Functions
1. Pump
2. Blood transport system around body
3. Carries O2 and nutrients to cells, carries away waste products
4. Lymph system – returns excess tissue fluid to general circulation

Structure – Circulatory system involves:
- Heart
- Arteries
- Veins
- Capillaries
- Blood and lymph are part of circulatory system

Major Blood Circuits
- General (Systemic) circulation
- Cardiopulmonary circulation
The Heart

- Muscular organ
- Size of a closed fist
- Weighs 12-13 oz
- Location – thoracic cavity
- **APEX** – conical tip, lies on diaphragm, points left
- Stethoscope – instrument used to hear the heartbeat

Structure

- Hollow, muscular, double pump that circulates blood
- At rest = 2 oz blood with each beat, 5 qts./min., 75 gallons per hour
- Ave = 72 beats per minute
- 100,000 beats per day
- **PERICARDIUM** – double layer of fibrous tissue that surrounds the heart
- **MYOCARDIUM** – cardiac muscle tissue
- **ENDOCARDIUM** – smooth inner lining of heart
- **SEPTUM** – partition (wall) that separates right half from left half
Superior vena cava and inferior vena cava – bring deoxygenated blood to right atrium

Pulmonary artery – takes blood away from right ventricle to the lungs for $O_2$

Pulmonary veins – bring oxygenated blood from lungs to left atrium

Aorta – takes blood away from left ventricle to rest of the body

Chambers and Valves

- **SEPTUM** divides into R and L halves
- Upper chambers – **RIGHT ATRIUM** and **LEFT ATRIUM**
- Lower chambers – **RIGHT VENTRICLE** and **LEFT VENTRICLE**
- Four heart valves permit flow of blood in one direction
TRICUSPID VALVE – between right atrium and right ventricle

BICUSPID (MITRAL) VALVE – between left atrium and left ventricle

Semilunar valves are located where blood leaves the heart - PULMONARY SEMILUNAR VALVE and AORTIC SEMILUNAR VALVE
PHYSIOLOGY OF THE HEART

The heart is a double pump. When the heart beats…

Right Heart

Deoxygenated blood flows into heart from vena cava ➔
right atrium ➔ tricuspid valve ➔ right ventricle ➔
pulmonary semilunar valve ➔ pulmonary artery ➔
lungs (for oxygen)

Left Heart

Oxygenated blood flows from lungs via pulmonary
veins ➔ left atrium ➔ mitral valve ➔ left ventricle ➔
aortic semilunar valve ➔ aorta ➔ general circulation (to
deliver oxygen)
Blood Supply to the Heart – from **CORONARY ARTERIES**

Heart Sounds = *lubb dupp*

### Control of Heart Contractions

**SA (sinoatrial) NODE = PACEMAKER**
- Located in right atrium
- SA node sends out electrical impulse
- Impulse spreads over atria, making them contract
- Travels to AV Node

**AV (atrioventricular) NODE**
- Conducting cell group between atria and ventricle
- Carries impulse to bundle of His

**BUNDLE OF HIS**
- Conducting fibers in septum
- Divides into R and L branches to network of branches in ventricles (Purkinje fibers)

**PURKINJE FIBERS**
- Impulse shoots along Purkinje fibers causing ventricles to contract

**ELECTROCARDIOGRAM (EKG or ECG)**
Device used to record the electrical activity of the heart.

**SYSTOLE** = contraction phase
**DIASTOLE** = relaxation phase

Baseline of EKG is flat line

P = atrial contraction
QRS = ventricular contract
T = ventricular relaxation

**HOLTER MONITOR** – 24 hour EKG
CARDIOPULMONARY CIRCULATION – heart and lungs

SYSTEMIC CIRCULATION – from the heart to the tissues and cells, then back to the heart

Cardiopulmonary Circulation
“As the Blood Flows” Appendix MD08.03A

ARTERIOLES – small arteries
VENULES – small veins

Systemic Circulation
AORTA – largest artery in the body
- First branch is coronary artery
- Aortic arch
- Many arteries branch off the descending aorta
Blood Vessels
ARTERIES
- Carry oxygenated blood away from the heart to the capillaries
- Elastic, muscular and thick-walled
- Transport blood under very high pressure

CAPILLARIES
- Smallest blood vessels, can only be seen with a microscope
- Connect arterioles with venules
- Walls are one-cell thick and extremely thin – allow for selective permeability of nutrients, oxygen, CO₂ and metabolic wastes

VEINS
- Carry deoxygenated blood away from capillaries to the heart
- Veins contain a muscular layer, but less elastic and muscular than arteries
- Thin walled veins collapse easily when not filled with blood
- VALVES – permit flow of blood only in direction of the heart
- JUGULAR vein – located in the neck
**Blood Pressure**

Surge of blood when heart pumps creates pressure against the walls of the arteries

**SYSTOLIC PRESSURE** – measured during the contraction phase

**DIASTOLIC PRESSURE** – measured when the ventricles are relaxed

Average systolic = 120  
Average diastolic = 80

**PULSE** – alternating expansion and contraction of an artery as blood flows through it.

Pulse sites:

- **BRACHIAL**
- **CAROTID**
- **RADIAL**
- **POPLITEAL**
- **PEDAL**
Diseases of the Heart

ARRHYTHMIA (or dysrrhythmia) – any change from normal heart rate or rhythm

BRADYCARDIA – slow heart rate (<60 bpm)

TACHYCARDIA – rapid heart rate (>100 bpm)

Murmurs – indicates defect in heart valve – valves fail to close properly, causing gurgling or hissing sound.

MitrAL VALVE PROLAPSE – mitral valve closes imperfectly – symptoms occur in response to stress, including fatigue, PALPITATIONS (heart feels like it is racing) headache, chest pain, and anxiety.
Infectious Diseases of the Heart

Cause = virus or bacteria
Treatment = antibiotics

PERICARDITIS – inflammation of outer membrane covering the heart – symptoms are chest pain, cough, dyspnea (difficulty breathing), tachycardia, and fever.

MYOCARDITIS – inflammation of heart muscle – symptoms the same as pericarditis

ENDOCARDITIS – inflammation of the membrane that lines the heart and covers the valves, causes rough spots in the endocardium which may lead to the development of a thrombus

RHEUMATIC HEART DISEASE – childhood strep may lead to rheumatic fever, antibodies that form to protect from strep throat and rheumatic fever may attack the lining of the heart – especially the bicuspid or mitral valve. Valve becomes inflamed and may be scarred – valve narrows and won’t close properly.
Coronary Artery Disease

**ANGINA PECTORIS** – chest pain, caused by lack of oxygen to heart muscle, treat with nitroglycerin to dilate coronary arteries

**MYOCARDIAL INFARCTION**

- MI or heart attack
- Lack of blood supply to myocardium causes damage
- Due to blockage of coronary artery or blood clot
- Atherosclerosis – plaque build-up on arterial walls, or arteriosclerosis – loss of elasticity and thickening of wall.
- Amount of damage depends on size of area deprived of oxygen
- Symptoms – severe chest pain radiating to left shoulder, arm, neck and jaw. Also nausea, diaphoresis, dyspnea.
- Immediate medical care is critical
- Rx – bedrest, oxygen, medication
- Morphine for pain, tPA to dissolve clot
- Anticoagulant therapy to prevent further clots from forming
- Angioplasty and by-pass surgery may be necessary
CONGESTIVE HEART FAILURE
- Ventricles unable to contract effectively and blood pools in the heart
- Edema in lower extremities
- Blood backs up into lungs
- Rx – drugs to strengthen heart beat (digoxin) and diuretics to reduce fluid

CONDUCTION DEFECT – occurs when conduction system of heart affected

HEART BLOCK – interruption of message from SA to AV node

Heart Surgery

ANGIoplasty – procedure to help open clogged vessels – may also be called “balloon surgery.”

CORONARY BY-PASS – usually, a healthy vein from the leg removed and attached before and after the coronary obstruction, creating an alternate route for blood supply to the myocardium.
HEART TRANSPLANT

- Why? Irreparably damaged myocardium, valves or blood vessels, or baby/child with congenital heart defect
- Problem? Histocompatibility
- Rx? Immunosuppressants
- Artificial hearts? First used in 1982. What is the current status?

PACEMAKERS

Demand pacemaker – fires only when heart rate drops below programmed minimum

Who needs a pacemaker?

STENT

Tiny, expandable stainless steel tube that holds coronary artery open following angioplasty

CPR – cardiopulmonary resuscitation, used in the presence of cardiac arrest

DEFIBRILLATION – electrical shock to bring the heart back to a normal rhythm.

AED – automated external defibrillator
<table>
<thead>
<tr>
<th>Disorder</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ANEURYSM</strong></td>
<td>ballooning of an artery, thinning and weakening</td>
</tr>
<tr>
<td><strong>ARTERIOSCLEROSIS</strong></td>
<td>arterial walls thicken, lose elasticity</td>
</tr>
<tr>
<td><strong>ATHEROSCLEROSIS</strong></td>
<td>fatty deposits form on walls of arteries</td>
</tr>
<tr>
<td><strong>PHLEBITIS</strong></td>
<td>inflammation of lining of vein, accompanied by clotting of blood – symptoms are edema, pain and redness</td>
</tr>
<tr>
<td><strong>EMBOLISM</strong></td>
<td>traveling blood clot</td>
</tr>
<tr>
<td><strong>VARICOSE VEINS</strong></td>
<td>swollen, distended veins – heredity or due to posture, prolonged periods of standing, physical exertion, age and pregnancy</td>
</tr>
<tr>
<td><strong>HEMORRHOIDS</strong></td>
<td>varicose rectal veins</td>
</tr>
<tr>
<td><strong>PERIPHERAL VASCULAR DISEASE</strong></td>
<td>blockage of arteries, usually in legs</td>
</tr>
</tbody>
</table>
HYPERTENSION

- High blood pressure
- “silent killer” – usually no symptoms
- Condition leads to strokes, heart attacks, and kidney failure
- 140/90 or higher
- Higher in African-Americans and post-menopausal women
- Risk factors = smoking, overweight, stress, high fat diets, family history
- Treatment = relaxation, low fat diet, exercise, weight loss, medication

HYPOTENSION – low blood pressure, systolic <100

Diagnostic Tests

CARDIAC CATHETERIZATION – catheter fed into heart, dye injected, x-rays taken as dye moves through coronary arteries

STRESS TESTS – determine how exercise affects the heart, pt. on treadmill or exercise bike while electrocardiogram recorded

ANGIOGRAM – x-ray of a blood vessel using dye