1. **At the beginning of the semester, I talked about the 4 essential concepts one must understand in order to comprehend Anatomy and Physiology. What is the significance of each of the 4 essential concepts discussed in class? Provide an example of how each concept relates to material covered in the material for exam one.**

The four essential concepts to understand and comprehend for Anatomy and Physiology are the Principle of Complementarity, physiology uses/depends on gradients, chemical emphasis on how we regulate protein function by regulating its shape, and negative feedback regulation is essential to homeostasis. First, the principle of complementarity states that the function is dependent on the form or that anatomy (the structure) determines the physiology (the function) and is true at the cellular and gross level. For example, and erythrocyte, or red blood cells, are relatively small in shape and size to allow for a much greater surface area for a large volume. They also lack mitochondria and only generate ATP through anaerobic processes. This way, they do not consume any oxygen making them the efficient oxygen transporters the human body needs.

The second essential concept is that physiology uses/depends on gradients whether it be ion gradients across a plasma membrane or pressure gradients such as blood pressure. This concept states that movement will occur from a level of high concentration to a low concentration. For example, during diffusion, or passive transport, molecules easily flow from an area of high concentration to an area of low concentration without the need for energy, ATP. Without the need for energy or other factors, molecules will diffuse from an area of high concentration to an area of low concentration.

The third concept is chemical emphasis on how we regulate protein function by regulating it's shape. This is in relation to the proteins in our body. For example, enzymes catalyze a reaction by speeding up or slowing down a reaction. When a protein is in shape a, then it is dormant, but when an enzyme binds to the protein, it changes its shape into shape b and turn on or activate that protein. For example, the enzyme amylase will attach itself to its respective protein causing the protein to activate and help in the breakdown of complex sugars in the saliva to aid digestion.

The fourth concept is a negative feedback loop, or negative feedback regulation. This concept is essential to homeostasis, is a dynamic state, and will therefore always be ever-changing. In a negative feedback loop, a stimulus causes an imbalance to your body. Then a receptor will detect this stimulus and the information will travel up your nervous system where you will integrate that information (becoming consciously, or subconsciously aware) so that the body can generate a course of action or output using an effector. An effector will act to eliminate the stimulus and once it is eliminated, the body returns to homeostasis. Thermoregulation is a good example. When you get hot, your skin begins to warm up and your skin temperature rises. The temperature sensitive receptors send information to your brain, or control center, to act on the information by an efferent pathway. The efferent pathway will send a message to the sweat glands and you begin sweating. You may even feel encouraged to step into the shade or a cooler area. The sweat cools your body down and restores homeostasis by eliminating the stimulus. Similarly, , when your body temperature becomes cooler than normal, the temperature receptors detect the coldness by efferent pathways so it can send information to the brain. The brain will then act upon this stimulus by using efferent pathways

to send information to the skeletal muscle to cause you to shiver. This causes your muscles to contract and relax in a rapid order to release a lot of heat and raise body temperature to achieve homeostasis. The stimulus is then eliminated which will result in the stopping of shivering.

2. **Describe the synthesis of a tubulin molecule and then describe the synthesis of a collagen molecule. Then compare and contrast the synthesis of a cytosolic protein and a secreted protein.**

Tubulin is an element of the cytoskeleton. It disassembles for meiosis or mitosis divisions by helping to separate the chromosomes. In axons, an increased concentration causes the synthesis of tubulin from membrane-bound or free ribosomes. Collagen is found in all connective tissue and is the single most abundant protein in the body. It is responsible for the strength of bones, tendons, and ligaments and is made up of helical tropocollagen molecules that are packed together to form a strong ropelike structure. Inside the endoplasmic reticulum (ER) of a fibroblast cells, a pre-pro-collagen alpha chain is translated on a ribosome and the hydroxylation of Pro and Lys formed. The ER releases the chain from the ribosome into the cytosol where glycosylation (a modification of the protein) occurs. Three procollagen chains twist into a triple helix formation and are secreted from the cell to cross link and produce collagen fibers.

A cytosolic protein is a protein that can function inside the cell and is the result of transcription and translation. In the nucleus transcription occurs when an RNA polymerase transcribes a copy of a DNA gene (the three-coded region) to produce an mRNA transcript. In the nucleus, the mRNA transcript is edited. The introns are then cut out and the exons are spliced together. Then, the transcript is transported out to the cytosol where ribosomes (RNA associated with protein) translate the mRNA into a protein with the aid of tRNA. tRNA is a molecule with an amino acid that helps select the appropriate amino acid that is coded in the mRNA. Then, the ribosomes select and binds on to mRNA at the start cite where it starts to read and move forward in 3 base pair segments. The ribosome has 3 internal sites (a, p, and e site). At the A site (initiation), correct tRNA is selected with the correct amino acid. At the P site (elongation), there is transfer of the amino acid string to this new tRNA. Then the E site (termination) kicks out the old transfer RNA. Portions of mRNA moves 3 codon segments over and repeats the process until reaching the termination codon. This is Translation. This process makes a cytosolic protein (an enzyme, structural protein, regulatory protein, etc).

There are differences in the synthesis of a secreted protein such as the organelles. In this synthesis, there is use of the rough ER, which is well developed in secretory cells, the Golgi apparatus, and vesicles. The synthesis beings in the pores of the ER membrane with associated proteins known as receptors. The signal recognition particle (SRP) is a small protein that can be recycled and is essential in synthesizing secreted and packaged proteins. The SRP leads the ribosome in the early elongation process to move to the rough ER where the SRP will bind to the SRP receptor. As the ribosomes continues translation (elongation) the growing polypeptide can be inserted through the pore at the receptor site and into the lumen of the ER. The SRP causes allow the ribosomes to associate with the ER. The ribosome then translates the mRNA into proteins which are put into endoplasmic reticulum. Once the SRP is cleaved off the protein

is folded into its correct shape. Then proteins pinch off into a vesicle and are transported to the Golgi apparatus. The translation step occurs the same as the synthesis of cytosolic proteins, but the SRP which binds to the peptide chain, causes everything to move to the ER. From the rough ER, the vesicle will pinch off and migrate to the Golgi apparatus which has two faces: the cis face and trans face. The Cis face receives the vesicle from the rough er and the trans face has another vesicle from leaving the Golgi apparatus. In the Golgi, additional modifications to the proteins occur. These proteins are sent to specific parts of the ER where vesicles are formed with similar proteins. These proteins are secretion proteins and can also become the membrane of the cell. If it isn't a cytosolic protein, the extra steps are the SRP moving the ribosome to the rough ER where the peptide is put into the lumen and modified, stuffed into a vesicle, shipped off to the Golgi where it is further modified, concentrated, and packaged in a new vesicle for secretion.

3. **What is connective tissue and how are the 4 types of connective tissue related? Include a discussion of the characteristic and structural components of connective tissue.**

Connective tissue is abundant and diverse and is laid early in the embryonic development. It is essential for growth and development of the human being and is important in all stages of life. The major functions of connective tissue are binding and support, protection (bone, ribcage), insulation (found as adipose tissue and to retain heat and cushion organs such as kidneys), and the transportation of substances such as heat within the body and red blood cells. The common properties of connective tissue are the common origin of the tissue that result from embryonic cells known as mesenchyme. Mesenchymes are responsible for all the cells that make up connective tissue cells (blood cells, adipose tissue cells), extracellular matrix, and most are non-cellular, and degrees of vascularity which is lack of uniformity.

The four cellular descendants which are fibroblasts (cells that are still mitotically capable, cell has not exited the cell cycle and is still capable of going through the subphases of interphase and mitosis), chondroblasts, osteoblasts, and hematopoietic stem cells.

First, fibroblasts go through division and produce the extracellular matrix while fibrocytes maintain that area. They give rise to **connective tissue proper** which have two kinds: loose connective tissue and dense connective tissue. Loose connective tissue includes areolar, adipose, and reticular tissue while dense connective tissue include regular, irregular, and elastic tissue.

Secondly, there are chondroblasts which are responsible for laying down new cartilage. Once they are encompassed to maintain an area, it becomes cartilage. Cartilage limits access to nutrients and becomes a chondrocyte. They function to maintain an area as cartilage as hyaline cartilage, fibrocartilage, and elastic cartilage.

Thirdly, there are osteoblasts which once encompassed become osteocytes. They turn into compact bone and spongy (cancellous bone).

And fourthly, there is the Hematopoietic stem cell which when encompassed, becomes Blood cells and macrophages. Stem cells form bone marrow which produces red blood cells that carry oxygen throughout the body. They also generate a smaller white blood cell

The characteristics and structural components of connective tissue include the structural elements such as ground substance and fibers. The ground substance in the fibers make up the

extracellular matrix. cells secrete the ground substance and fibers into extracellular fluid. Ground substance is unstructured material that fills the space between the cells and are made up of cell adhesion proteins that connect the tissue cells to the matrix elements. Also, proteoglycans are another protein that makes up ground substances. They have a protein core that glycosaminoglycans (GAGs) which attach to and intertwine and trap water and regulate GS viscosity. It lastly is made up of interstitial fluid. Fibers can be made from collagen proteins which are secreted from the cell into extracellular space and spontaneously assembles into cross-linked fibers to increase tensile strength. Then there are elastic fibers that are a specialized type of collagen that are stiff but with elastin, stretch and recoil and are found where elasticity is needed such as skin, lung, and blood vessels. Then there are reticular fibers that form fine, delicate networks that filter things, they are not tough or elastic. Found in spleen, lymph nodes, and basement membrane tissues.

4. Discuss the process of tissue repair involved in normal healing of a superficial wound.

There are three steps in tissue repair. First, there is the Inflammation stage. Second, there is the organization stage. And thirdly, there is the regeneration and fibrosis stage. All of these stages can overlap with each other, but are chronological, so one must begin before the next does.

First, when skin is cut, there is an open wound or breach in a barrier that becomes susceptible to bacteria and other foreign bodies to penetrate though the wound. First, after the injury, the inflammatory stage will kick in. The Inflammatory response results from injured tissue that releases chemoattractants (inflammatory chemicals) via immune cells that live in the connective tissue. These molecules recruit white blood cells to the area that was injured to offer protection from foreign matter from entering the body. However, for the immune cells to get there, the blood vessels in the area dilate to allow more blood flow. They also become leaky and allow more water in to cause edema. When these capillaries and blood vessels become leaker, it allows the blood cells to enter the space outside the blood vessel. It then activates platelets and clotting protein, which stop the bleeding of the blood vessels and cause the formation of a scab (a temporary seal on the wound). In the inflammation stage, there are the injured cells and localized immune cells that secrete and activate an increase in fluid, an increase in immune cells, a stop the bleeding, and the formation of a scab.

While this is happening, the organization phase has been activated. In the organization phase, granulation tissue is being formed (a pinkish tissue with a lot of new blood). The capillaries being formed is where nutrient exchange occurs (CO_2, amino acids, glucose). The new fibroblasts which lay down new collagen fibers help hold the two portions of the wound together to keep it from separating. Macrophages come in and clean up debris, dead cells, etc. The nutrients for the last phase become available for the granulation phase.

Last is the regeneration and fibrosis stage where the connective tissue that is laid down by the fibroblasts is thicker and denser than it was prior to the injury. That is a scar. Scar is excess connective tissue that was laid down. Regeneration of the epithelium also occurs. Early on, the cells in the basal layer spread out when they have time to rest and produce more cells which

work upwards to the apical surface, replacing the injured epithelium. This usually takes about a week in younger and healthier people.

Resources:

Human Anatomy Textbook and Lecture Videos