurs that the right side of the heart is likely to fail at an early age because blood flow from the right ventricle into the lungs is greatly impeded. The right side of the heart dilates (grows larger), and the muscle becomes greatly enlarged in order to withstand the load. Also, a loud stenotic murmur is heard over the pulmonary valve area. In many cases, this stenotic (narrowed or constricted) area can be surgically enlarged so that the heart resumes normal function.

Patent ductus arteriosus (left - to - right shunt) - During fetal life, the lungs are collapsed, and the elastic factors that keep the alveoli collapsed also keep the blood vessels collapsed. As soon as the baby is born, the lungs inflate; the alveoli fill and resistance to blood flow through the vascular tree decreases tremendously allowing pulmonary arterial pressure to fall. Simultaneously, the aortic pressure rises due to cessation of blood flow through the placenta. As a result, blood flow through the ductus arteriosus ceases at birth, and blood even flows backward from the aorta to the pulmonary artery. This new state of blood flow causes the ductus to close within a few hours to a few days after birth. However, in about 1 out of 5000 babies, the ductus never closes, causing the condition patent (open) ductus arteriosus. As the child grows, reaching an age of about three years, a blowing murmur begins to be detected in the pulmonic area of the chest - the so-called "machinery murmur." This condition can be surgically corrected by closing the patent ductus.

Tetralogy of fallot (right - to - left shunt) - Most common cyanotic* malformation in babies, (commonly termed a "blue baby") consisting of four anomalies (four = tetra) in concert:

1. Aorta originates from the right rather than the left ventricle; or it overrides the interventricular septum.
2. Pulmonary artery is greatly reduced (stenosed) so that less than normal amount of blood passes from the right side of the heart to the lungs, instead of blood passing into the aorta.
3. Blood from the left ventricle flows through a ventricular septal defect (hole in the interventricular septum) into the right ventricle and then into the aorta or directly into the overriding aorta.
4. A greatly enlarged right ventricle develops. This is caused by the fact that the right side of the heart must pump large quantities of blood against the high pressure in the aorta. Subsequently, the musculature becomes highly developed, and the right ventricle enlarges.

The major physiological difficulty caused by tetralogy of fallot is a "shunting" of blood past the lungs without it becoming oxygenated. As much as 75% of the venous blood returning to the heart may pass directly from the right ventricle into the aorta without becoming oxygenated.

In recent years, this dysfunction has been treated successfully by surgery. One type of treatment is to create an "artificial" ductus arteriosus by making a small opening between the aorta and the pulmonary artery, thereby correcting the cyanosis and increasing the life expectancy of the child (from 1 - 10 years to 50 years). Another operation is to open the pulmonary stenosis and close the septal defect in those cases where possible.

* Cyanosis - a dark bluish or purplish coloration of the skin due to deficient oxygenation of the blood.