

2009 Health Science–Training Handout

This event encompasses the **anatomy and physiology of the Nervous, and Circulatory Systems the effects of disease and drugs on their health.**

■ BASIC ANATOMY AND PHYSIOLOGY

- ❖ **Skeletal system**
- ❖ **Circulatory system**
- ❖ **Major diseases**
- ❖ **Treatment and prevention of diseases**

■ PROCESS SKILLS - observations, inferences, predictions, calculations, data analysis, and conclusions.

■ Event Parameters

- ❖ **Non-programmable calculators**
- ❖ **No other resources are allowed**

The following are suggested topics for state or regional contests. All topics will be used at the national level.

SKELETAL SYSTEM

All Competition Levels

- Bones of the axial and appendicular skeleton
- Names and the structure/formation of types of joints and the muscle and ligament attachments
- Cellular composition, structure and function of bones, bone marrow and cartilage
- Structures of bones in cross-section
- How to distinguish between types of vertebrae (e.g. cervical, thoracic and lumbar)
- The effects of exercise on the skeletal system and the diseases mentioned
- The diseases on each level from the cell to the whole person as listed for each disease/injury: osteoarthritis, osteoporosis, fractures, disc herniation, scoliosis, anterior cruciate ligament tears, medial collateral ligament damage

National Competition Only:

- Additional disorders: spinal Stenosis, achondroplasia, juvenile rheumatoid arthritis, spinal fractures, and ankylosing spondylitis, osteosarcoma
- Treatments and preventions for all conditions listed above (drugs, surgery, diet, etc.)
- Label the bones of the skull
- Salter-Harris fracture classification system

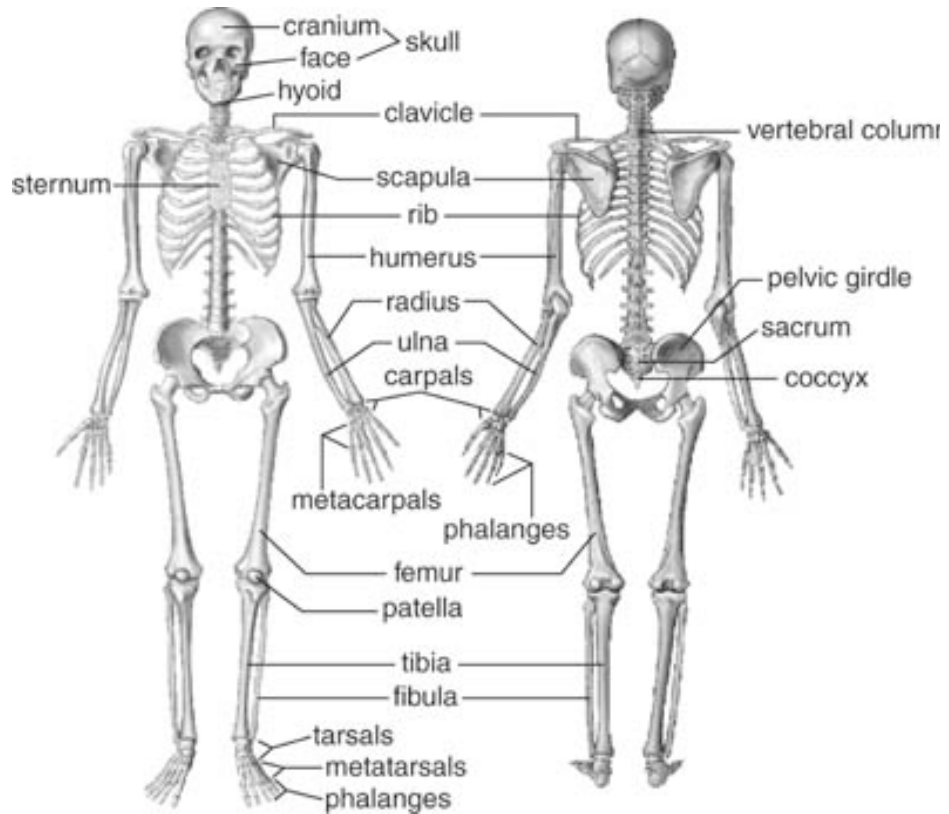
SKELETAL SYSTEM:

Functions

- Support & shape to body
- Protection of internal organs
- Movement in union with muscles
- Storage of minerals (calcium, phosphorus) & lipids
- Blood cell production

Skeleton

- 206 Bones
- **Axial skeleton:** (80 bones) in skull, vertebrae, ribs, sternum, hyoid bone
- **Appendicular Skeleton:** (126 bones)- upper & lower extremities plus two girdles
- Half of bones in hands & feet

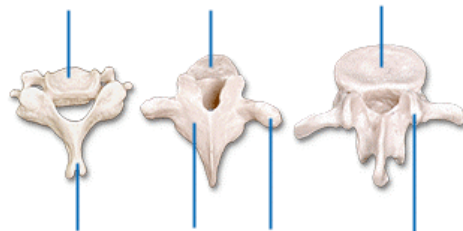


Types of Bone

- **Long bones:** longer than they are wide; shaft & 2 ends (e.g.: bones of arms & legs, except wrist, ankle & patella)
- **Short bones:** roughly cube-shaped (e.g.: ankle & wrist bones)
- **Sesamoid bones:** short bones within tendons (e.g.: patella)
- **Flat bones:** thin, flat & often curved (e.g.: sternum, scapulae, ribs & most skull bones)
- **Irregular bones:** odd shapes; don't fit into other classes (e.g.: hip bones & vertebrae)

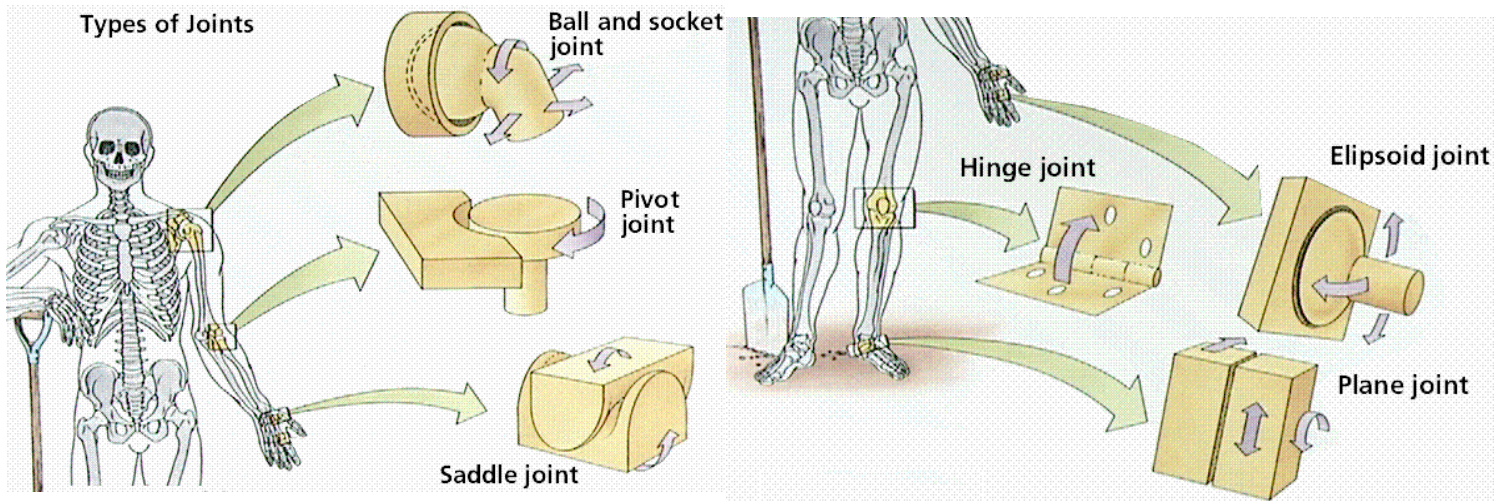
Types of Vertebrae:

- **Cervical (7)**- transverse foramina, bifid spinous processes, vertebral prominens
 - Atlas- 1st; supports head
 - Axis- 2nd; pivots to turn head
- **Thoracic (12)**- long spinous processes, rib facets
- **Lumbar (5)**- large bodies thick, short spinous processes



Types of Synovial Joints

- **Ball & Socket** - allows for complete range of motion Example: shoulder, hip
- **Pivot** – one bone pivots in the arch of another Example: Axis/Atlas, and proximal radioulnar joint
- **Saddle** – two directional movement between thumb and trapezium carpal
- **Hinge** – like door hinge – bending & extending Example: elbow, knee, finger joints
- **Ellipsoid (Condyloid)** – side to side and back & forth Example – radius end into carpal bones
- **Plane or Gliding** – least moveable – side to side only Examples: intercarpal & intertarsal joints, between vertebrae



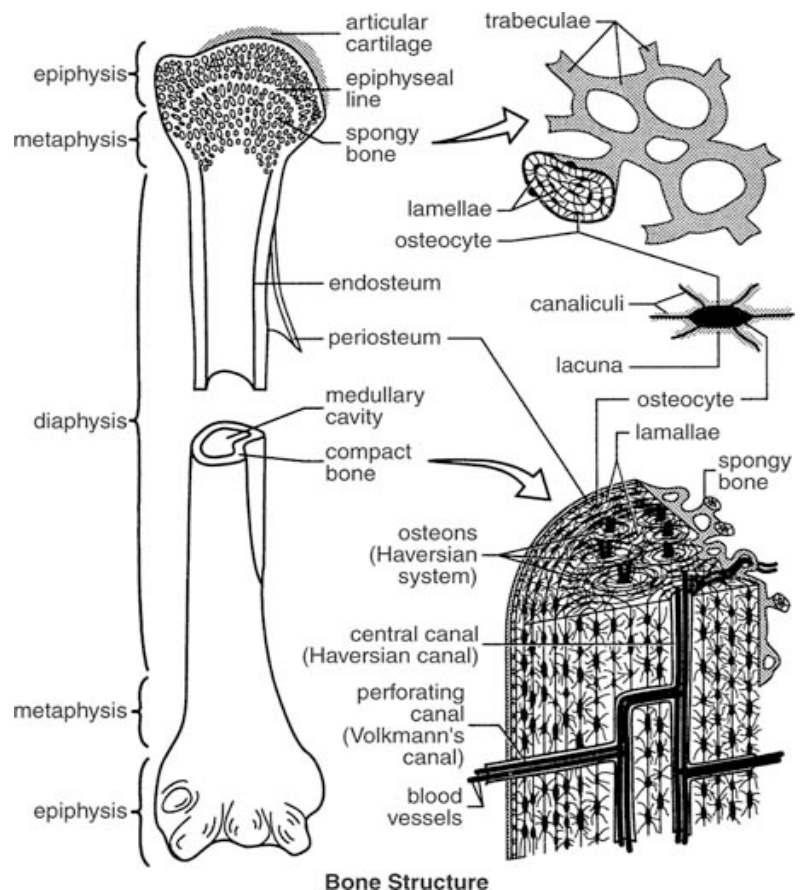
Cellular Structure of Long Bone

Compact bone

The hard outer layer of bones is composed of compact bone tissue, so-called due to its minimal gaps and spaces. This tissue gives bones their smooth, white, and solid appearance, and accounts for 80% of the total bone mass of an adult skeleton. Compact bone may also be referred to as dense bone or cortical bone.

Spongy bone

Filling the interior of the organ is the spongy bone tissue which is composed of a network of rod- and plate-like elements that make the overall organ lighter and allowing room for blood vessels and marrow. Spongy bone accounts for the remaining 20% of total bone mass, but has nearly ten times the surface area of compact bone.



Types of cells constituting the bone

- **Osteoblasts** – bone forming cells synthesize and secrete unmineralized ground substance and are found in areas of high metabolism within the bone
- **Osteocytes** – mature bone cells made from osteoblasts that have made bone tissue around themselves. These cells maintain healthy bone tissue by secreting enzymes and controlling the bone mineral content; they also control the calcium release from the bone tissue to the blood.
- **Bone lining cells** - made from osteoblasts along the surface of most bones in an adult. Bone-lining cells are thought to regulate the movement of calcium and phosphate into and out of the bone
- **Osteogenic cells** - respond to traumas, such as fractures, by giving rise to bone-forming cells and bone-destroying cells
- **Osteoclasts** – bone absorbing cell – large cells that break down bone tissue – important to growth, healing, remodeling

Red and Yellow Bone Marrow

The formation of blood cells, termed **hematopoiesis**, takes place mainly in the red marrow of the bones.

In infants, red marrow is found in the bone cavities. With age, it is largely replaced by yellow marrow for fat storage.

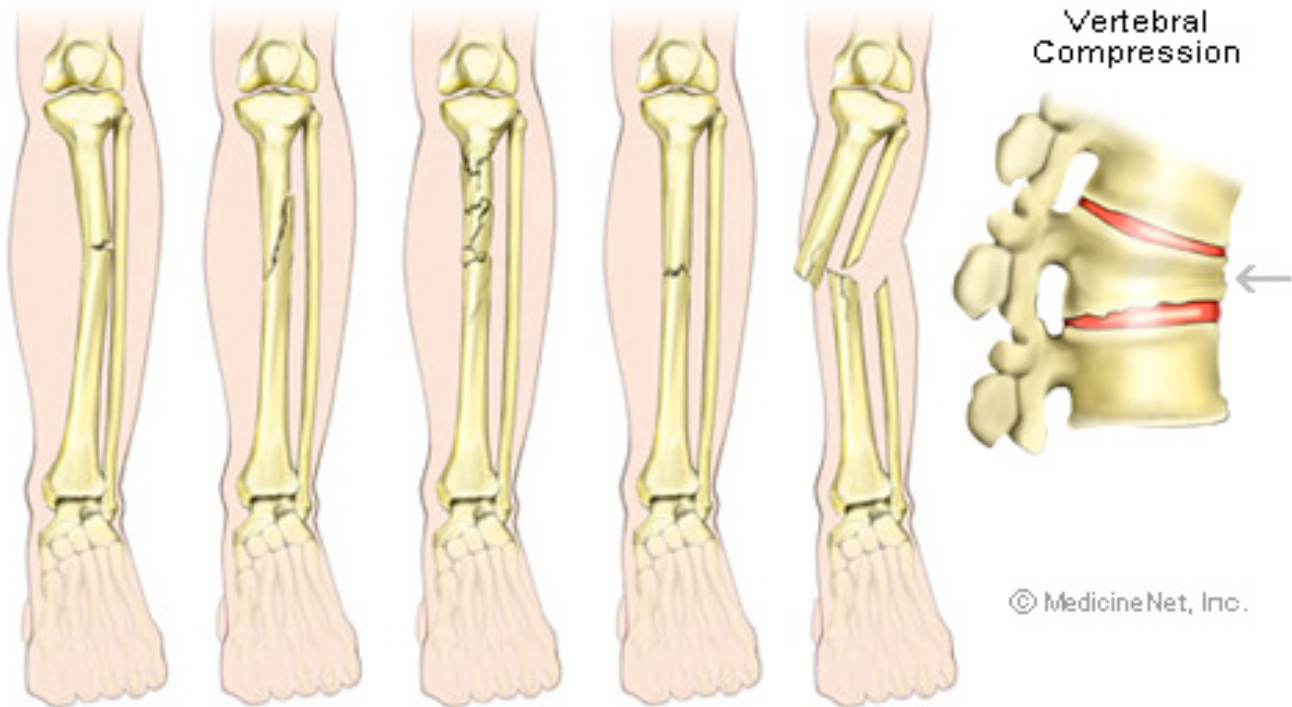
In adults, red marrow is limited to the spongy bone in the skull, ribs, sternum, clavicles, vertebrae and pelvis. Red marrow functions in the formation of red blood cells, white blood cells and blood platelets.

Cartilage – Characteristics and Types

- Mostly water; no blood vessels or nerves
- Tough, resilient
- New cartilage forms from chondroblasts
- Heal poorly
- **Hyaline Cartilages:** fine collagen fiber matrix- most abundant type- found in articular (movable joint) cartilages, costal cartilages (connect ribs to sternum), respiratory cartilages (in larynx & upper respiratory passageways) & nasal cartilages
- **Elastic Cartilages:** similar to hyaline cartilage, more elastic fibers (very flexible) – found in external ear & epiglottis (larynx covering)
- **Fibrocartilage:** rows of chondrocytes with thick collagen fibers; highly compressible with great tensile strength- found in menisci of knee, intervertebral discs & pubic symphysis

Typical Bone Fractures

Greenstick Spiral Comminuted Transverse Compound



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Typical Bone Fractures

Bone Repair Process

- Injury – broken blood vessels, hematoma
- Invasion of blood vessels & generalized cells (2-3 days)
- Fibroblasts develop (1 week)
- Chondroblasts develop
- Callus forms (4 weeks)
- Remodeling with osteoclasts (8 weeks)

Skeletal Disorders

- **Spinal Stenosis**-narrowing of the spinal column
- **Achondroplasia**-Defect in the formation of cartilage at the epiphysis of long bones (dwarfing)
- **Juvenile Rheumatoid Arthritis**-chronic inflammatory diseases involving the joints or other organs in children under 16
- **Ankylosing spondylitis**-immobility of a joint in the spine
- **Osteosarcoma**-malignant sarcoma of bone
- **Osteoarthritis**-A type of arthritis marked by progressive cartilage deterioration in synovial joints and vertebrae
- **Osteoporosis**-Loss of bone mass that occurs throughout the skeleton. Predisposes people to fractures
- **Disc Herniation**-Rupture of the soft tissue that separates two vertebral bones into the spinal canal
- **Scoliosis**-A lateral curvature of the spine.

CIRCULATORY SYSTEM

All Competition Levels:

- The Heart- chambers and valves of the heart, electrical stimulation of myocardio tissue
- Blood Vessels- arteries, arterioles, veins, venules, capillaries
- Blood- plasma, hematocrit, red blood cells, ABO-blood typing, Rhesus factor, oxygen transport, hemoglobin
- The Heart- pacemaker tissue, interpreting ECG (EKG) readings
- Measurement of the pulse rate and blood pressure
- Relevant calculations include systolic and diastolic pressure, mean arterial pressure, stroke volume and cardiac output
- Blood- platelets and blood clotting, regulation of blood plasma volume and acidity, MN-bloodtyping, basic genetics of ABO, Rh, and MN bloodtypes (ONLY) including paternity mysteries

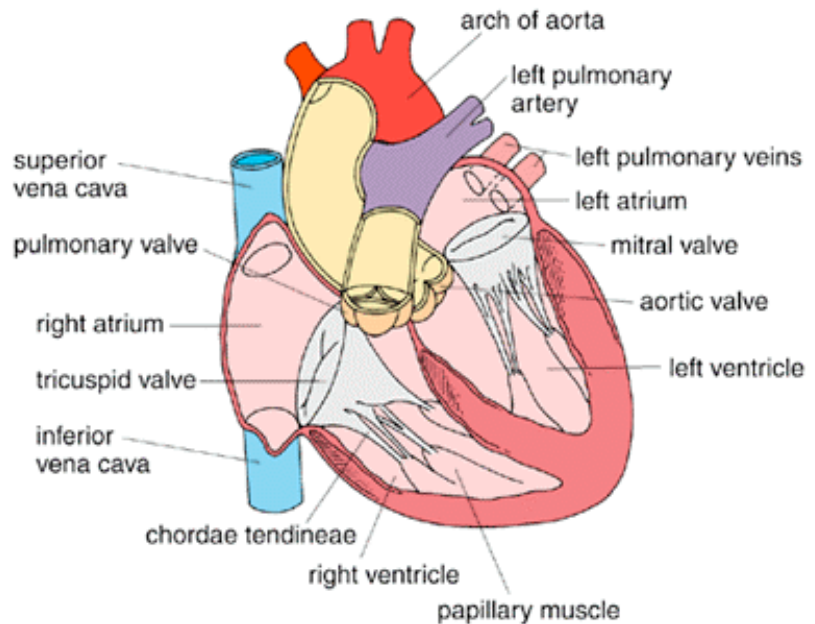
National Level Only:

- Blood Vessels- continuous vs. fenestrated capillaries, blood brain barrier
- Lymphatic System- white blood cells, lymph nodes, lymph ducts, lymphatic capillaries, lymphoid organs (spleen, thymus), tissue fluid

Circulatory System

Know:

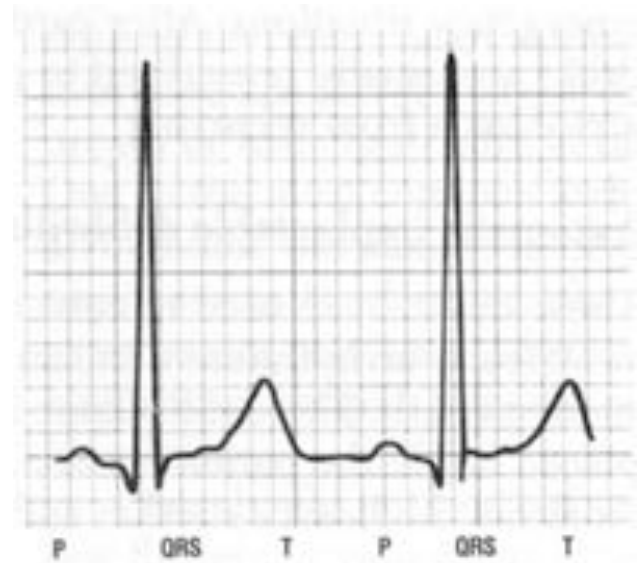
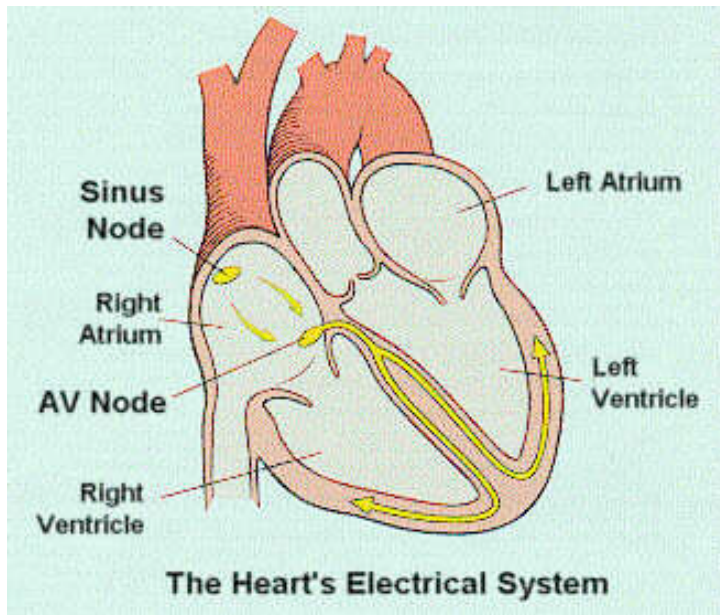
Flow of blood through system
Electrical system of the heart
Control of heart and activities
Blood flow, blood pressure
Blood vessels and their differences
Blood chemistry
Blood genetics
Lymph circulation
Disorders and treatment



Flow of Blood through the Body:

vena cava → right atrium → tricuspid valve → right ventricle → pulmonary valve → pulmonary artery → pulmonary capillary bed → pulmonary veins → left atrium → bicuspid (mitrial valve) → left ventricle → aortic valve → aorta → arteries → arterioles → tissue capillaries → venules → veins → vena cava

Electrical System of the Heart



Electrocardiogram (ECG or EKG) = record of spread of electrical activity through the heart

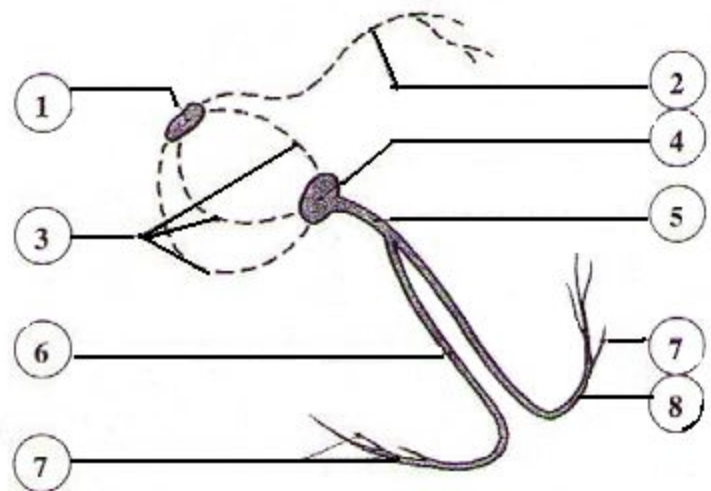
P wave = caused by atrial depolarization (contraction)

QRS complex = caused by ventricular depolarization (contraction) and atrial relaxation

T wave = caused by ventricular repolarization (relaxation)

ECG = useful in diagnosing abnormal heart rates, arrhythmias, & damage of heart muscle

1. **Sinoatrial Node (SA Node)**-Pacemaker of the heart
2. **Intra-atrial Pathway**-carries electricity through atria
3. **Internodal Pathway**-carries electricity through atria
4. **Atrioventricular Node (AV Node)**-Back up pacemaker. Slows conduction
5. **Bundle of His**-last part of conduction in atria
6. **Right Bundle Branch**-carry electricity through R. Ventricle
7. **Purkinje Fibers**-distribute electrical energy to the myocardium
8. **Left Bundle Branch**-carries electricity through L. Ventricle



Inherent rates for each of the three pacemaker sites

Sinus Node	60 to 100 beats per minute
AV Junction	40 to 60 beats per minute
Ventricles	20 to 40 beats per minute

Relevant Formulas

Stroke volume (SV) = milliliters of blood pumped per beat

Heart rate (HR) = number of beats per minute

Cardiac output (CO) = heart rate times stroke volume

$$CO = HR \times SV$$

Pulse pressure (PP) = the difference between systolic pressure (SP) and diastolic pressure (DP)

$$PP = SP - DP$$

Mean Arterial Pressure (MAP) (2 equations):

Formula 1: MAP = diastolic pressure + 1/3 pulse pressure

Formula 2: MAP = 2/3 diastolic pressure + 1/3 systolic pressure

Blood Vessels

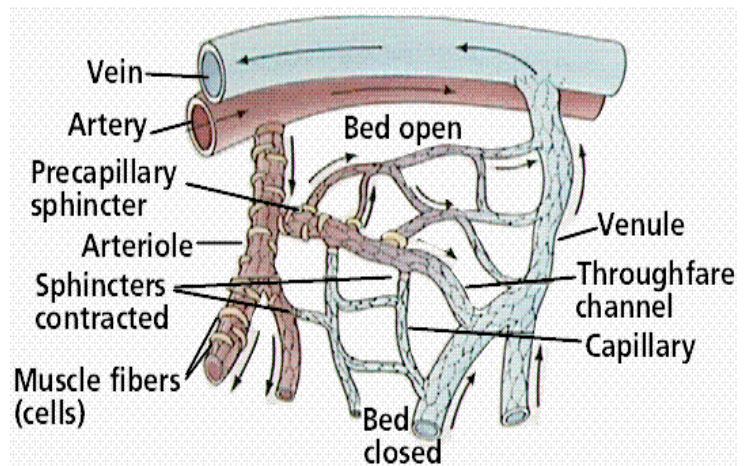
Arteries – largest vessels – carry blood from the heart.

Arterioles- smaller version of arteries, carry blood to the capillaries

Capillaries – smallest vessels, one cell thick, transfer materials to and from blood

Venules – small version of veins, carry blood from capillaries to veins

Veins – carry blood back to heart, have valves to stop backflow



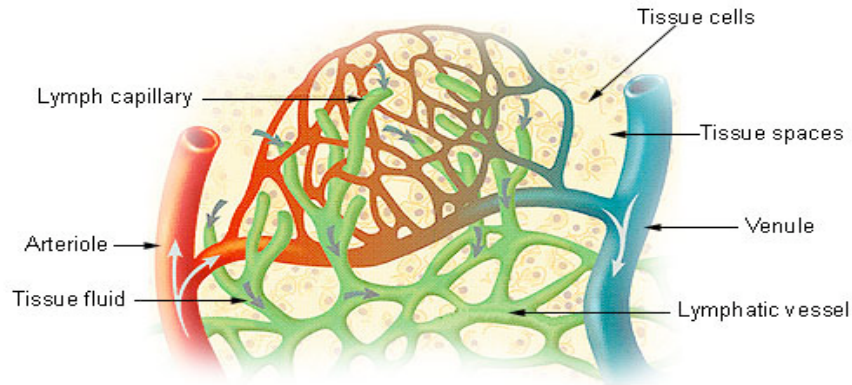
Blood – Functions

- Transportation:
 - oxygen & carbon dioxide
 - nutrients
 - waste products (metabolic wastes, excessive water, & ions)
- Regulation - hormones & heat (to regulate body temperature)
- Protection - clotting mechanism protects against blood loss & leucocytes provide immunity against

Lymph Vessels and Lymph Circulation

- Lymph vessels are thin walled, valved structures that carry lymph
- Lymph is not under pressure and is propelled in a passive fashion
- Fluid that leaks from the vascular system is returned to general circulation via lymphatic vessels.
- Lymph vessels act as a reservoir for plasma and other substances including cells that leaked from the vascular system

Lymph Capillaries in the Tissue Spaces



Interstitial fluid → Lymph → Lymph capillary → Afferent lymph vessel → Lymph node → Efferent lymph vessel → Lymph trunk → Lymph duct {Right lymphatic duct and Thoracic duct (left side)} → Subclavian vein (right and left) → Blood → Interstitial fluid...

Effects of Exercise on Circulatory and Skeletal System

Circulatory System

- Exercise decreases the risk of atherosclerosis; it decreases BP or causes a slower rise in BP
- Exercise decreases LDLs, decreases cholesterol, and increases HDLs

Skeletal System

- Exercise slows decline in minerals and maintains joint mobility
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Disorders of the Circulatory System

- **Arteriosclerosis** - a general term describing any hardening (and loss of elasticity) of medium or large arteries
- **Atherosclerosis**-Common form of arteriosclerosis-cholesterol, lipid, calcium deposits in the walls of the arteries
- **High Cholesterol**-elevated level of cholesterol. Increases risk of Coronary Heart Disease
- **Stroke**-Sudden loss of neurological function caused by vascular injury to the brain
- **Myocardial Infarction**-loss of living heart muscle as a result of coronary occlusion
- **high blood pressure** – hypertension
- **high cholesterol** – can cause deposits on walls of blood vessels

Practice Activity – Competition Design

Develop Stations which collect data, interpret actual experimental data, and/or address questions related to the function of the **skeletal** and **circulatory systems** in health and disease.

Formulate questions and answers related to these stations.