A Cellular Landscape

Student POGIL Activity Sheets
Developed by Cathy Cornett, MS, UW-Platteville

The manager should:

- assign/determine the roles for individuals within the group
- pick-up enough ‘Student POGIL Activity’ sheets to distribute one to each member of the group
- pick-up the ‘Recorder’ sheet and give it to the group’s recorder
- keep the group on task

Notes to Self (Sept 2013)

This POGIL was first put-together in Fall 2013 (9/29/13) for General Biology lecture. The model is David Goodsell’s Cell Landscape. (Biology received 2-11ft posters and 4-~4ft posters as part of the CBM CREST project.)

The intent of this POGIL is two-fold: to provide a sense of scale and to begin forming a dynamic image of cellular function.

A bit of an introduction will be helpful to many students – Just talk for a minute or two – use a few keywords - ( one aspect of our immune system involves antibodies free in the plasma portion of our blood; antibodies are proteins; plasma cells produce antibodies; plasma cells express genes – produce proteinaceous antibodies that are secreted/released from the cell; doing so involves a cellular process with a number of cell structures involved),

http://www.ncbi.nlm.nih.gov/books/NBK26884/

Some students seemed disoriented and bewildered when first looking at the poster. They began to lose interest (became overwhelmed?). It seemed helpful to tell them that everyone, including the cell scientists, start out this way. The scientists look for expected/recognizable patterns, and ask themselves if color or shape carries meaning within the poster. The clues in the activity and on the poster are meant to guide you in understanding the cell.

-Shared with Margaret Franzen, Center for Biomolecular Modeling, MSOE.
A Cellular Landscape

How big is a cell?
How big are the structures and chemicals composing a eukaryotic cell?
How does a cell go about making and secreting protein?

Please look at Dr. David Goodsell’s Cellular Landscape.
All cell structures and machinery are drawn to scale.
Colors provide chemical and structural information.

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 protein and RNA.)
   - ___________________________ - the largest
   - ___________________________
   - ___________________________
   - ___________________________
   - ___________________________ protein
   - ___________________________
   - ___________________________ ATP
   - ___________________________
   - ___________________________ water molecule - the smallest
Continue studying Dr. David Goodsell’s Cellular Landscape.

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

5. The left of the large image is the nucleus / cell membrane.

6. The ribosomes / phospholipid bilayer of cellular membrane is shown in green. Phospholipids make-up the majority of the cell membrane, the envelope of the nucleus, the rough endoplasmic membrane, the membrane of the transport vesicles, and the membrane of the golgi. The phospholipids are indicated by a thick (~3/8 - 5/8” wide) green strip and the proteins within the membranes are indicated by additional green shapes.

7. Chromosomes are displayed in yellow / pink within the nucleus, DNA is shown wrapped around histone proteins.
   a. When sections of DNA are needed, they are unwrapped, unwound, and read by RNA polymerase. RNA polymerase (a protein enzyme) copies small sections of the DNA in RNA format. The light purple-pink ribbons are RNA / RNA polymerase / nucleosomes.
   b. Properly edited RNA is delivered out of the nucleus through ______________ spanning the double-layered nuclear membrane.

8. The membrane around the endoplasmic reticulum is lined with transport proteins which bind the purple ribosomes / cytoskeleton. As the ribosomes synthesize new protein, it is guided inside the endoplasmic reticulum.
   a. The double-membrane of the ______________ is shown in green.
   b. The ______________ are shown in purple.
   c. The different proteins of the cytoskeleton fibers are shown in turquoise.
   d. Portions of the chromosomes are shown in yellow. The ______________ is wrapped around histone proteins, forming nucleosomes.
   e. The antibody proteins being synthesized by the cell are shown in yellow. We can see them forming in the endoplasmic reticulum, being modified in the golgi, and making their final trip to the cytoplasm in transport vesicles pulled by kinesin along microtubules (microtubules are part of the cytoskeleton).
   f. Additional proteins assist in docking and fusion of the transport vesicle. The transport vesicle contents are secreted / digested, or released exterior to the cell membrane.
9. The process of antibody production begins in the nucleus, continues within structures of the cytoplasm and finishes as the proteinaceous antibodies are released outside of the cell.
   a. DNA is copied into RNA within the nucleus / cytoplasm.
   b. In the cytoplasm, RNA is used to direct synthesis of protein at the ribosomes / nucleus.
   c. Newly formed protein enters the endoplasmic reticulum / nucleus where its folding is assisted and polysaccharide chains are added.
   d. The transport vesicles / cytoskeleton carry the new proteins within the spherical perimeter of their membrane.
      i. First, the proteins are taken to the golgi / cell membrane where the proteins are processed and sorted. Additional sugars and lipids may be added and sugars may be trimmed too.
      ii. After the golgi, transport vesicles take their antibody cargo to the endoplasmic reticulum / cell membrane where the proteins are released to the exterior.

10. 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.
    a. ___________________________ - first
    b. ________ ribosome __________
    c. ___________________________
    d. ___________________________
    e. ___________________________
    f. ___________________________
    g. ________ cell membrane _______ - last
Recorder Sheet

- The Recorder sheet is given to the recorder only
- The Recorder notes group responses here
- Group responses will be reported to the class by the Reporter using the Recorder sheet
Recorder’s Sheet

3 If individual water molecules, glucose molecules, and ATP molecules were included in this drawing, they
would be drawn…. (circle one)

Larger than the cell
Smaller than individual atoms
Larger than the nucleus
Bigger than the nucleus but smaller than the cell
Bigger than individual atoms but smaller than ribosomes

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

___________ - the largest
___________
___________
___________ protein
___________
___________ ATP
___________
___________ water molecule - the smallest

10 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.

a. ________________ - first
b. __________ ribosome
c. ________________d. ________________
e. ________________
f. ________________
g. __________ cell membrane - last
POGIL NOTES (for instructor)
Title: A Cellular Landscape

Question(s):
- How big is a cell?
- How big are the structures and chemicals composing a eukaryotic cell?
- How does a cell go about making and secreting protein?

Purpose: This POGIL asks students to consider Dr. David Goodsell’s Cellular Landscape of a white blood cell in order to establish a sense of scale for cellular structures and the process of protein production.

What must be known/done to begin:
- Awareness of “life is chemistry”; biological macromolecules and roles for life
- A bit of an introduction will be helpful to many students (antibody, secretion, plasma cell, http://www.ncbi.nlm.nih.gov/books/NBK26884/). The Y shaped structure of antibody. An antibody is protein with some carbohydrate attached. Specific cells make specific antibodies once they have been ‘trained’?? Antibodies make up ~20% of soluble blood protein, etc

What to do later?: Continue learning about cells (assignment, reading, powerpoint, etc): prokaryotic vs. eukaryotic cells & cellular structures, doing so with a ‘dynamic cell’ and ‘structure-function’ perspective.

Learning Cycles

1. Develop list of characteristics for scientific activity
   - Model: A Cell Landscape (Dr. David Goodsell’s laminated poster, available through 3D Molecular Designs at Milwaukee School of Engineering
   - Concept to invent: Cells are small entities composed of structures which are in turn composed of chemicals.
   - Additional pieces of information (smaller ideas) within the learning cycle
     - A cell is approximately ______ in size.
     - A white blood cell is an example of a eukaryotic cell.
     - Cells make chemicals.
     - Some of these chemicals are secreted and have a functional role outside the cell..
   - Students might wonder:

2. Additional learning cycles could be added (such as quasi-science/pseudo-science)
   - Model: A Cell Landscape (Dr. David Goodsell’s laminated poster, available through 3D Molecular Designs at Milwaukee School of Engineering
   - Individual point made: Structure – Function relationships for the following structures in the process of producing antibodies
     - nucleus (DNA)
     - rough endoplasmic reticulum
     - golgi
     - transport vesicle
     - cytoskeleton
     - cell membrane
o Additional pieces of information (smaller ideas) within the learning cycle
  • Individual structures are composed of biological macromolecules
  • Individual structures have a recognizable shape & placement as well as chemical composition
  • Individual structures play specific roles in an overall cellular process
  • Cells are dynamic entities with numerous structures and chemical processes taking place simultaneously

o Students might wonder:
MORE...

A Good Follow-up will be a reading assignment with directed questions.

Model:

3D Molecular Designs (at MSOE) Cellular Landscape Poster. Dr David Goodsell has produced a number of cellular/molecular landscapes.... Posters and a book, ‘The Machinery of Life’. He is also involved in the Molecule of the Month presentation at PDB (Protein Data Bank). He is at Scripp’s Institute.

UW-Platteville has the book and several posters. We have two large and 4 big posters of this model. They are kept in the Molecular Models area (Botany prep as of 9/2013. We are thankful to have these items – ‘gifts’ of participation in the CBM-CREST project (workshop summer 2013 with following work).

Poster availability: http://www.3dmoleculardesigns.com/news2.php#DavidGoodsell