ANATOMY AND PHYSIOLOGY AND PATHOPHYSIOLOGY

CONTENTS

TYPES OF TISSUES AND FUNCTIONS
SKIN STRUCTURE AND FUNCTIONS
BLOOD AND IMMUNE SYSTEM
GASTROINTESTINAL SYSTEM
CARDIOVASCULAR SYSTEM
NERVOUS SYSTEM
SKELETAL SYSTEM
MUSCLES
TYPES OF TISSUES AND FUNCTIONS
Four basic types: epithelial (covering), connective (support), muscle (movement), and nervous (control/integration)

Tissue functions: protection, absorption, filtration, excretion, secretion, sensory reception

Epithelial Tissue: Covering/lining or glandular
Glandular; 2 basic types:
Endocrine - "ductless" - produce hormones
Exocrine - have ducts - sweat oil. saliva, bile enzymes, mucin (mucus)

Connective Tissue: support protection, insulation, transportation
characteristics: large extracellular matrix
Four Basic Classes of Connective Tissue:
1. Connective Tissue Proper
Loose - adipose, areolar - storage, support organs or vessels Dense - regular, elastic - tendons and ligaments
2. Cartilege: cushion, structure, support, laid down before bone
3. Osseous (bone) - bring in beef bone, compact – rigid, spongy - marrow
4. Blood: RBCs, WBCs, Platelets, Plasma matrix

Muscle Tissue: movement and support
characteristics: very cellular, very vascularized, contains myofilaments
3 Types: 1. Skeletal: extremely long fibers, striated, multinucleated - attached to skeleton - under voluntary control
2. Cardiac: uninucleate, striated, branched, connected at intercalated discs - heart only
3. Smooth Muscle: no striations, uninucleate - digestive tract, vessels, etc

Nervous Tissue: regulate and control body processes
characteristics: cell bodies with extremely long processes called axons and dendrites - supporting cells.
THE SKIN-STRUCTURE

THE FUNCTIONS OF THE SKIN
Regulation of body temperature (heat exchange)
Protection
Sensation
Excretion
Immunity
Synthesis of Vitamin D

The skin is an organ that consists of several types of tissues and performs specific activities.
The tissues comprising the skin are the epithelium of the epidermis and the connective tissues of the dermis.
The two principal layers of the skin are the epidermis and the dermis.

THE EPIDERMIS

The epidermis is organized into five distinct layers. These are the stratum corneum, stratum spinosum, stratum granulosum, stratum lucidum, and stratum basale.
Surface layer-no blood vessels

The outermost layer of the epidermis, the **stratum corneum**, is the primary barrier to permeation of most drugs and chemicals. The **stratum corneum** is between 10 and 50 mm thick (10 microns) and contains dead keratinized cells (keratinocytes) with lipid lamellae filling the intercellular regions.

**Skin color is due to melanin** in the epidermis, carotene in the dermis, and blood in the capillaries of the dermis. Differences in skin color are due to the amount of melanin produced and the extent of its dispersal. **Malignant melanoma**, (cancer of the melanocytes), is a particularly serious skin cancer. Liver, or age spots, are non-cancerous clusters of melanin.

Produced in the deepest layers of epidermis

The epidermis is composed of keratinized stratified squamous epithelium and contains several cell types.

The [cell types](#) found in the epidermis are keratinocytes, melanocytes, langerhans’ cells, and merkel cells.

**Skin Cell Types**

**Keratinocytes**
The most abundant cell type of the epidermis is the keratinocyte. These cells produce keratin proteins that provide some of the rigidity of the outer layers of the skin. Keratinocytes also form the bulk of the material in hair follicles. Dandruff and hair are dead keratinocytes.

**Fibroblasts**
The dermis is produced largely by fibroblasts, which during embryonic development are part of the mesenchyme. The fibroblasts produce the collagens and elastins that make skin very durable, from within.

**Melanocytes**
Melanocytes are cells in low abundance in the epidermis that produce the pigment melanin. The pigment made in melanocytes is transferred to the cells of the hair or epidermis.

Melanin absorbs harmful ultraviolet (UV) light before the UV radiation can reach the nucleus. Melanin protects the DNA in the nucleus from UV radiation damage. When melanin is produced and distributed properly in the skin, dividing cells are protected from mutations that might otherwise be caused by harmful UV light.

Differences in skin color are due mostly to differences in the types and amount of pigment in our keratinocytes. Skin darkening (tanning) from sun exposure is caused by
the movement of existing melanin into keratinocytes, and by increased production of melanin by the melanocyte.

**Langerhans cells**
These are star-shaped resident immune cells, macrophages. A macrophage is a cell that protects your body from injury or illness. Macrophages break up or destroy (phagocytise) the invading organisms. These macrophages process the invading organisms and present antigens to the T-lymphocytes. The T-lymphocytes are immune-system cells which ultimately identify a substance as foreign or dangerous to the body.

**Merkel's Cells**
Only a few of these cells are present in skin; they are more numerous in the palms and soles (feet). These cells are probably sensory mechanical receptors that respond to stimulus, such as pressure or touch.

Cells constantly dividing, producing daughter cells which are pushed upward to the surface, surface cells die and develop keratin.

**THE DERMIS** - true skin. (corium)

The dermis consists of two distinct regions. The outer, papillary region, is composed of loose, connective tissue and elastic fibers; and the inner, reticular layer, is composed of dense, irregularly-arranged connective tissue and collagenous and elastic fibers.

The outer layer contains nerve endings for touch, thermal sensations, pain, tickling, and itching.

**Accessory Organs of the Skin**
The accessory organs of the skin include hair, glands, and nails.

**Hair**
- It is distributed variously over the body where it functions in protection.
- Each hair is composed of a shaft and a root. Surrounding the root is the hair follicle, which is composed of two layers of epidermal tissue.

**Glands**
- Accessory glands of the skin include sebaceous (oil), sudoriferous (sweat), and ceruminous (wax) glands.
  - Sebaceous glands, with few exceptions, are associated with the hair follicle and secrete an oily substance called sebum which prevents skin dryness and water evaporation, and keeps the skin soft.
  - Blackhead or pimples represent enlargement of the sebaceous glands due to unreleased quantities of sebum.
  - Sudoriferous glands, or sweat glands, can be divided into apocrine glands and
eccrine glands.

**Apocrine glands** are found in the armpit, pubic region, and the pigmented area of the breasts.

**Eccrine Glands** are found throughout the skin except the lips, nail beds, and eardrums.

**Ceruminous glands** are modified sudoriferous glands present in the external ear. They produce a sticky substance called **cerumen** which provides a **barrier against foreign bodies**.

**Nails**
- Nails are hard **keratinized epidermal cells** over the dorsal surfaces of the terminal portions of the fingers and toes.

Most age related changes occur in the **dermis**.
Elastic fibers lose some elasticity, thicken and clump leading to the formation of wrinkles.

**Homeostasis and body temperature**
The skin helps to regulate the **homeostasis of body temperature** through a **negative feedback system**.

**Perspiration** from sweat glands and dilation of the superficial blood vessels help to remove **excess heat from the body**.

**Constriction** of the blood vessels in the skin aids in conserving heat when body temperature drops.
MOUTH

Tongue has bony attachments (styloid process, hyoid bone) attached to floor of mouth by frenulum. Posterior exit from mouth guarded by a ring of palatine/lingual tonsils. **Enlargement = sore throat, tonsillitis.**

Ducted salivary glands open at various points into mouth. This process involves teeth (muscles of mastication move jaws) and tongue (extrinsic and intrinsic muscles). Mechanical breakdown, plus some chemical (ptyalin, enzyme in saliva).

OESOPHAGUS

The oesophagus (about 10") is the **first part** of the digestive tract proper and shares its distinctive structure. Basic tissue layers of the gut are

1. **mucosa**- Innermost, moist lining membrane. **Epithelium** (friction resistant stratified squamous in oesophagus, simple beyond) plus a little connective tissue and smooth muscle.
2. **submucosa**. Soft connective tissue layer, blood vessels, nerves, lymphatics
3. **muscularis externa**. Typically circular inner layer, longitudinal outer layer of smooth muscle
4. serosal fluid producing single layer.

**STOMACH**

Cardioesophageal sphincter guarding entrance from oesophagus. **Pyloric sphincter** guarding the outlet is much better defined. Fundus, body and pylorus recognized as distinct regions. **Stomach secretes both acid and mucus** (for self protection). Surface area increased by **rugae**. Serves as a temporary store for food

**Stomach secretions**

<table>
<thead>
<tr>
<th>Secretions</th>
<th>Purpose</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mucus</td>
<td>Lubricant, protects surface from acid</td>
<td>Mucus cell</td>
</tr>
<tr>
<td>Intrinsic factor</td>
<td>Vitamin B12 absorption (in small intestine)</td>
<td>Parietal cell</td>
</tr>
<tr>
<td>Acid (H⁺)</td>
<td>Kills bacteria, breaks down food, converts pepsinogen</td>
<td>Parietal cell</td>
</tr>
<tr>
<td>Pepsinogen</td>
<td>Broken down to pepsin (a protease)</td>
<td>Chief cell</td>
</tr>
<tr>
<td>Gastrin</td>
<td>Stimulates acid secretion</td>
<td>G cell</td>
</tr>
</tbody>
</table>

**SMALL INTESTINE**  
(Duodenum, Jejunum, ileum)

**Duodenum**

First part of small intestine. C shaped 10” long and curves around head of pancreas and entry of common bile duct. **Chemical degradation of small controlled** amounts of food controlled by pyloric sphincter begins here, **enzymes secreted by pancreas** and duodenum itself aided by **emulsifying bile (which also lowers pH)**. Duodenal ulcers caused by squirting of acid stomach contents into duodenal wall opposite sphincter.

**Jejunum** (8 feet) and **ileum** (12 feet) continue degenerative process. **Surface area increased by plica circulares (circular folds)** carrying villi; cells of villi carry microvilli. Each villus has a capillary and a lacteal (lymphatic capillary) Absorption of digested foodstuffs is via these to the rich venous and capillary drainage of the gut. Towards the end of the small intestine accumulations of lymphoid tissue (**Peyer's patches**) more common. Undigested residue of food is rich in bacteria.

**LARGE INTESTINE**

Jejunum terminates at caecum. Caecum is small saclike evagination, important in some animals as a repository for bacteria/other organisms able to digest cellulose. A blind ending appendix may give trouble (**appendicitis**) if infected. The large intestine has three longitudinal **muscle bands** (**taenia coli**) with bulges in the wall (hastra) between them.
These may evaginate in the elderly to become **diverticuli** and infected in **diverticulitis**. The large intestine resorbs water then eliminates drier residues as faeces. Regions recognized are the **ascending colon**, from appendix in right groin up to a flexure at the liver, transverse colon, liver to spleen, descending colon, spleen to left groin, then sigmoid (S-shaped) colon back to midline and anus. Anus has voluntary and involuntary sphincter and ability to distinguish whether contents are gas or solid. No villi in large intestine, but many **goblet cells secreting lubricative mucus**.

**COLON**
The **colon** is the part of the large intestine from the cecum to the rectum. Its primary purpose is to extract water from feces. It consists of the ascending colon on the right side, the transverse colon, the descending colon on the left side, the sigmoid colon, and the rectum. Intestinal flora exists - mixing, absorption,

**ACCESSORY DIGESTIVE ORGANS**

**SALIVARY GLANDS**
Three pairs, parotid, submandibular, sublingual. Mumps begins as infective parotitis in the parotid glands in the cheek. The others open into the floor of the mouth. **Saliva** is a mixture of **mucus and serous fluids**, each produced to various extents in various glands. Also contains salivary **amylase**, (starts to break down starch) **lysozyme** (antibacterial) and IgA antibodies. In some mammals (and snakes!) saliva may be poisonous, quietening down living prey.

**PANCREAS**
**Endocrine and exocrine gland**. Exocrine part produces many enzymes which enter the duodenum via the pancreatic duct. **Endocrine part produces insulin, blood sugar regulator**.

**LIVER AND GALLBLADDER**
**Bile**, a watery greenish fluid is produced by the liver and secreted via the hepatic duct and cystic duct to the gall bladder for storage, and therefrom on demand via the common bile duct to an opening near the pancreatic duct in the duodenum. It contains bile salts, bile pigments (mainly bilirubin, essentially the **non-iron part of haemoglobin**) cholesterol and phospholipids. **Jaundice** (yellow skin) results from elevated bilirubin levels. **Bile salts and phospholipids emulsify fats**, the rest are just being excreted. Gallstones are usually cholesterol based, may block the hepatic or common bile ducts causing pain, jaundice.

**LIVER**
Multifunctional: important in this context since the capillaries of the small intestine drain fat and other nutrient rich lymph into it via the hepatic portal system.
ARTERIES

Arteries are blood vessels that carry blood away from the heart. In all cases but one, arteries carry oxygen-rich blood from the heart to the rest of the body. Thick walled, with extensive elastic tissue and smooth muscle and are under high pressure. The blood volume contained in the arteries is called stressed volume.

The only exception is the, pulmonary artery which carries oxygen-poor blood from the heart to the lungs.

Arterioles: The smallest branches of the arteries. Are the site of highest resistance in the cardiovascular system. Have smooth muscle wall that is extensively innervated by autonomic nerve fibers.

Arteriolar resistance is regulated by the autonomic nervous system. α1-Adrenergic receptors are found on the arterioles of the skin and splanchnic circulations.
β2-adrenaregic receptors are found on the arterioles of skeletal muscle.

Capillaries: Have largest total cross-sectional and surface area and thin walled. Consists of a single layer of endothelial cells surrounded by basal lamina. Capillaries are the site of exchange of nutrients, water and gases.

Capillaries are the primary exchange vessels within the body. Across the capillary endothelium, oxygen, carbon dioxide, water, electrolytes, proteins, metabolic substrates and by-products (e.g., glucose, amino acids, lactic acid), and circulating hormones are exchanged between the plasma and the tissue interstitium surrounding the capillary.

Systemic circulation

Systemic circulation begins with the aorta the major artery that travels from the heart down the length of the chest and abdomen. The aorta begins by extending upward from the heart. This section is called the ascending aorta. Then it forms a “u,” known as the aortic arch. The aortic arch supplies blood to the upper chest area, including the:

From the aortic arch, the aorta travels downward through the chest and abdomen as the descending aorta.

Ascending aorta: One of four sections of the aorta, the main artery that carries oxygen-rich blood from the heart. This section leaves the heart and then branches into the left and right coronary arteries that carry oxygen-rich blood back to feed the heart muscle.

This forms U shape, the top shape is known as aortic arch, if birth defect causes this section to become constricted or pinched this condition is called coarctation of aorta.

Descending aorta, which includes the thoracic aorta (down the length of the chest) and abdominal aorta (down the length of the abdomen), supplies blood to the chest and lower portion of the body. The descending aorta splits off into two smaller iliac arteries that provide blood to the pelvis and lower limbs.

Carotid artery: which supplies blood to the head and neck. These arteries supplies brain with blood. If they become clogged, resulting in stroke. A buildup of plaque within the carotid arteries (carotid artery disease) significantly increases the risk of stroke.

Middle cerebral arteries: These are branches of internal carotid arteries that supply lateral regions of the brain with oxygen-rich blood. A blood originating in the carotid artery can break free and become lodged in the brain causing a stroke. The middle cerebral arteries are common sites of stroke.

Subclavian arteries: which supply blood to the upper chest and arms.
Coronary arteries; which supply the heart itself with oxygen-rich blood.

These smaller arterial branches carry oxygen-rich blood into the regions farthest from the heart, such as the fingertips, toes and scalp. As the branches continue to narrow (into arterioles), they develop into the smallest blood vessels in the body, which are known as capillaries. A capillary is so narrow that red blood cells must pass through it one at a time. There are more than a billion capillaries in the body, with a total surface area of about 1,000 square miles.

Capillaries play a vital role in circulation because they are the sites where the actual exchange of nutrients and waste products takes place at the cellular level. Each red blood cell nourishes the body’s cells with oxygen, water and glucose, and then carries waste products away. The blood (now oxygen-poor and full of waste products) travels from the capillaries into the venules and the veins back to the heart.

Subclaviun arteries: These arteries supply the upper chest and arms with blood.
Venae cavae: These are the large veins that empty the oxygen poor blood from the body into the right atrium of the heart.

Internal thoracic arteries: The portion of arteries is often used in bypass graft operation. Coronary arteries: These arteries are first branch of aorta. When this arteries become blocked blood flow to the heart is limited resulted in weakened blood flow or heart attack.

Renal arteries: These arteries supply blood to the kidneys, Hypertension can cause to kidneys to cause malfunction and they may become permanently damage.
**Iliac arteries**: channels to blood to the pelvis and lower extremities. If these are arteries and their branches become blocked a person may experience in walking (a condition called **claudication**)

**Femoral arteries**: The femoral arteries help drugs to the legs. During catheter-based procedure, catheter is often inserted femoral arteries and guided to heart.

### VEINS

Returns blood to the heart. The **vena cava largest vein**.
Veins are thin-walled and under low pressure. Contains the **highest proportion of blood** in the cardiovascular system.

The blood volume contained in the veins is called unstressed volume. The greatest volume resides in the venous vasculature, where 70-80% of the blood volume is found.

**Veins** are blood vessels that carry blood toward the heart. **Veins** carry **oxygen-poor** blood from the rest of the body to the heart in all cases but one. The only exception is the set of pulmonary veins that carry oxygen-rich blood from the lungs to the heart.

Oxygen-poor blood leaves the body’s cells through the capillaries and travels to small veins called **venules** and then larger veins, such as the **saphenous veins** in the **legs** and **hips**. Veins in the lower part of the body connect with the **inferior vena cava**, and veins in the upper part of the body connect with the **superior vena cava**. Both of these **venae cavae** empty into the upper-right chamber of the heart.

**Jugular veins**: These veins transport oxygen poor-blood from the heart neck region back to the heart.

**Suphenous vein**: This vein is commonly used as bypass vessel in coronary bypass surgery.

**Venules**: Formed from merged capillaries. venules which also serve as exchange vessels, particularly for large macromolecules as well as fluid. Like the resistance vessels, are capable of dilating and constricting, and serve an important function in regulating capillary pressure.

<table>
<thead>
<tr>
<th>Arteries (blood with oxygen)</th>
<th>Veins (blood with carbon dioxide)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Carotid artery</strong>: carries blood to head</td>
<td><strong>Jugular veins</strong>: carries blood from head</td>
</tr>
<tr>
<td><strong>Aorta</strong>: branches to supply blood to most arteries throughout the body</td>
<td><strong>Superior vena cava</strong>: collects from veins in upper body</td>
</tr>
<tr>
<td></td>
<td><strong>Inferior vena cava</strong>: collects blood from veins in lower body</td>
</tr>
</tbody>
</table>

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**Pulmonary artery**: carries blood to arms

**Pulmonary veins**: carries blood from lungs to heart

**Branchialis artery**: carries blood to lung

**Cephalic vein**: carries blood from arms

**Femoral artery**: carries blood to legs

**Femoral vein**: carries blood from leg

### DIRECTION OF BLOOD FLOW:

From the lungs to the left atrium via the pulmonary vein
From the left atrium to the left ventricle through the mitral valve
From the left ventricle to the aorta through the aortic valve
From the aorta to the systemic arteries and the systemic tissues (i.e. cerebral, coronary, renal splachnic, skeletal muscle, and skin)
From the tissues to the systemic veins and vena cava
From the vena cava (mixed venous blood) to the right atrium
From the right atrium to the right ventricle through the tricuspid valve
From the right ventricle to the pulmonary artery
From the pulmonary artery to the lungs for oxygenation

<table>
<thead>
<tr>
<th>Vessel type</th>
<th>Function</th>
<th>Diameter (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aorta</td>
<td>Pulse dampening and distribution</td>
<td>25</td>
</tr>
<tr>
<td>Large arteries</td>
<td>Distribution</td>
<td>1-4</td>
</tr>
<tr>
<td>Small arteries</td>
<td>Distribution and resistance</td>
<td>0.5 –1.0</td>
</tr>
<tr>
<td>Arterioles</td>
<td>Resistance (pressure/flow regulation)</td>
<td>0.01-0.50</td>
</tr>
<tr>
<td>Capillaries</td>
<td>Exchange</td>
<td>0.006-0.0010</td>
</tr>
<tr>
<td>Venules</td>
<td>Capacity function (blood volume)</td>
<td>0.01-0.5</td>
</tr>
<tr>
<td>Veins</td>
<td>Capacity function (blood volume)</td>
<td>0.5-5.0</td>
</tr>
<tr>
<td>Vena cava</td>
<td>Collection</td>
<td>35</td>
</tr>
</tbody>
</table>

### BLOOD PRESSURE AND VOLUME:

The mean aortic pressure is about **95 mmHg** (millimeters of mercury) in a normal individual.
The **aorta** and **arteries** have the highest pressure.
Blood pressure in capillaries is 25-30 mmHg, depending upon the organ. The pressure falls further as blood travels into the veins and back to the heart.

Pressure within **the thoracic vena cava near the right atrium is very close to zero**, and fluctuates from a few mmHg negative to positive with respiration.

**Systolic pressure** (S): The highest arterial pressure during a cardiac cycle and is measured after the heart contracts (systole) and blood is ejected into arterial system.
**Diastolic pressure** (D): is the lowest arterial pressure during a cardiac cycle and is measured when heart is relaxed (diastole) and blood is returning to the heart via the veins.

For **healthy person** systolic pressure is 120 mmHg and diastolic pressure is 80 mmHg. 

\[
\frac{S}{D} = \frac{120}{80} \text{ mm Hg}
\]

then the mean arterial pressure will be approximately 93 mmHg.

High blood pressure is >140 mm Hg and higher for systolic.

Doctors will say your blood pressure is too high when it measures 140/90 mmHg or higher over time

People who have blood pressure in the range of 130-139/85-89 mmHg may be at risk of developing HBP

**ARRHYTHMIAS (DYSRHYTHMIA)**

Cardiac arrhythmias are related to abnormal electrical activity within the heart resulting in either altered rhythm or impulse conduction.

**MYOCARDIAL ACTION POTENTIAL CURVE**

Myocardial action potential curve reflects action potential, that describe electrical activity of five phases.
**Phase 0: Rapid Depolarization:** $Na^+$ enters the cell  
**Phase 1: Early rapid repolarization:** $K^+$ leaves the cell  
**Phase 2: Plateau:** $Ca^{2+}$ enters the cell  
**Phase 3: Final rapid repolarization:** $K^+$ pumped out of the cell as  
**Phase 4: Slow depolarization:** $K^+$ inside the cell and $Na^+$, $Ca^{2+}$ out side the cell

### ELECTROCARDIOGRAPH WAVE FORMS

The electrical activity occurred during depolarization and repolarization transmitted through electrodes attached to the body and transformed by an electrocardiograph (ECG) into series of waveforms;

- **P wave**: indicated atrial depolarization  
- **PR interval**: indicates the spread of the impulse from the atria through Purkenje fibres.  
- **QRS complex**: indicates ventricular depolarization  
- **ST segment**: indicates phase 2 of the action potential- the absolute refractory period.  
- **T wave**: shows phase 3 of the action potential-ventricular depolarization.
DIURETICS MECHANISM OF ACTION

**Thiazide diuretics**

Inhibits the NaCl transporter in the distal tubule, resulting in an increase in the excretion of Na+Cl-/H2O.

**Loop diuretics**

Inhibit the Na+/K+/2Cl- channel in the Thick ascending loop.

**Potassium sparing diuretics**

Inhibit Na+ reabsorption and K+, resulting in decreased Na+ reabsorption and K+, H+ excretion.
SKELETAL SYSTEM

- Skull
- Clavical
- Scapula
- Sternum
- Ribs
- Vertabral Column
- Pelvic Girdle
- Sacrum
- Femur
- Patella
- Fibula
- Tibia
- Humerus
- Radius
- Ulna
- Carpals
- Metacarpals
- Phalanges
KNEE
The critical elements of the knee include bones, ligaments, tendons, and cartilage. The femur is the large bone of the thigh. The tibia is the large bone of the lower leg, while the fibula is the smaller bone in the lower leg. Two ligaments are found on the sides of the knee, specifically, the Medial Collateral Ligament and Lateral Collateral Ligament. Inside the knee two ligaments connect the femur and tibia. They are the Posterior Cruciate Ligament and Anterior Cruciate Ligament.

HIP
The pelvic girdle consists of two coxal bones which unite in the front with the symphysis pubis and in the back with the sacrum. The coxal bones are composed of the ilium, the ischium, and the pubis.

SHOULDER
The bone structure of the shoulder consists of the following:
Scapula (shoulder blade)
the clavicle (the collar bone)
humerus (upper arm).
The Spine

SPINE
The spine consists of vertebrae, with shock absorbing discs (ligaments) in between, and the spinal cord which is the source of all nerve roots emanating from the spine. Nerve impingement in the spine occurs because of herniation of the disc or discs (multiple herniation) where the exterior of the disc (the annulus) tears causing the interior of the disc (the polposus) to explode into the spinal cord, pressing the nerve roots, and radiating pain through the associated muscles. These tears can heal through the formation of scar tissue. However, scar tissue is not as strong as the original disc, and continuing disc tears can create a downward spiral culminating in disc degeneration. As this degeneration progresses the disc core (the nucleus pulposus) loses some of its water content, becomes thick, and ceases its absorptive function, leading to a possible collapse of the disc. Bone spurs forming on the vertebra can be a normal bodily adaptation. Eventually, these bone spurs can envelope the nerve leading to the most serious and degenerative stage of back problems which is spinal stenosis, which is a narrowing of the spinal canal. This can touch a multitude of nerves and create tremendous pain, lost mobility and other dysfunction in the areas supplied by the affected nerves.