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David Goodsell's Cellular Landscape

In this activity, you and your collaborative group will learn about eukaryotic cell structure and function as you study David Goodsell's Cellular Landscape poster. For a group of 4 students, the following roles will be filled by group members:

Group roles. Place the name of each group member next to the job they are responsible for during this activity.

1. ___________________ Reader: Reads the information in the handout to the group.
2. ___________________Locator: helps locate the information or structure on the poster. Takes the time to make sure all group members are in agreement with regards to the structure or information located.
3. ___________________Labeler: responsible for placing proper labels on the poster.
4. ___________________Recorder: Records group responses to the questions in the activity

In the case that your group has only three members, the labeler and recorder can be completed by only one person. All group members work collaboratively as they discuss and locate the items to be labeled.

This piece of art is based on scientific work. It was designed to tell some of the story of protein production and secretion in a cell. Dr. Goodsell chose to illustrate a small section of white blood cell (eukaryotic cell of the immune system) in the act of producing and then secreting antibody. All cellular protein production relies on DNA and ribosomes. Eukaryotic protein production involves information from the DNA stored in the nucleus, and ribosomes that follow the instructions. The rough endoplasmic reticulum, golgi, cytoskeleton, vesicles, and the cell membrane are also involved in the secretion production and secretion of proteins.

You may Google these two questions, but the rest of this activity is based on prior knowledge or information from the poster.

What does secretion mean? ____

What is an antibody? ____

Part I: Getting Oriented

This section is designed to help you gain some understanding of these questions: How big is a cell? How big are the structures and chemicals composing a eukaryotic cell?

To learn the answers to these and other questions, please look at Dr. David Goodsell's Cellular Landscape. All cell structures and machinery are drawn to scale. Colors provide chemical and structural information. Narration is found in the text boxes, and will help you interpret what you are seeing.

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1. What magnification is used in this drawing? _______________________

2. At this magnification…
   a. An individual atom would be the size of ___________________________.

   b. A cell would be the size of ___________________________.

   c. A person would be the size of ___________________________.

3. If individual water molecules, glucose molecules, and ATP molecules were included in this drawing, they would be drawn…. (circle one)
   a. Larger than the cell
   b. Smaller than individual atoms
   c. Larger than the nucleus
   d. Bigger than the nucleus but smaller than the cell
   e. Bigger than individual atoms but smaller than ribosomes

4. Place the following in order of size: **cell**, **water molecule**, **protein**, **glucose molecule**, **ATP**, **phospholipid**, **ribosome**, **nucleus**. (Ribosomes are nearly spherical and are shown as large two-piece purple structures; they are chemically composed of several different proteins and many molecules of RNA.)

   -___________________________ -the largest

   -___________________________

   -___________________________

   -__________protein___________

   -___________________________

   -___________ATP_____________

   -___________________________

   -_______water molecule_______ -the smallest

5. **Cellular membrane** is represented by green in this illustration. **Phospholipids** are the molecules that make-up the majority of cellular membranes, though you do not see the structure of individual phospholipids in this illustration. Two layers of phospholipids make up each membrane, so membranes are often referred to as *phospholipid bilayers*. Cellular membranes form the boundaries of the nucleus, the rough endoplasmic membrane, the membrane of the transport vesicles, and the membrane of the Golgi apparatus, as well as the outside membrane of the cell. In this illustration, phospholipid membranes are indicated by a thick green strip. Proteins that are also part of the membrane are indicated by additional green shapes embedded within the phospholipid membrane.

   ✓ Place a Post-it® flag on the membrane of every membrane-bound structure you see, and label it "lipid bilayer." (use the same color of Post-it® flag for all lipid bilayers)

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Part II: Cellular Pathways - The making of a protein and protein export from the cell.

1. All the way to the left of this poster, David Goodsell illustrated the **nucleus**.
   - ✓ Locate the microcrograph on the left of the poster. Using a transparency marker, circle the portion of the nucleus found on this micrograph.
2. The micrograph has a colored stripe, which allows you to locate the region of this cell that is illustrated on the rest of this poster.
   - ✓ Move your focus to the Goodsell illustration. Again using a transparency marker, circle the portion of this landscape that represents the nucleus of this cell.

3. Carefully examine the nucleus. Chromosomes (**DNA**) within the nucleus are displayed in yellow. DNA is wrapped around histone proteins (orange-yellow with 4 "tails") most of the time. When sections of DNA are needed, they are unwrapped, unwound, and read by **RNA polymerase**. RNA polymerase (an enzyme) copies small sections of the DNA into **RNA**. RNA is a molecule very similar to DNA. It has a 4 letter code that contains the same information a DNA molecule has. The light purple-pink ribbons are RNA.
   - ✓ Using a post it note, label the following structures
     - ✓ DNA
     - ✓ Histone
     - ✓ RNA polymerase
     - ✓ RNA

4. RNA is a working copy of the protein recipe that is located in the DNA. While DNA never leaves the nucleus, RNA can leaves the nucleus through nuclear pores. **Nuclear pores** are structures made of proteins that span the double-layered nuclear membrane.
   - ✓ Using a Post-it® note, label the nuclear pore through which the RNA message travels.

5. The membrane around the **endoplasmic reticulum** is lined with specialized proteins, which attach the purple ribosomes to the Endoplasmic reticulum. As the ribosomes synthesize new protein, it is guided inside the endoplasmic reticulum.
   - ✓ Next to a ribosome, place a post-it that describes the function of the ribosome.
   - ✓ The ribosome is attached to an organelle that is made of a double-membrane. This organelle and its contents, named the _______________________ is shown in green.

6. You have a skeleton that gives your body support and a shape. Your cells have a skeleton as well, and this cellular skeleton is called the ___________________. The different proteins that comprise this structure shown in turquoise throughout the landscape.
   - ✓ Use a Post-it® note to label this structure on the poster. Label in at least 3 different locations. (Don't be afraid to move your focus throughout the poster.)

7. In the cellular scene represented by this poster, the cell is producing *antibodies*, small protein structures that fight disease in your body. In order to fight this disease, specialized cells (white blood cells or leukocytes) produce these antibodies and then dump them into your blood stream. Once in your blood stream, antibodies can travel and find and fight specific pathogens that might be infecting you.

   a. The antibody proteins being synthesized by the cell are shown in yellow. They first form in the endoplasmic reticulum.

- ✓ Using a post it flag, label a nascent (new) antibody being formed in the Endoplasmic Reticulum. (hint: look in the endoplasmic reticulum closest to the nucleus.)

b. If the antibody is an example of a protein made by the ribosome, explain what the ribosome is actually doing. Hint: proteins are polymers…

____

____

c. The growing proteins are produced in the ribosome and inserted into the lumen (interior) of the endoplasmic reticulum. What is the job of the endoplasmic reticulum? (Don't Google this… think. What happens to a polypeptide to give it a working structure?

____

____

d. The ribosome anchored on the endoplasmic reticulum, which is fluid in nature, moves in a zig zag pattern along the ER as the protein continues to grow. Once the antibody is fully formed and folded, it is sent to the golgi apparatus where it will be modified into its final form. The antibody (or any protein produced in the ER) travels to the Golgi in a *vesicle*.

- ✓ Locate a vesicle filled with antibody molecules that is travelling from the ER to the Golgi. Label it with a Post-it® note "in transit to Golgi".

e. Note that when the vesicle forms, it does so with the assistance of proteins that help the membrane form a bud.

- ✓ Using a Post-it®, label these proteins as "vesicle forming proteins." On this poster, you can see these proteins on the vesicle that is coming off of the ER.

f. This vesicle will arrive at, and fuse with, the Golgi.

- ✓ What is the function of the Golgi?

  ____

  ____

- ✓ Using a Post-it®, label the Golgi on the side where the vesicle will arrive. "Vesicle arrives here."

- ✓ Go to the class website. View the animation "inside of a cell" . Take the time to identify vesicles arriving on and exiting from the Golgi.

g. After the proteins are modified in the Golgi, they are again placed in a vesicle. These antibodies are now ready to be released from the cell, where they can travel in the blood stream. In order to leave the cell, they must first be packaged in a vesicle once again.

- ✓ Using a Post-it®, label a vesicle leaving the Golgi with a label "ready for export."

h. As the vesicle is heading towards the cell membrane, it follows a pathway along a cytoskeletal "highway". In order to move down this path, the vesicle is attached to motor proteins known as "kinesins." These proteins use energy as they change shape, much as your muscles use energy and you can walk along a path.

- ✓ Using a Post-it®, label these kinesins as "motor proteins."

i. Once the vesicle reaches the cell membrane, it fuses with the cell membrane and dumps the antibodies into the extracellular space (space outside the cell). Now the antibodies can be released into the blood, through which they can travel throughout the body and be used to fight infection.

✓ Using a Post-it®, label the Extracellular space.

8. Place the following structures in the order they participate in antibody production [golgi, cell membrane, ribosome, endoplasmic reticulum, nucleus, transport vesicle, transport vesicle] Use transport vesicle **twice**.

9. Which of the structures named in question 8 above include boundaries made of lipid bilayers (membranes)?

10. Which structure named in question 8 is NOT a membrane bound organelle?

If you would like to, take a photo of your work so you can refer to it later if you like.

Clean off your landscape by removing all of your Post-its® and wiping off the transparency marker with a wet towel.

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Summary Questions: To complete as homework.

1. List as many different roles (or functions) proteins play in the cell as you can.

2. In your own words, describe the steps of how a cell produces and exports a protein. Be sure to include the important structures or pathways followed in protein production.

3. The "connected" system we focused on in this activity is known as the "endomembrane system", and is responsible for the production and export of proteins. However, not all organelles in a cell are a part of this system. In the space below, list at least 4 other cell organelles or cell structures not addressed in this activity, and the job of each of these organelles.