The Cell Factory

Creating a model cell using electron micrographs

Cells are the smallest structural and functional units of the human body that are alive. In fact, each cell has its own individual requirements independent of its neighbors. The well-being of the whole organism depends on the wellbeing of all the cells. In addition, because each kind of cell has a very specific job to do within the body, one kind of cell may look entirely different from another. However, all cells are made up of the same component parts. How is this possible?

Part 1

A close look at cellular structures

The cellular basis of life was unknown until the invention of the light microscope in the 17th century. In addition to being very tiny and needing magnification, cells are largely transparent when viewed under a light microscope and need to be treated with special stains. What we are attempting to see with these stains are the cell's "organs", or **organelles**. Like the organs in our body, each organelle has a specific function within the body of the cell. An organelle is a permanent structure within a cell with a characteristic structure. Many organelles have a surrounding membrane.

* Open Cell - light microscope. The cell in this image was magnified 1,000x. The cells on this slide were treated with stains that make some of the structures visible but not all of them.

* Observe the structures in this image and identify the plasma membrane, the nucleus, nucleolus and the cytoplasm. To check your answers, use the > key or the scroll bar at the bottom of the image to move to the second image in this stack.

A closer look at cellular structures

Unfortunately, the best research light microscopes can only magnify up to 2,000x. To see organelles more clearly, a transmission electron microscope (TEM) is used to magnify them up to 100,000 times.

- Open Animal cell - TEM. This image shows a rat kidney cell magnified 10,000´ with a transmission electron microscope (TEM). This cell contains many of the structures contained in most cells.

- Observe the structures in this image and identify the plasma membrane, nuclear membrane, and the cytoplasm. Check your answers by using the > key.

- Compare the images created by each type of microscope.

- Compare the cytoplasm in both images closely by magnifying each image with the magnifying tool.

Questions **- On your answer sheet, answer the following questions:**
1. Describe the differences you see in the cytoplasm of the two images.
2. Describe one advantage and one disadvantage of using each type of microscope.

Part 2

Measuring cellular structures

In order to understand the structure of organelles better, we can measure them to determine their relative size. To make meaningful measurements, we have to tell the computer how large our unit of measurement is. This is called setting the scale.

Setting the scale

- Use the straight line tool to measure the length of the scale bar at the bottom of the image.
- From the menu bar, choose Analyze/Set Scale. The length you measured will be automatically filled in in the Distance in Pixel box. You have to change the Units to micrometers and enter the Known Distance as 1.0. Click OK.

Measuring

Once our scale is set, we can measure structures within the cell in micrometers. First, let's measure the diameter of the entire cell. Under the menu Window, click Results. Another window should open where you measurements will show up in whatever unit you have *set.*

- Use the straight line selection tool to select the distance from one side of the cell to the other.
- Measure the distance you selected by selecting Analyze/Measure (or use the key command shortcut).
- View your measurement recorded by the computer. The most recent measurement is at the bottom of the list in the Results window.

Questions
3. Record the diameter (length) of the cell in the table on your Data Sheet.

- Measure the diameter of the nucleus and three other visible structures. Use the magnifying glass tool to zoom in on small structures. Choose some and record your measurements in the table on your **Data Sheet**.

4. To get a sense of relative sizes, calculate the ratio and percent size of each structure compared to the whole cell, as described below. Record these values in the table on your Data Sheet.

size ratio = diameter of structure / diameter of cell **% size = size ratio X 100**

- Close Cell - Light microscope and Animal cell - TEM.
- Open the Organelles folder. Check the Open All box to open all the images.
- Examine the images of each organelle closely. Try to identify each of the structures indicated on the image.
- Adjust the brightness and contrast of each image to help you see details. Change look up table (color) if you think it will help.
- Set the scale for each image (as described above) and measure each of the organelles listed in the table on your **Data Sheet**. You may have to magnify the image to see the length of the scale bar in each image. They are not all the same length.

Questions
5. Are your measurements of the organelles in the high magnification images about the same as your measurement from the whole cell image?
6. Describe the function of each of the organelles in the chart on your Data Sheet.

- Close all images.

Specialized cells
The model cell you see in textbooks and online, are a simplified composite of many different types of cells. Most cells in the human body (and other higher organisms) are specialized to perform very specific functions.

- Open the Liver cell. Observe the large number of mitochondria present in this cell.

Questions
7. Why do you think this cell needs so many mitochondria?
8. How is the proportion of the various organelles related to the specialized nature of a cell?
9. For each of the following specialized cells, describe any differences you would expect to find in the type and relative numbers of organelles in each specialized cell. Explain your answer.

A pancreatic cell that secretes a lot of insulin (a protein).

A kidney cell that pumps salts.

A skeletal muscle cell that contracts frequently.

Part 3

Creating a model cell - To demonstrate your understanding of the components of a cell, create a model cell using the TEM images of the organelles that you were looking at in Part 2. The organelle images in your model should be scaled to approximately the correct size. Your model must include:

- the plasma membrane (your outline), nucleus, endoplasmic reticulum, ribosomes, Golgi complex, vesicles, mitochondria, and microtubules
- labels indicating what each structure is

Use Word or ImageJ to create your picture. The following instructions are for ImageJ

Creating a new image window

- Create a new image window to place your model cell on. Make the window 552 ´ 436 and give it a title (for example, Barge model cell).
- **Use the pencil tool to draw an outline of your cell**, almost to the border of your new window.

Now you are ready to place the first organelle into your model. Let's start with the nucleus because it's the largest organelle in the cell. Before copying the image of the nucleus and pasting it into the model, we need to scale the organelle image to make it approximately the correct size.

Scaling an image to resize it

- Open the Nucleus image in the Organelles folder. How big or small is this organelle in relation to the outline of your cell? Does it need to be enlarged or shrunk? Refer to your size ratios from question #4.
- Choose Image/Scale. In the X scale dialog box, enter the factor by which you want to scale the image (for example, 0.8 = 80%). The Y scale should be automatically matched. Click OK.
- Use the freehand tool to make a selection around the nucleus.
- Choose Edit/Copy to copy the image to the clipboard.
- Activate your model cell by clicking on it. Choose Edit/Paste to paste the image into your model cell. Move your organelle where you want it and then click outside the selection to paste it. **Once you click outside your selected object it is pasted and you cannot move it.**
- Repeat the scaling, copying and pasting processes for each of the required organelles.

Labeling your model cell

- Use the Text tool to label the organelles in your model cell. Adjust the font size and style in the Edit/Options menu while your text box is still selected.

Your Cell Model

Organelle function is vital to the cell, thus to a living organism. When they don't function correctly, homeostasis can be interrupted and disease can occur. Organelles can contribute to a disease state in several ways. First, the organelle itself may be dysfunctional either because it contains one or more defective biomolecules that impair function, or because it has been damaged by exposure to harmful sub- stances such as chemicals, heavy metals, or oxygen radicals. Second, an organelle can, through its normal function, exacerbate damage occurring elsewhere in the cell. For example, as we have seen, misfolded proteins in the ER can trigger apoptosis, even in circumstances in which it is counterproductive.
[http://www.smusd.org/cms/lib3/CA01000805/Centricity/Domain/1876/Organelles%20and%20Human%20Diseases.pdf]

Think about the organelles you included in your cell model and their function. What could go wrong if a particular organelle stopped functioning? What might happen to the cell, to the living organism?

Choose three organelles you included in your image and think about these questions in relation to those specific organelles.

10. Create a document to upload to Moodle. In your document, include the following:
    1. Your name and biology period
    2. Your cell model image with labels
    3. Your discussion of three organelles that are included in your image
       Include in your discussion
       3a. Organelle's name 3b. Function of organelle
       3c. What could go wrong with the cell or living organism if the organelle malfunctions
       3d. Why you find this organelle interesting/distressing/perplexing/amazing/…