

Problem 1. Short answer.

- (a) What is the difference between cytoplasm and cytosol?

Cytoplasm is everything inside the cell membrane, including organelles.
Cytosol is just the fluid component inside the membrane.

- (b) What is a protein? Provide a formal definition.

A protein is a chain of amino acids that perform functions that are necessary for the cell to survive. Proteins are generated from a process called the Central Dogma.

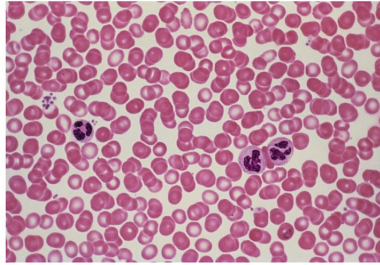
- (c) What does it mean to be *selectively permeable*? What are the benefits of having a selectively permeable membrane?

The term *selectively permeable* means that certain things can pass through but not others. The benefits of having a selectively permeable membrane is that the cell can let in “beneficial” molecules and filter out “detrimental” molecules. This is key to maintaining homeostasis, which is necessary for the cell’s survival.

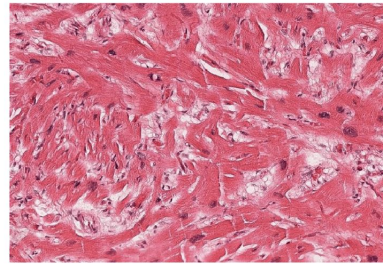
- (d) Describe the Central Dogma in sufficient detail. Be sure to mention where transcription and translation take place.

The Central Dogma is divided into two steps: transcription and translation. In transcription, mRNA molecules are synthesized from the template strand. mRNA has the same sequence as the coding strand and a complementary sequence to the template strand. Of course, this takes place in the nucleus, where DNA is found. After transcription, mRNA travels to a ribosome (usually in the rough endoplasmic reticulum), where translation takes place. In translation, a tRNA molecule attaches different amino acids to a polypeptide chain. Each amino acid corresponds to a codon, which is a set of three bases in mRNA. The amino acid chain always begins with Methionine, which corresponds to the universal START codon, AUG. The polypeptide chain gets cleaved off once a STOP codon is read. The polypeptide chain folds and becomes a fully functional protein.

Problem 2. Identify the cells that are shown in the following images.



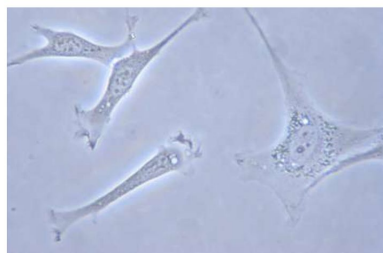
(A)



(B)



(C)

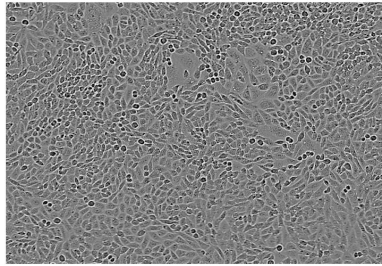


(D)

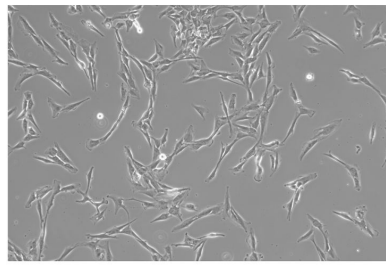
Fill in the blanks with the corresponding letter. Choose (E) if the type of cell does not correspond with any of the four images above.

- (a) Picture **B** contains myocytes.
- (b) Picture **A** contains red blood cells.
- (c) Picture **E** contains cancer cells.
- (d) Picture **D** contains fibroblasts.
- (e) Picture **E** contains macrophages.
- (f) Picture **E** contains endothelial cells.
- (g) Picture **C** contains neurons.

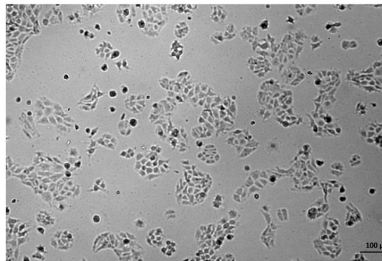
Problem 3. Estimate the cell confluency in the following images.



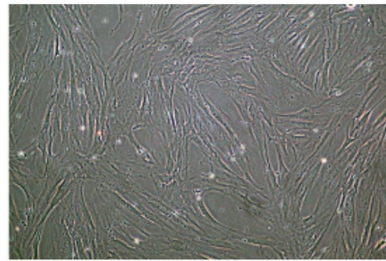
(A)



(B)



(C)



(D)

Fill in the blanks with your estimations.

Answers within $\pm 10\%$ are acceptable.

- (a) Picture A contains cells at **ninety** percent confluency.
- (b) Picture B contains cells at **thirty** percent confluency.
- (c) Picture C contains cells at **thirty** percent confluency.
- (d) Picture D contains cells at **eighty** percent confluency.

Problem 4. Short answer and multiple choice.

- (a) Many antibiotics work by targeting and disabling the ribosomes of prokaryotic cells. Which part of the Central Dogma is affected by this? Explain.

Translation is affected by this since this step occurs in the ribosomes. Because the ribosomes are disabled, the polypeptide chain will not be formed.

- (b) Recall that a fluorophore is a type of molecule that emits a specific wavelength when conjugated to a certain type of protein or biological molecule. Ethidium homodimer is a fluorophore that fluoresces red when it binds to DNA. However, it only emits this color in the presence of dead cells and fails to fluoresce in the presence of live cells. Explain why.

(Hint: Think about the behavior of cell membranes.)

The membranes of dead cells are not intact, and therefore are not selectively permeable. Thus, ethidium homodimer is able to bind to the DNA inside the cell. In live cells, ethidium homodimer cannot pass through the cell membrane to begin with, so it cannot fluoresce.

- (c) What cell type would you expect to have the least amount of mitochondria? (Hint: Mitochondria is an organelle that generates energy for the cell.)

- ☐ Neurons, which transmit sensory and cognitive information throughout the nervous system.
- ☒ Red blood cells, which move passively through the bloodstream.
- ☐ Myocytes, which allows your muscles to generate force.
- ☐ Stem cells, which differentiate into other types of cells.

- (d) What cell type would you expect to have the greatest amount of lysosomes? (Hint: Lysosomes are organelles that contain digestive enzymes.)

- ☐ Stem cells, which differentiate into other types of cells.
- ☐ Myocytes, which allows your muscles to generate force.
- ☒ Macrophages, which digests foreign materials and harmful species like certain microorganisms and tumor cells.
- ☐ Red blood cells, which move passively through the bloodstream.