SCIENTISTS IN SCHOOL
SCIENTIFIQUES À L'ÉCOLE

Teacher Resource Package

Let us help you piece together the science!

Background Information an overview of the topic and theoretical concepts.

Hands-on Activities

Activity 1 - pen/paper activity
Activity 2 - short, easy-to-do activity (30-60min)
Activity 3 - short, easy-to-do activity (30-60min)
Activity 4 - longer activity (greater than 1 hr)
Activity 5 - complex activity

Teacher Resources

Literary Resources
Website Resources
Interactive White Board Resources
Multi-media

Student Resources

Literary Resources
Interactive Websites

Please help us improve our teacher resource packages!

If you have any feedback about this package or suggestions for new resources to include, please don't hesitate to contact us at: inquiries@scientistsinschool.ca.

Cell Explorers

If you look at a human being and an onion they appear to have nothing in common, yet they have more similarities than you might think. Under a microscope, we can see that they are both composed of basic units of fluid filled packages called cells. Every life form on earth is made of one or many cells that share an evolutionary history. Animals, plants and fungi share a unicellular common ancestor some 1.6 billion years ago. Since many genes involved in basic cellular functions, are shared across organisms, scientific research on any type of cell, even bacteria, has the potential to teach us something about ourselves. For example, yeast are a unicellular fungi with which we share 25% of our genes and many genes known to be misregulated in cancer were first discovered in yeast.

Background Information

Cellular metabolism

Plant and animal cells use oxygen and food to make energy needed to maintain themselves, and release carbon dioxide as a waste product. Plants use carbon dioxide in photosynthesis to build their own carbohydrates (food) and release oxygen. These are examples of life-sustaining chemical reactions referred to as cellular metabolism.

Cells chemically break down food in reactions that produce ATP (adenosine triphosphate) molecules, which are like batteries that can be used whenever energy is required to do a job. In prokaryotic cells, like bacteria, the conversion of food to ATP occurs at the cell membrane. In eukaryotic cells, like plant and animal cells, a specialized organelle, the mitochondria, produces energy more efficiently. For photosynthesis, plant cells have chloroplasts, organelles that grab energy from the sun and convert it to ATP to power the building of carbohydrate molecules.

It is believed that mitochondria and chloroplasts used to be their own cells, which is supported by the fact that these organelles both contain their own genetic material (DNA-deoxyribonucleic acid). The endosymbiotic theory proposes that the mitochondria and chloroplast cells were eaten by larger cells. The large cells may have benefited from the eaten cells if they carried on producing energy or making food while on the inside and eventually the eaten cells lost the ability to live on their own. The chloroplasts were likely photosynthetic bacteria before they got eaten. Today algae, unicellular photosynthesizing organisms, live inside some animal cells, like corals and even salamanders - yes there are solar powered salamanders!

Osmosis

Cell membranes are permeable to water and some small molecules but larger molecules do not passively cross the membrane. Osmosis is the tendency of water to move across the membrane from an area of high water and low solute concentration to an area with low water and high solute concentration until the water concentration is equal on both sides. If solute concentrations are higher outside a cell, water gets sucked out of the cell and the cell shrinks. Osmosis is the reason why you should not drink sea water, which will increase the salt outside your cells and suck water out of your cells. If solute concentrations are higher on the inside of the cell, water will move into the cell causing it to swell and potentially burst. Our cells work to avoid swelling by actively pumping out atoms (such as sodium and calcium) to decrease solute concentrations on the inside. The kidneys maintain water and solute concentrations in our body fluids.

The cell of a paramecium has more solutes than the freshwater it lives in. To prevent itself from bursting, it has a vacuole that continuously pumps water out. Bacteria, fungi and plants have a cell wall outside of the cell membrane, so their cells cannot swell or burst but become turgid. In plants, turgid cells give plants structure.

From Developmental Biology to Stem Cell Research

Multicellular organisms begin as a single cell. That cell multiplies, forming a cluster of similar looking, unspecialized cells, which later turn into very different looking specialized cells that perform different jobs. Nerve cells can be one metre in length and are long with branched ends to communicate with other cells. Heart cells beat with a regular rhythm and immune cells hunt down pathogens. How can cells be so different when they have the same DNA containing approximately the same 30,000 genes? Different combinations of genes are turned on in different cell types. Developmental biologists try to find out how embryonic cells decide which specialized cell they are going to become, and which genes they need to turn on in order to specialize. Embryonic cells that can form many types of cells are called embryonic stem cells. Embryonic stem cells, isolated from human and mouse embryos, are being researched as potential treatments for diseases because of their ability to repair and replace diseased tissue with new healthy tissue. Of course the use of embryonic cells from human embryos is controversial.

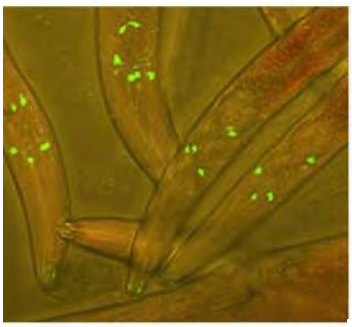
In adults there remain pools of unspecialized cells called adult stem cells that are able to form many cell types and these are much less controversial than embryonic stem cells. Stem cells allow us to replace those 600,000 skin cells that we lose every hour! Bone marrow transplants are donated stem cells that can be used to replace immune cells in leukemia patients. It is hoped that stem cells will provide treatments to diseases such as blindness, diabetes and spinal cord injuries. In the laboratory, some cell types can be reprogrammed to a stem cell state. Scientists are trying to sort out exactly how to make stem cells become the right specialized cell type and go to the right place in the patient.

Cells in Biotechnology

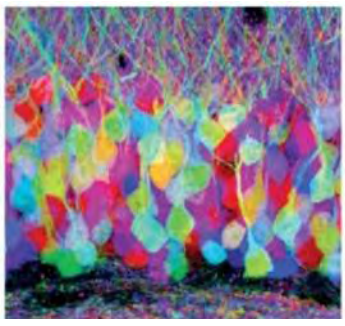
Using genetic engineering, it is possible to insert a gene from one species into another, for production of a protein of interest in large quantities. Many vaccines and therapeutic proteins are produced in this way. The bacteria *Escherichia coli* and yeast perform well at this task but some human proteins need to be produced in a mammalian cell to attach mammal specific modifications. Chinese Hamster Ovary cells are one of the few mammalian cells suited to high throughput production and produce the most therapeutic proteins. Recently plant cells are being developed for pharmaceutical production, called “pharming” instead of “farming”. For example, a replacement enzyme for patients with a lysosomal storage disease is being produced in carrot cells.

Looking at Cells with Fluorescent Microscopy

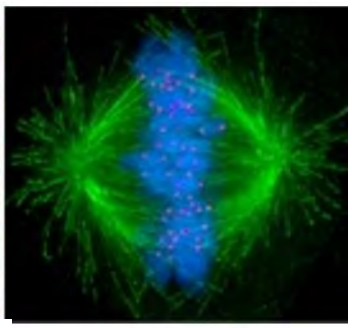
Fluorescent microscopy, a way of looking at cells that are labelled with fluorescent tags, is an important tool for cell biologists. Fluorescent markers are available that light up different parts of the cell. If a scientist has a genetic sequence but does not know anything about the protein, a fluorescent tag can be attached to the protein to track where it goes in the cell.



Specific nerve cells light up in worms. (Source: Heiti Paves (Own work) (*http://creativecommons.org/licenses/by-sa/3.0)*, via Wikimedia Commons) *(12/08/13)*



Brainbow: Multicolour labelling of Source: Jeff W. Lichtman and Joshua R. Sanes (*http://creativecommons.org/licenses/by/3.0)*, via Wikimedia Commons *(12/08/13)*



Mitosis: Chromosomes (blue) lines Source: Afunguy at en.wikipedia [Public domain], via Wikimedia Commons *(12/08/13)*

Activity 1: Cell Analogy: A Cell is Like….

Time: 30 minutes or take home project

Other Application: Language-Making Connections, Communication

Key Terms: analogy, organelles

Group Size: Single or pairs

Materials:

☐ "Cell Analogy" datasheets per student (Part 1 & 2, pgs. 4-7)

Learning Goals: Students will learn about the functions of the parts of a cell. Students will learn how making analogies can enhance their own understanding of a subject.

Pictures of cells in textbooks can fail to convey the bustle of activity going on inside the cell. Cell analogies help to conceptualize the inside of a cell as a busy place with molecules moving around getting important jobs done. Scientists use analogies to help themselves think about things that cannot be seen. Analogies are important in science communication and are used by scientists and science journalists to help them explain complicated information to a non-scientist audience.

Procedure:

1. Review with students about the parts of a cell using the diagram and description of the cell parts (Part 1: What makes up a cell – the unit of life?).
2. Students will choose an analogy for a cell. Some examples include city, factory or school, but there are many possibilities. Students will fill in the cell parts with the appropriate label for their analogy and give the common function between that cell part and the analogous part (Part 2: Your analogy…a cell is like____). For example, if a cell is like a city, the nucleus would be the library because it stores information.

Fun Fact: Origin of 'Cell'

The name "cell" was coined by Robert Hooke who discovered plant cells in 1665. When he looked through his microscope at a thin slice of cork, he thought the compartments looked like "little rooms" –cellulae in

Discussion:

Discuss with students about which analogies fit with a cell as a whole or how the individual parts of the cell relate to different analogies.

An example of an analogy between the cell and a city has been provided (pages 8-9). Additional resources for using a city as an analogy for a cell can be found at *http://www.open.edu/openlearn/nature-environment/natural-history/cells-are-cities-simple-version (11/06/15)* and *http://www.mrsec.psu.edu/education/nano-activities/cells/cell_in_the_city/index.asp (11/06/15)*

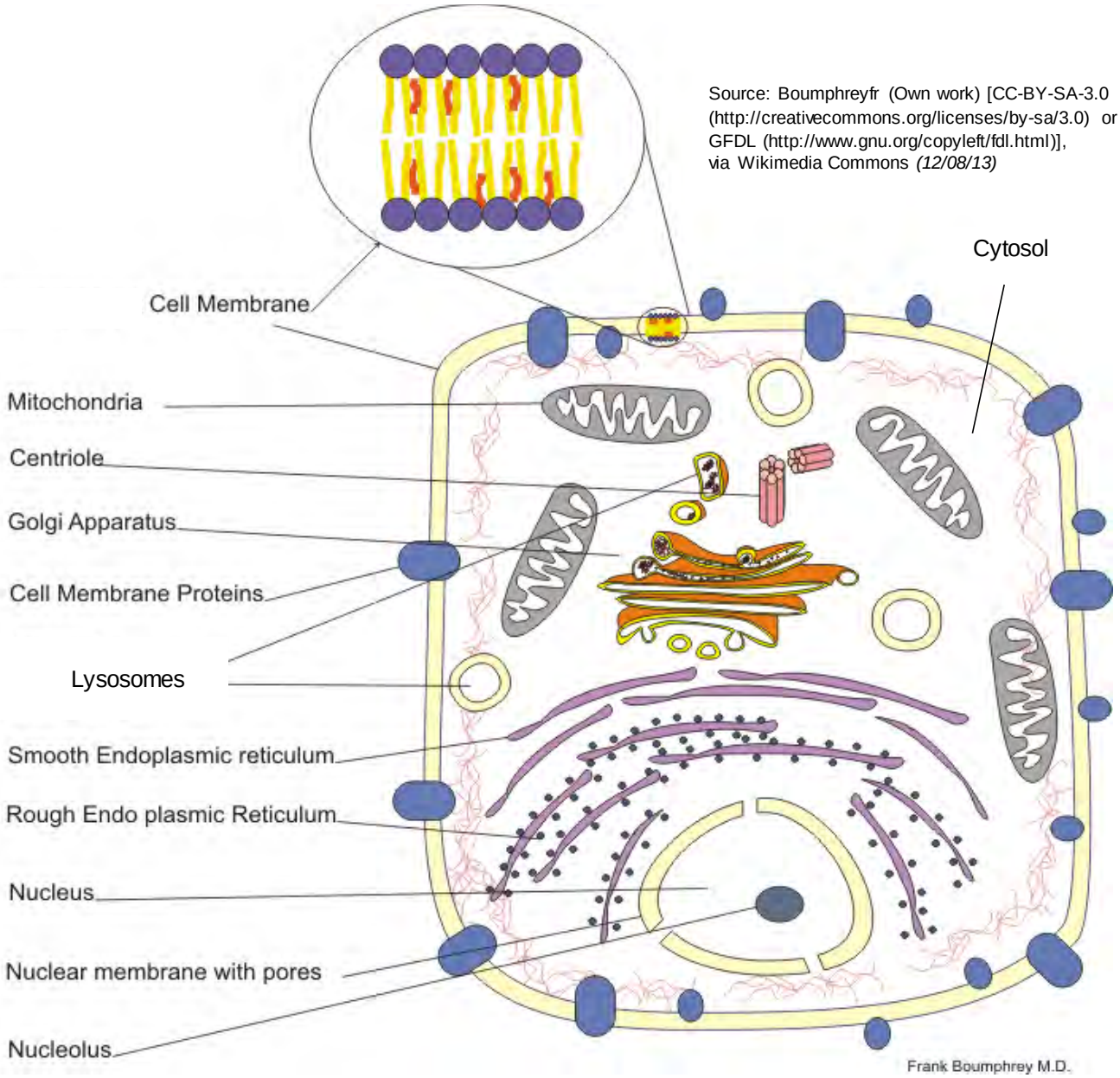
Extension:

Students could further extend the use of analogies to the human body and the individual cell types such as: skin, muscle, nerves, fat, red blood cells, white blood cells, intestinal cells and hormone secreting cells. For example, the human body could be like an office building. The nerve cells could be the internet cables and the skin cells could be the bricks.

Name: _____

Cell Analogy: A Cell is Like …

Part 1: What makes up a cell – the unit of life?



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Part 1 continued: A Brief Description of Cell Parts

Cytosol: The intracellular fluid that does not hold any of the organelles. The cytosol is made up of water and other molecules. Some molecules make up the cytoskeleton which provide structure and create compartments and pathways by which molecules can be transported within the cell. Many chemical reactions take place in the cytosol.

Cell Membrane: The outer membrane surrounding the cell and creating a protected microenvironment, controlling which substances come in and out. The cell membrane must allow nutrients into the cell and receive messages from molecules like hormones. Waste products must exit the cell.

Mitochondria: The energy the cell needs to live is produced in organelles called mitochondria. Energy, in the form of the molecule ATP, is produced from nutrients in the mitochondria. ATP is used throughout the cell whenever energy is required to do a task such as chemical reactions, active transport of molecules in or out of cell, cell division and cell movement.

Golgi Apparatus: The Golgi apparatus is an organelle important for preparing protein molecules for transportation within or outside of the cell.

Cell Membrane Proteins: Proteins in the cell membrane are important for communicating with other cells, transporting molecules and ions across the membrane and relaying signals between the exterior and interior of the cell.

Lysosomes: Membrane bound pockets within the cell where degradation and recycling of waste occurs. Toxic waste materials from chemical reactions are converted to less harmful components, or old organelles are broken down into molecules to be reused.

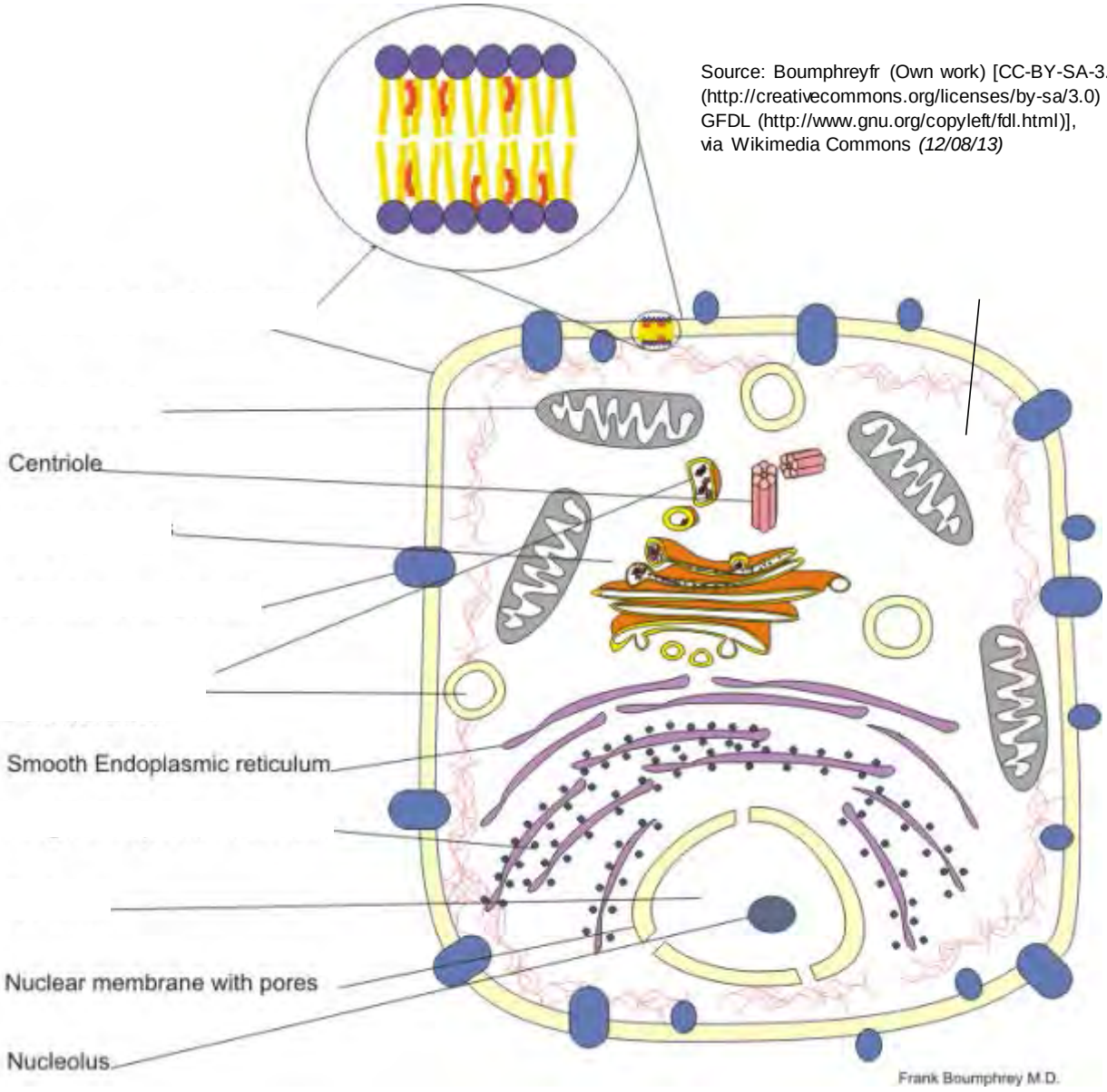
Rough Endoplasmic Reticulum: This organelle adds the finishing touches, such as protein assembly, folding and quality control, to proteins that are made by ribosomes and then transports them in the cell. The ribosomes (black dots on diagram) associated with the endoplasmic reticulum give it that "rough" appearance under the microscope. Messenger RNA is translated into protein by ribosomes either in the cytoplasm or in association with the endoplasmic reticulum.

Nucleus, DNA and RNA: The nucleus contains chromosomes made up of DNA containing the genetic code. DNA contains the plans or blueprints needed to produce all the parts of the cell. The nucleus receives signals such as whether the cell needs to multiply or repair itself, and the appropriate genes are accessed by special machinery that makes copies of the DNA genes in the form of RNA molecules (transcription). The RNA molecules leave the nucleus and ribosomes translate the genetic code.

Name: _____

Part 2: Your analogy…A cell is like _____

Fill in the cell parts with labels that fit your analogy:



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Part 2 continued: Common Function Relating to Analogy

Cell Membrane is like…

Cell Membrane Proteins are like…

Mitochondria are like…

Golgi Apparatus is like…

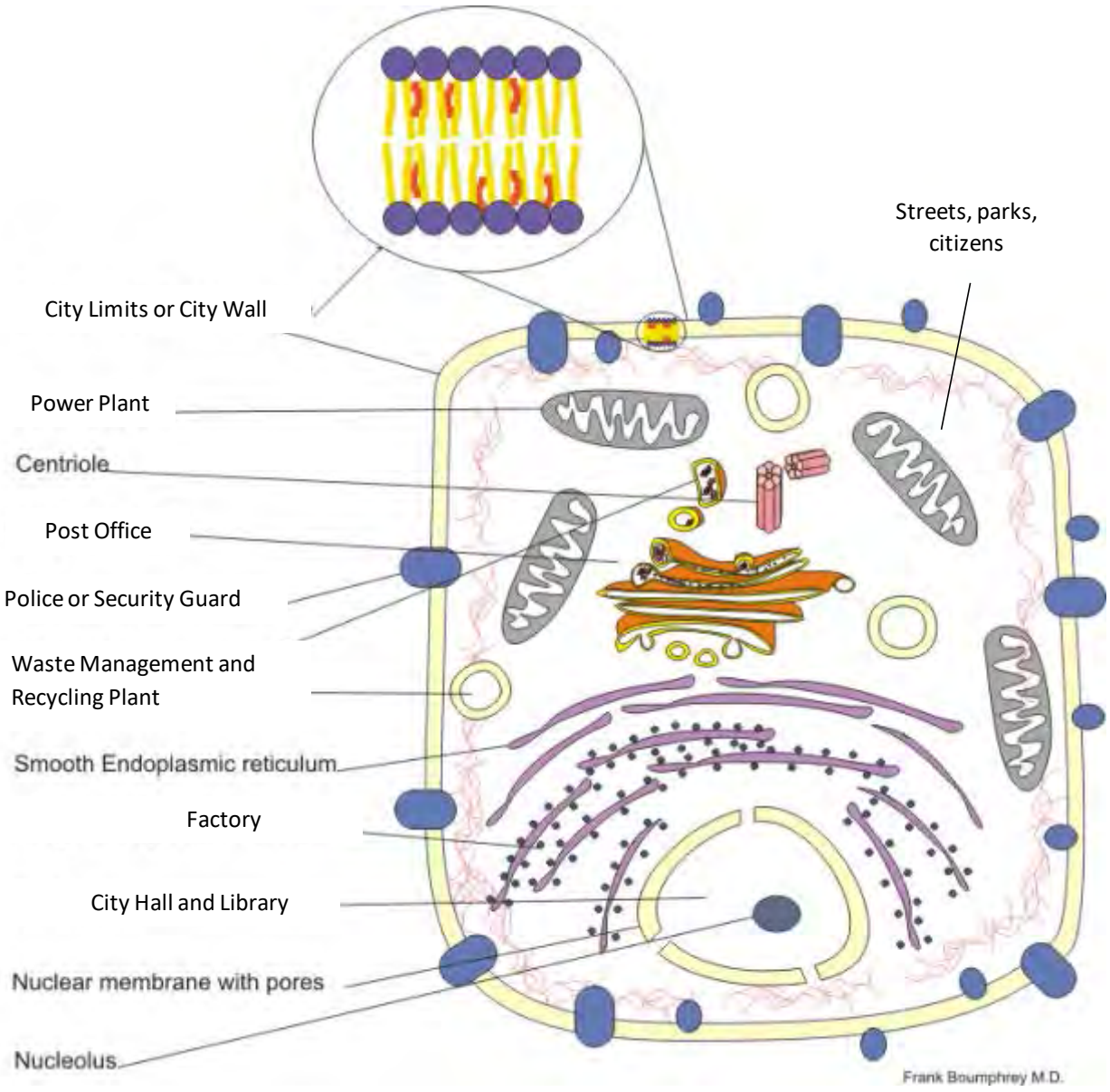
Lysosomes are like…

Cytosol is like…

Rough Endoplasmic Reticulum is like…

Nucleus (including DNA and RNA) is like…

Example of a completed datasheet using a city as an analogy:



Examples of common functions between the cell part and the analogous part within a city:

Cell Membrane is like… City wall or city limits
The Cell Membrane is like an old world city wall acting like a barrier providing protection for the cell. Only certain molecules can get in. The cell controls the environment within the cell like a city has rules about what can be done within city limits.

Cell Membrane Proteins are like…Police or security forces
Cell membrane proteins are like gate-keepers, police or security forces controlling what goes in and out of the cell.

Mitochondria are like…Power Plant
The inside of the cell has the hustle and bustle of big city. ATP and electricity are used throughout the cell and the city respectively. Another great analogy is that mitochondria and ATP are similar to banks and money. ATP is sometimes referred to as cellular currency as it is exchanged for actions or "services" within the cell.

Golgi apparatus is like… Post Office
Golgi apparatus prepares proteins with tags that direct transport to the right places, like stamps and addresses.

Lysosomes are like… Waste Management or Recycling Plant
Lysosomes are like garbage collectors, collecting waste products managing safe disposal. Like in recycling, lysosomes break down large molecules to parts the cell can reuse.

Cytosol is like… City streets, parks and open spaces
This could be any areas within the city that citizens can move around in.

Rough Endoplasmic Reticulum is like… Factory
This is where proteins are modified, similar to where products are manufactured in a factory.

Nucleus is like… City Hall or Library
The nucleus is like city hall where decisions are made about how to use resources. The nucleus is also like a library where important documents are stored. If the cell needs to make more structural proteins because it is growing, transcriptional machinery in the nucleus needs to access the genetic code (DNA), which would be like accessing city plans. Transcriptional machinery make RNA copies of genes, which are like photocopies, to be read by ribosomes which manufacture the needed proteins.

Fun Fact: Who is the closest relative to animals?

The closest known relatives to animals are choanoflagellates, protists found in freshwater and saltwater, which can live as a single cell or in colonies. Researchers study choanoflagellates to find clues to how animals became multicellular.

Activity 2: Cellular Respiration

Time: 1 hour

Key Terms: yeast, cellular respiration, metabolism, fermentation

Group Size: 2 students per group

Materials:
Measuring Station:

- ☐ warm tap water
- ☐ pitcher for water
- ☐ sugar
- ☐ dry baker's yeast
- ☐ 1 tablespoon
- ☐ 2 teaspoons
- ☐ 1 measuring cup (2 c capacity)

At Each Group:

- ☐ 2 clean bottles (0.5-1L) with 1 cup fill line
- ☐ 2 balloons
- ☐ 1 30 cm string
- ☐ 1 ruler
- ☐ 2 sheets of letter paper
- ☐ masking tape
- ☐ "Cellular Respiration" datasheet per student

Learning Goal: Students will explore the differences in carbon dioxide output of yeast grown without and with sugar.

When looking at dry baker's yeast it is hard to imagine that it is alive. Dry baker's yeast has a grainy appearance and is made up of live yeast that is encapsulated in a coat of dry dead yeast cells and dry yeast growth medium. Adding water activates the yeast metabolism and it can begin to grow. Like all the cells in our body, yeast cells undergo cellular respiration, meaning they metabolize food and give off carbon dioxide. The carbon dioxide gas is what makes bread rise and have that bubbly appearance.

Procedure:

There will be a measuring out station with yeast, teaspoon, sugar, tablespoon, water pitcher, measuring cup and teaspoon for stirring.

1. For each student group, set out two bottles and label them +sugar and –sugar. Set out two balloons and two pieces of paper.
2. At the measuring station, add 1 packet of dry yeast or 2 teaspoons dry yeast to each bottle. Using the paper, create a funnel by folding the paper in half and then open it up. Put the yeast on the crease area of the paper and carefully pick up the paper and pour the yeast into the bottle.
3. Using the pitcher, pour warm water into the –sugar bottle to the 1 cup fill line.
4. Add 1 cup of warm water (same temperature as in step 3) and 1 teaspoon of sugar to measuring cup and stir until dissolved. Pour into the +sugar bottle.
5. At the student's desk, put the lids on the bottles and shake about 5 times. Remove lid.
6. Secure balloon on neck of bottle. Make sure it fits tightly. If loose, seal with masking tape.
7. Record the start time and any physical observations (changes in solution, level of foam, changes in the balloon).
8. Record observations and measure the balloon circumference with a string and ruler at 5 minute, 10 minute, 30 minute and 1 hour as well as when the balloon is standing.

Observations: Both of the yeast solutions will look a little foamy but the foam will rise in the bottle with the sugar. Rising foam level is an indicator of cellular respiration and output of carbon dioxide gas. The balloon in the bottle with sugar will blow up but the one without sugar will not. Below is a sample of a completed datasheet of observations and measurements.

Time	Observations		Balloon Circumference	
	- sugar	+ sugar	- sugar	+ sugar
9:30 (start)	yeast solution looks foamy	yeast solution looks foamy	n/a	n/a
9:35	foam level not changed; balloon is empty	foam level has risen; balloon is empty	n/a	n/a
9:40	balloon is empty	balloon has a little bit of gas	n/a	n/a
9:45	balloon is empty	balloon is standing upright	n/a	17 cm
10:00	balloon is empty	balloon is getting bigger	n/a	19 cm
10:30	balloon has a little bit of gas but not standing up	balloon is getting bigger	n/a	20 cm

Discussion:
What is aerobic respiration? Anaerobic respiration? Fermentation?

Aerobic respiration, anaerobic respiration and fermentation are all different forms of cellular respiration, which is the conversion of food to energy in the form of ATP by a series of chemical reactions. Aerobic respiration requires oxygen, and is the reason we need to breathe in oxygen to live. If oxygen is not available, fermentation, a quicker but less efficient means of ATP production, can be used. Human cells normally use aerobic respiration but muscles can supplement aerobic respiration, which takes more time to generate ATP, with a form of fermentation called lactic acid fermentation that produces some extra energy quickly. Sprinters have more muscles specialized for lactic acid fermentation than long distance runners. Yeast can use aerobic respiration or fermentation but prefer fermentation. Anaerobic respiration is a separate chemical pathway used by some bacteria that live in environments with low amount of oxygen where alternative compounds such as nitrates and sulfates are used to make ATP.

In the experiment, the carbon dioxide was released from the yeast into the liquid and the air in the bottle, creating foam and blowing up the balloon. In our bodies, carbon dioxide waste leaves each of our cells and is carried in the blood to the lungs where it is expelled when we breathe.

Yeast take in the nutrients they need to live from their environment but in a multicellular organism like humans, food is taken in through the digestive system and blood carries nutrients to all of our cells.

Extensions:
Enzymes perform important steps in cellular metabolism. Conditions such as temperature, pH and salinity affect the enzymes abilities to do their jobs. Some suggestions for experiments include:

- test how pH affects yeast respiration by adding vinegar to make the solution more acidic. Try adding one tablespoon of vinegar or experiment with different amounts.
- test how the addition of salt affects the yeast respiration. Try adding one tablespoon salt or experiment with different amounts.
- test the effects of different water temperatures on yeast metabolism.
- in addition to measuring the balloon circumference, you could record the time at which the balloon first stands up for each condition.

Name: _____

Cellular Respiration

Time	Observations		Balloon Circumference	
	- sugar	+ sugar	- sugar	+ sugar
Start				
5 minutes				
10 minutes				
Balloon Standing				
30 minutes				
1 hour				

Activity 3: Culturing Microbes on Solid Medium

Time:
Homemade gelatin plates prepared by teacher beforehand: 15 minutes then let solidify overnight.

Teacher preparation of yeast before experiment: 15 minutes

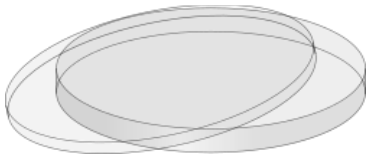
Activity: 20 minutes plus observations once per day for 2-3 days.

Key Terms: yeast, microbes, culturing

Group Size: 3 students per group

Materials for preparation of homemade gelatin plates:

- ☐ stove
- ☐ sauce pan
- ☐ mixing spoon
- ☐ plain gelatine
- ☐ water
- ☐ sugar
- ☐ beef bouillon
- ☐ measuring spoons
- ☐ Petri dishes OR muffin tins with foil muffin liners, aluminum foil, sandwich zip lock bags



Learning Goal:
Students will observe that cells grow by multiplying. On a solid surface, new cells will remain close to the original parent, forming a colony. Single yeast cells are not visible to the naked eye but after cells multiply, colonies form, each originating from a single yeast cell.

Fungi and bacteria, although not usually visible to the naked eye, are naturally present on fruit and vegetables and are responsible for food spoilage. The white film on plums and grapes is yeast, a unicellular fungi. Usually we discard food that is mouldy because it might make us sick but not all microbes are harmful to eat. The blue lines on blue cheese are from the mould *Penicillium*, which is a different species in the same genus of moulds which produce penicillin as an antibiotic medicine. Students will learn the technique of culturing microbes to observe organisms present on fruits, vegetables and blue cheese.

Culturing microbes is an important tool in science and medicine. If you have a sore throat a doctor may take a throat swab and culture it to find out which type of bacteria could be causing the sore throat. Streaking is a technique for isolating individual strains of a microbe. When laboratory scientists want to grow some bacteria or yeast for an experiment they like to start from a single colony on a streaked plate because it represents a single strain.

Preparation procedure for homemade gelatin plates (makes 25-30; prepare the day before class):

1. Line muffin trays with foil liners. Cover with sheet of aluminum foil. If using petri dishes, have them in stacks of 3 or 4 with lids on .
2. In a sauce pan, mix 4 packets of gelatin with 4 cups of cold water, 8 tsp sugar, 4 tsp bouillon granules (or 4 bouillon cubes).
3. Heat to boiling while stirring constantly. Then let cool slightly.
4. Pour into foil muffin liners or petri dishes. Cover with foil or lids and let cool for one hour at room temperature and let set overnight in refrigerator.
5. If using muffin liners, place each in individual sandwich zip lock bags.

Option: Instead of homemade gelatin, Sabaroud Dextrose Agar plates may be purchased from Boreal Science (Item 88W0920).

Materials for Experiment:

For streaking out plates:

- ☐ homemade gelatin plates or purchased Sabaroud Dextrose Agar plates (1 per student)
- ☐ markers for labelling the plates or zip lock bags
- ☐ "Culturing Microbes" datasheet per student

Baker's Yeast station:

- ☐ baker's yeast
- ☐ ½ cup measuring cup
- ☐ warm tap water
- ☐ coffee mug
- ☐ flat wooden toothpicks
- ☐ bowl to hold toothpicks lying sideways

Fruit (wild yeast) station:

- ☐ grapes or plums
- ☐ cotton swabs (Q-tips)
- ☐ coffee mug with a small amount of water in the bottom to hold wet cotton swabs

Blue cheese station:

- ☐ blue cheese
- ☐ flat wooden toothpicks
- ☐ bowl to hold toothpicks lying sideways

Procedure:

For streaking out plates:
Within each group of three, one student will streak out baker's yeast, another student will do wild yeast and one student will do the blue cheese mould.

Teachers should set up three streaking stations each with a waste receptacle handy. To avoid contamination, keep the media plates covered or in zip lock bags before and after streaking out plates. Wash hands before handling the toothpicks.

Baker's Yeast Station:

1. Teacher will dissolve a package of yeast or 2 ¼ teaspoons yeast into ½ cup warm water in a coffee mug. ***Allow yeast to activate for 15 minutes***.
2. Toothpicks have a narrow and wide end. For streaking out the yeast, pick up the toothpick by the narrow end and streak with the wide end. Dip the toothpick in the yeast solution and GENTLY rub it to the surface of the gelatin without letting your fingers touch the surface of the plate. Try to avoid digging into the gelatin but do not worry too much if this happens. Follow the zig zag pattern shown (Figure 1A).
3. The streaks are marked 1, 2, 3 (Figure 1A). Use a new toothpick for each streak. Streak 2 starts from streak 1 and spreads it out. Streak 3 starts from streak 2 and spreads it out. Label the plate or zip lock bag.

Fruit Station (wild yeast):

1. Rub wet end of swab all over fruit.
2. Rub the moist swab over the plate in a zig zag pattern covering as much of the plate as possible in one streak (Figure 1B). Label the plate or zip lock bag.

Compared with baker's yeast, there will be a lot less wild yeast. The use of a moistened swab will pick up more yeast.

Blue Cheese Station (mould):

1. Apply toothpick to blue vein in the cheese and rub gently.
2. Gently rub toothpick in a zig zag pattern covering as much of the plate as possible in one streak (Figure 1B). Label the plate or zip lock bag.

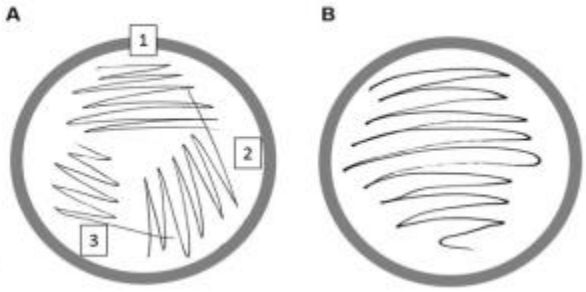


Figure 1. A. 3-streak pattern for baker's yeast. The purpose of repeating the streak pattern is to decrease the amount of yeast on the toothpick each time so that individual cells will be spaced out on the plate and grow into individual colonies. **B.** Single streak pattern for wild yeast on fruit and blue cheese mould.

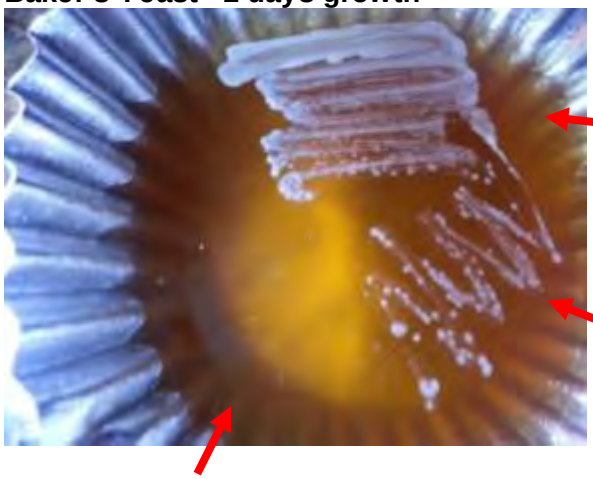
Incubation:

1. Immediately after streaking, plates should be labelled and covered with lids or placed inside zip lock bags (but not sealed).
2. Store at room temperature out of direct sunlight. For gelatin plates the cooler the room the better.
3. Look at growth on plates after 24 hours and record observations on datasheet. Repeat each day for up to 3 days at room temperature.

Observations:

These photos show sample observations of growth on homemade gelatin plates.

Baker's Yeast - 2 days growth

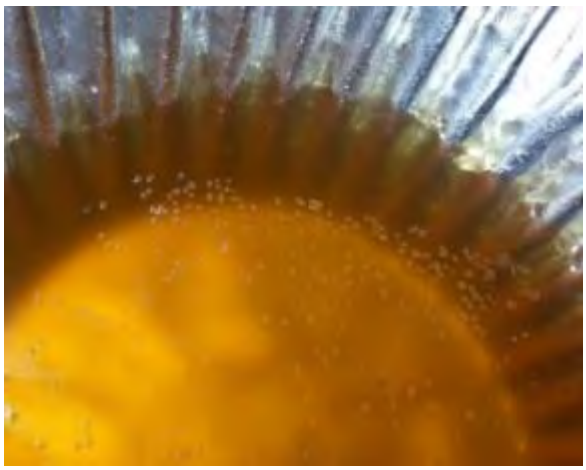


Streak 1 – Heavy growth. Colonies are not isolated.

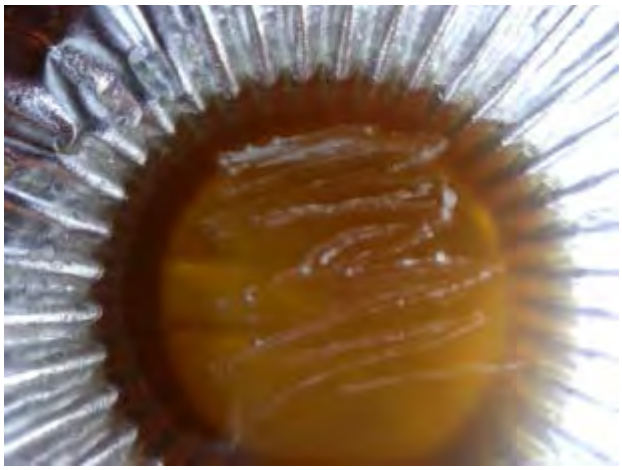
Streak 2 – Some isolated colonies are present.

Streak 3 – In this case no colonies grew in streak 3.

Wild yeast from grapes – 1 day growth



Mould from blue cheese – 1 day growth



Special note on using gelatin: If you are using homemade gelatin plates and your room temperature is very warm (above 24°C), after the first or second day you may find that the gelatin begins to liquefy. The microbes break down the gelatin and at higher temperatures, the gelatin may not remain solid. You may place the plates in the refrigerator for overnight periods (or over the weekend) and bring them out to room temperature during the day. The fungi will grow slower but the plates will stay solid for longer.

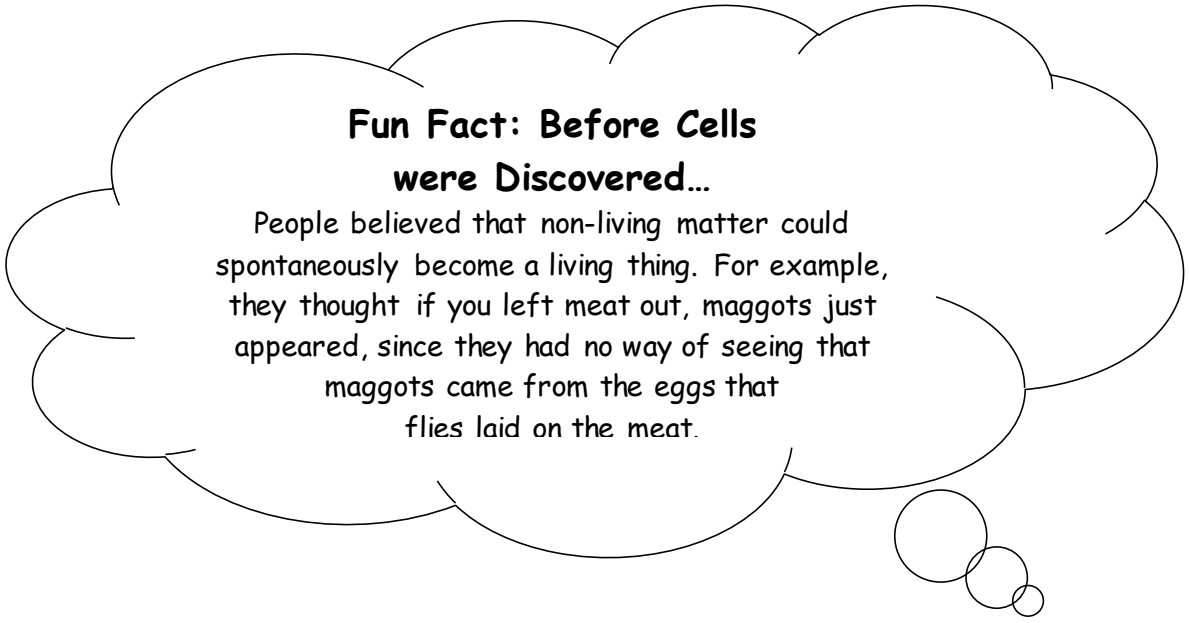
The following completed datasheet provides an example of recording growth in 2 days:

Day	Baker's yeast	Wild yeast	Blue Cheese
1	Streak 1 – white smear Streak 2 – no growth Streak 3 – no growth	- tiny whitish colonies visible	- streak is showing growth of white mould
2	Streak 1 – white smear Streak 2 – white blobs and isolated colonies Streak 3 – a few tiny single colonies	- larger colonies	- some of the mould is turning blue

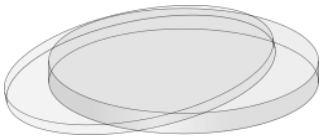
Discussion:
The first breads made by people were flatbreads. Ask the students how they think yeast first came to be used in bread. Answer: Likely natural contamination of flour with yeast produced the first rising bread.

Since there was no store bought yeast around, how did they add yeast to their bread? Answer: A small amount of dough with live yeast was kept from each baking session and added in with a new batch of bread.

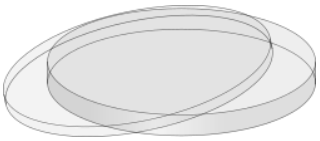
Ask the students why it is important for scientists to isolate colonies and use a single strain of yeast for experiments. Answer: All yeast in a single strain will be genetically identical. Different yeast strains can have different characteristics, such as what they like to eat and how fast they grow. Repeated experiments on a single strain of yeast will be more consistent than in a mixed population in which the proportions of different types could change from one experiment to the next.



Name: _____



Culturing Microbes



Day	Baker's yeast	Wild yeast	Blue cheese
1			
2			
3			

Activity 4: Simulation of Disease Transmission

Time:
Homemade gelatin plates prepared by teacher beforehand: 15 minutes then let solidify overnight.

Teacher preparation of yeast before experiment: 15 minutes

Activity: 20 minutes plus observations once per day for 2-3 days.

Key Terms: yeast, microbes, culturing

Group Size: 9 - 11 students per group

Materials for preparation of homemade gelatin plates:

- ☐ stove
- ☐ sauce pan
- ☐ mixing spoon
- ☐ plain gelatine
- ☐ water
- ☐ sugar
- ☐ beef bouillon
- ☐ measuring spoons
- ☐ Petri dishes OR muffin tins with foil muffin liners, aluminum foil, sandwich zip lock bags

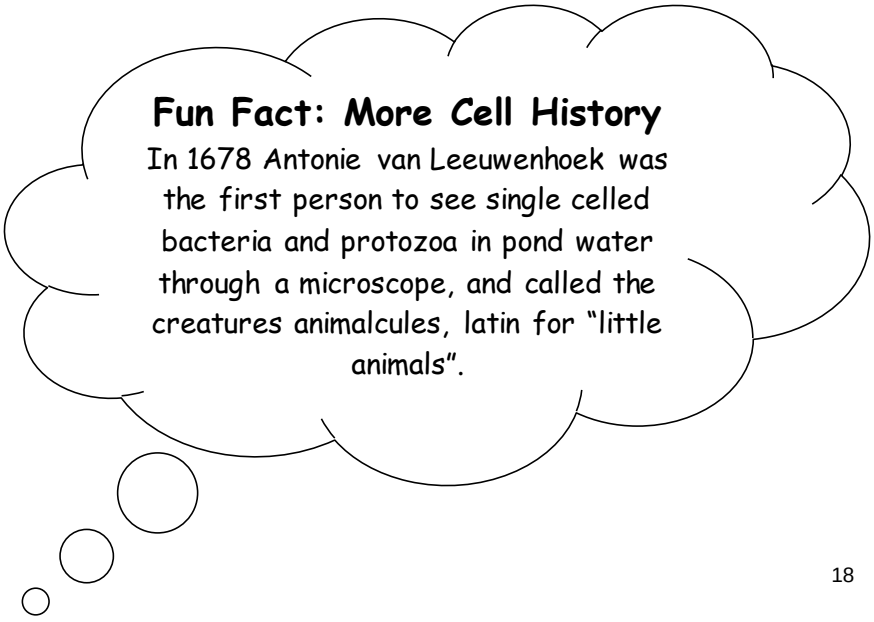
Learning Goal:
Microbes can cause disease. Students will see how germs can spread by hand shaking. Students will analyze their data and make conclusions based on their findings.

The common cold and other diseases caused by viruses and bacteria are spread from person to person by contact such as hand shaking. In this experiment, a harmless microbe, baker's yeast, will be used to illustrate how diseases might spread through hand contact between people. In disease outbreaks, the index case is the first person affected. This activity simulates a contagious disease that is spread by hand contact and it is the job of the students' to determine from which person the disease, or in this case, the harmless yeast, originated.

Preparation procedure for homemade gelatin plates (makes 25-30; prepare the day before class):

1. Line muffin trays with foil liners. Cover with sheet of aluminum foil. If using petri dishes, have them in stacks of 3 or 4 with lids on .
2. In a sauce pan, mix 4 packets of gelatin with 4 cups of cold water, 8 tsp sugar, 4 tsp bouillon granules (or 4 bouillon cubes).
3. Heat to boiling while stirring constantly. Then let cool slightly.
4. Pour into foil muffin liners or petri dishes. Cover with foil or lids and let cool for one hour at room temperature and let set overnight in refrigerator.
5. If using muffin liners, place each in individual sandwich zip lock bags.

Option: Instead of homemade gelatin, Sabaroud Dextrose Agar plates may be purchased from Boreal Science (Item 88W0920).



Materials for hand shaking activity:

- ☐ homemade gelatin plates or purchased Sabaroud Dextrose Agar plates (1 per student)
- ☐ "Simulation of Disease Transmission" datasheet per student

For preparation 20 min before class activity:

- ☐ baker's yeast
- ☐ sugar
- ☐ suckers or lollipops
- ☐ warm tap water
- ☐ 1 coffee mug for yeast solution
- ☐ ¼ cup measuring cup
- ☐ teaspoon
- ☐ 2 paper plates per group

For each group:

- ☐ 1 coffee mug to hold cotton swabs
- ☐ cotton swabs (Q-tips)
- ☐ 2 paper plates with a sucker, labelled "A" and "B" from preparation above
- ☐ markers for labelling plates or zip lock bags

Figure 1. Zig zag pattern

Procedure:

Teacher Preparation of yeast and suckers (start 20 minutes before class):

1. Add one envelope or 2 teaspoons of yeast and 1 teaspoon of sugar to ¼ cup of warm water and ***leave for 10-15 minutes*** to grow. Add just warm water to the other cup.
2. For each student group, label 2 paper plates A and B. Wet one sucker per group with water and place on paper plate "A".
3. Wet one sucker per group by stirring it in the yeast solution and place it on paper plate "B" (you may want to reverse A and B with different groups so they are not all the same).
4. Be sure to keep track which plate has the "contaminated" sucker (yeast), as only you know which has the yeast on it.
5. Place some cotton swabs in a cup of water for each group.

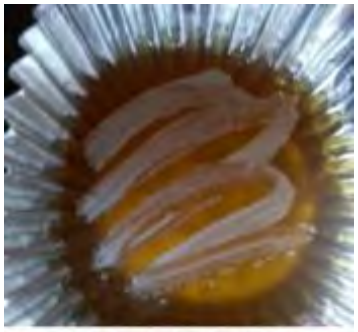
Procedure for hand shaking activity:

1. In each group one student will be designated the "scientist". Each student will be given one media plate for growing cultures, except for the scientist.
2. Ask students to wash their hands thoroughly with soap and water before they start the lab activity to minimize the presence of contaminating microbes.
3. Mark the students A1, A2, A3, A4, A5, B1, B2, B3, B4, B5 in each group.
4. Students A1 will roll sucker A around their hand and students B1 will roll sucker B around their hand. Discard the suckers.
5. The scientist of the group rubs wet cotton swab on the A1 and B1 student's hands and then rubs them all over the surface of a media plate in a zig zag pattern (see Figure 1).
6. Label media plates with name of student and their sample label, i.e. A1. If using petri dishes, label the bottom of plate. If using foil muffin liners, place them immediately back in the zip lock bag after swiping and label the bag.
7. A1 students shake hands with A2 and B1 students shake hands with B2.
8. The scientist rubs wet cotton swab on A2 and B2, rubs them on media plates and labels them.
9. A2 will shake hands with A3 and B2 will shake hands with B3.
10. Scientist rubs A3 and B3 hands with swabs, rubs them on media plates and labels them.
11. Repeat hand shaking and swabbing through A4, B4, A5 and B5.

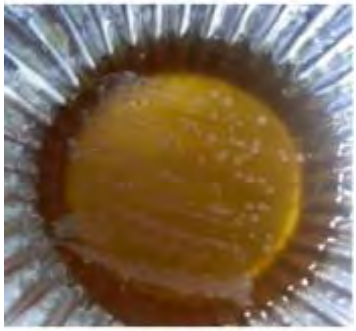
12. Incubate plates at room temperature for 24 hours, away from windows because sunlight will heat up the plates.
13. Look at plates and record observations on datasheet. Make a note of which plates have the most, medium and least growth. Growth will appear as white streaks, blobs or circles. Record any other growth observed which may be bacteria or mould. Check again at 48 hours or longer until you see some yeast growing.
14. After 2-3 days, there will be enough growth that each group will be able to identify and record whether A1 or B1 is the index case.

Special note on using homemade gelatin:
If you are using gelatin plates and your room temperature is very warm (above 24°C), after the first or second day you may find that the gelatin begins to liquefy. The microbes break down the gelatin and at higher temperatures, the gelatin may not remain solid. You may place the plates in the refrigerator for overnight periods and bring them out to room temperature during the day. The yeast will grow slower but the plates will stay solid for longer.

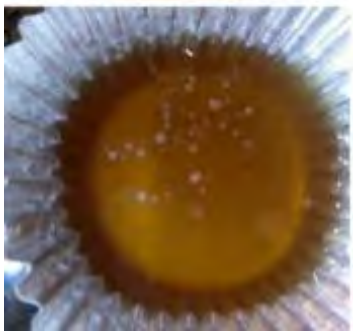
Observations:
Yeast will grow as white streaks, blobs and round colonies depending on the amount of yeast present. There may also be bacteria or moulds on the plates but these will look different. The yeast will show the most growth on either A1 or B1 plates, less on A2 or B2, less on A3 or B3 and the least on A4 and A5 or B4 and B5 but other microbial contamination will not likely show this pattern. The yeast may not transfer all the way to A5 or B5 and these plates may not show any yeast growth.



2 days growth: A1 index case showing lots of growth



2 days growth: A3 showing less growth than A1.



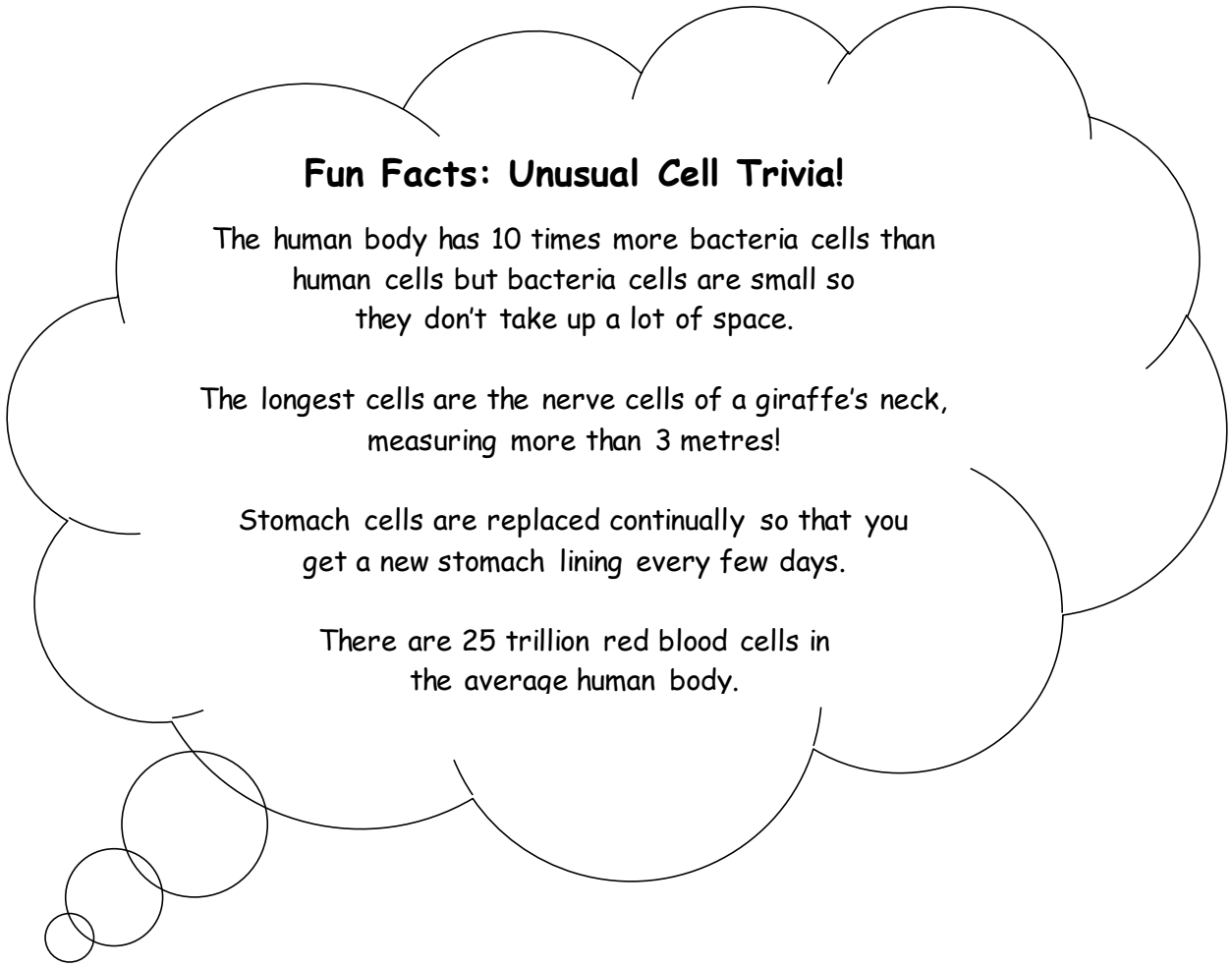
2 days growth: A4 showing less growth than A3.

The following is an example of observations seen from this experiment:

Plate	Person Sampled	Day 1	Day 2
A1	Theodore Schwann	- clear growth	- most growth
A2	Barbara McClintock	- faint growth	- less than A1
A3	Mary F. Lyon	- faint growth	- less than A2
A4	Robert Hooke	- no growth	- less than A3
A5	Marian Koshland	- no growth	- least growth

In the above example, A1 is the index case and yeast was transferred all the way to A5. While the B plates (or whatever ones do not have baker's yeast) will not grow baker's yeast, other contaminating microbe colonies may grow but they will look different from the baker's yeast and they will not show the gradient of most to least from B1 to B5.

Discussion:
Ask the class who is the index case for each group (A1 or B1) and why they came to that conclusion.



Name: _____

Simulation of Disease Transmission

Name of scientist for the group: _____

Plate	Person Sampled	Day 1	Day 2	Day 3
A1				
A2				
A3				
A4				
A5				
B1				
B2				
B3				
B4				
B5				

Which plates have yeast growth, A or B? _____

Who is the index case, A1 or B1? _____

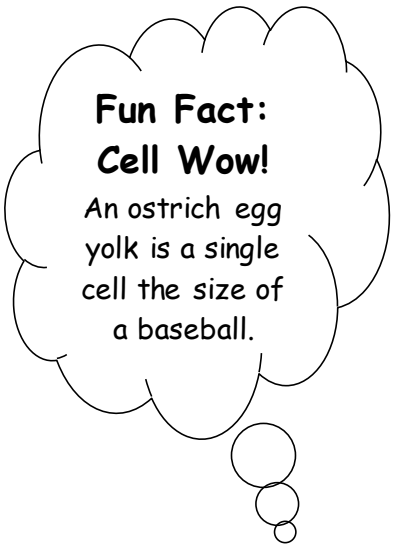
Activity 5: Eggs-ploring Osmosis

Time:
Day 1: 5 minutes
Day 3 or 4: 20 minutes
Day 4 or 5: 30 minutes

Group Size: 4-6 students per group

Materials per group:

- ☐ 3 eggs (white or brown)
- ☐ 3 glasses or mugs (short wide glasses work best)
- ☐ 1 shallow dish or container
- ☐ white vinegar
- ☐ corn syrup
- ☐ blue food colouring
- ☐ toothpicks
- ☐ plastic wrap
- ☐ ribbon or string 20 cm length
- ☐ copy of "Eggs-ploring Osmosis" datasheet per student (included)



Learning Goal:
Students will study osmosis using an experimental model, an egg with the shell removed. The membrane around the egg models the cell membrane. Students will recognize that changes in the egg under different conditions are analogous to changes in cells.

In chicken eggs, the yolk is an egg cell. As the egg matures, the egg white and shell form around the yolk. The membrane around the egg white can represent a cell membrane because, like a cell membrane, it is semipermeable. Small molecules like water can pass freely in and out but large molecules cannot.

Osmosis is the tendency of water to move across the membrane from an area of high water and low solute concentration to an area of low water and high solute concentration. An egg is about 90% water and 10% other molecules. Students will observe what happens when the egg (10% solute) is placed in water (0% solute) a solution that is hypotonic to the egg, meaning less solute concentration. Students will also observe what happens when the egg is placed in corn syrup, a hypertonic solution, containing more solute than the egg.

Procedure:

1. To remove the eggshell each group will put one egg in each glass and fill with vinegar. Alternatively multiple eggs can be placed in larger containers for this step.
2. Refrigerate for 24 hours to 3 days. Cover with plastic wrap to lessen the smell.
3. After 24-48 hours, the shell has thinned and is soft but the egg is opaque white. The experiment will work as long as the egg feels soft. If the eggs still feel hard, leave them another 24 hours. After 3 days in vinegar most of the shell is gone and the eggs will look translucent. If the egg is left too long in vinegar the membrane will become more fragile and the egg will be more difficult to handle and may burst during the experiment.
4. Carefully place the eggs in a bowl. Do this by gently pouring the egg out from the glass and catching it in your hand before placing it in the bowl. Dump out the vinegar and rinse the eggs under water.
5. Wrap the ribbon around the widest part of the egg and place the ribbon along a ruler. Record the width of each egg.
6. Place one egg in water with 2 drops of blue food colouring. Place another egg in a cup and cover with corn syrup. The egg will float but make sure there is syrup over the egg. Wrap the third egg with plastic wrap as a "no treatment" control.

7. Monitor the eggs two times within 1-4 hours of starting the experiment. Record observations such as appearance of eggs and presence of bubbles. Gently touch the eggs and record if the membrane feels tight like a turgid cell or deflated like a flat tire.
8. At 24 hrs record observations again on appearance and feel.
9. Rinse eggs off one by one by placing them in the bowl and rinse out the glasses. Unwrap the control egg. Take care not to mix up the eggs. Measure and record the width of all three eggs.
10. To find out if any of the blue dye travelled past the egg membrane, poke a hole in the egg membrane with a toothpick while holding it over the bowl (keep hole pointed down into dish because it really sprays out). Is there any blue dye in the liquid coming out?
11. Describe and calculate the increase or decrease in size in relation to the original size (see example on observation datasheet).

Observations:

The following is an example of observations recorded for this experiment.

Time	Control Egg	Egg in Water	Egg in Corn Syrup
0 (start)	14 cm	13.5 cm	15.5 cm - egg floats
1 hour	14 cm	13.5 cm -bubble in water and on egg	14.5 cm - egg looks and feels a bit deflated
3 hours	14 cm	14 cm - egg looks and feels bloated	13.0 cm - egg looks and feels more deflated
24 hours	14 cm	15 cm - egg looks and feels very bloated, like it might burst - membrane feels tight	12 cm - egg looks and feels like a flat tire

When the hole is made in the egg with food colouring, the liquid that comes out of the egg has blue dye.

Discussion and Possible Extensions:

Why did the egg in water look bloated and increase in size? Water moved into the egg because the inside of the egg had a higher solute concentration.

Why did the egg in corn syrup look deflated and decrease in size? Water inside the egg moved outside into the corn syrup, which has a higher solute concentration than the inside of the egg.

Since the blue dye got into the egg, what does this suggest about the size of the blue dye molecule?

Ask the class if they think they could make the corn syrup egg regain its shape and size. Osmosis is reversible. This can be observed by placing the corn syrup egg in water for 24 hours.

Since the corn syrup is hypertonic and the water is hypotonic, could you make a solution that is isotonic? What could you use? Salt or sugar dissolved in water could be used.

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Name: _____

Eggs-ploring Osmosis

Time	Control Egg	Egg in Water	Egg in Corn Syrup
0 (Start)	Size _____cm	Size _____cm	Size _____cm
1 hour	Size _____cm	Size _____cm	Size _____cm
3 hours	Size _____cm	Size _____cm	Size _____cm
24 hours	Size _____cm	Size _____cm	Size _____cm

Describe and calculate the increase or decrease in size in relation to the original size (see example below).

Example:
Egg before water treatment: 13 cm 15/13 = 1.15
Egg after water treatment: 15 cm

Egg before corn syrup treatment: 16 cm 12/16 = 0.75
Egg after corn syrup treatment: 12 cm

After the water treatment the egg grew to 1.15 times its original size.
After the corn syrup treatment the egg shrunk to 0.75 times its original size.

Teacher Resources

Literary Resources

Osmosis, Water Channels, and the Regulation of Cell Volume. Lodish H, Berk A, Zipursky SL, et al. 2000. Molecular Cell Biology. 4th edition. New York: W. H. Freeman; 2000. Section 15.8, Available from: http://www.ncbi.nlm.nih.gov/books/NBK21739/ *(12/08/2013)*

Website Resources

Microscopy

http://micro.magnet.fsu.edu/primer/index.html *(11/06/15)*
http://micro.magnet.fsu.edu/primer/java/lenses/simplemagnification/index.html *(11/06/15)*
Everything you wanted to know about microscopes, optics and how they work brought to you by Florida State University, the University of Florida, and the Los Alamos National Laboratory. Magnification is explained with a simple interactive tutorial.

General Cell Biology Background

http://www.nature.com/scitable/topicpage/what-is-a-cell-14023083 *(11/06/15)*
What Is a Cell? Is an introduction to cells explaining what cells are made of and what types of molecules are inside. It shows a nice size visual comparison of biological molecules and structures. *Scitable* by Nature Education series.

http://www.nature.com/scitable/topicpage/eukaryotic-cells-14023963 *(11/06/15)*
Eukaryotic Cells compares eukaryotic and prokaryotic cells and gives the theory on how eukaryotic cells got their organelles by one cell engulfing another (endosymbiotic theory). *Scitable* by Nature Education series.

Cell Metabolism

http://www.nature.com/scitable/topicpage/cell-energy-and-cell-functions-14024533 *(11/06/15)*
http://www.nature.com/scitable/topicpage/cell-metabolism-14026182 *(11/06/15)*
http://www.nature.com/scitable/topicpage/photosynthetic-cells-14025371 *(11/06/15)*
The above three links explain how cells take in nutrients, or make nutrients in the case of plants, and how nutrients and energy are used in the cell. *Scitable* by Nature Education series.

http://staff.jccc.net/pdecell/cellresp/fermentation.html *(11/06/15)*
From Johnson Community College, Overland Park, KS, USA. Fermentation pathway and fermentation in muscle cells.

http://www.bbc.co.uk/bitesize/standard/biology/biotechnology/living_factories/revision/1/ *(11/06/15)*
From BBC, information for students on yeast fermentation used in breadmaking, beer and cheese.

Yeast

http://www.redstaryeast.com/science-yeast/information-students *(11/06/15)*
All about yeast: What it is and how it was used in bread before anyone knew what it was.

http://www.nature.com/scitable/topicpage/l-h-hartwell-s-yeast-a-model-808 *(11/06/15)*
Pray, L. (2008) L.H. Hartwell's yeast: A model organism for studying somatic mutations and cancer. Nature Education 1(1). An overview of how yeast was used as a model by Nobel Prize winner (2001) Leland H. Hartwell to understand uncontrolled cell division in cancer.

Specific Topics in Cell Biology

http://phenomena.nationalgeographic.com/2010/08/08/an-introduction-to-the-microbiome/ *(11/06/15)*
Your body is a habitat for microbes, which outnumber your own cells by a factor of 10.This entertaining and fascinating article explains the good and bad aspects of the microbes that call our body home and how we and they mutually benefit.

http://www.actionbioscience.org/evolution/king.html *(11/06/15)*
Interview with Professor Nicole King from University of California-Berkeley about how unicellular organisms evolved into multicellular organisms.

http://www.newscientist.com/article/dn23090-zoologger-the-first-solarpowered-vertebrate.html#.Udeg4_nVBCg *(11/06/15)*
Endosymbiosis theory proposes that ancient plant cells acquired chloroplasts by engulfing a photosynthetic bacteria. This article reports on photosynthetic algae living inside salamander cells and providing them with glucose just like in plants! Could this turn into an animal chloroplast?

http://www.stemcellnetwork.ca/index.php?page=for-the-public&hl=eng *(11/06/15)*
Excellent information for the public on stem cell research provided by the Stem Cell Network at University of Ottawa: A nice background in the *What Are Stem Cells?* section. The *For Patients* section contains details about diseases for which stem cell therapies are being researched or used. The Stem Cell Timeline gives the most significant contributions to stem cell research including noteworthy contributions by Canadian scientists.

http://www.ucalgary.ca/pharmingthefuture/pmf *(11/06/15)*
University of Calgary provides information to the general public about how plants cells are being genetically engineered to make human proteins as medicines.

Interactive Whiteboard Resources

http://express.smarttech.com/?url=http://exchangedownloads.smarttech.com/public/content/c2/c2d60779-80ed-4dc4-b641-7222abb52b16/CellStructure.notebook# *(11/06/15)*
Cell biology lesson about animal and plant cells and different cell types in the body. A couple of nice little movies showing bacteria cells multiplying.

Multi-media

http://www.eurostemcell.org/films/a-stem-cell-story/English (flash) *(11/06/15)* (15 minutes)
http://www.youtube.com/watch?v=2-3J6JGN-_Y&feature=share&list=UUWRE5KuOGcxisnLxgkTJAMg
A highly engaging short film about stem cells, what they are, why they are important, including explanations by scientists, explained in a way that is accessible to all. Available in flash or youtube.

http://www.cell.com/cell_picture_show-stemcell *(11/06/15)*
Amazing images of stem cells by Cell, the scholarly journal.

http://www.cell.com/cell_picture_show-cellcycle *(11/06/15)*
Beautiful pictures and movies of cells dividing by Cell, the scholarly journal.

http://www.youtube.com/watch?v=QiMURLROjR8 *(11/06/15)*
Stomatal Opening and Closing. This is a simple demonstration using a balloon that may help students visualize how the amount of turgor pressure could allow the stoma to open or close. Teachers may want to perform this demonstration in front of the class.

Student Resources

Literary resources

What is Cell Theory? By Marina Cohen. 2011. St. Catherines, ON: Crabtree Publishing. ISBN 978-0-7787-7206-4. This is one title in the "Shaping Modern Science" series.
This book goes through the history of the microscope and development of cell theory to modern cell biology, introducing cell types, developmental biology and stem cells.

Website Resources

http://www.biology4kids.com/files/cell_main.html *(11/06/15)*
Cells explained in a very casual and fun manner. Clear examples of how cells function and how different cells have different functions. Click on topics on the right.

http://www.biology4kids.com/files/micro_main.html *(11/06/15)*
All about microorganisms. Explains differences between eukaryotes and prokaryotes. Click on topics on the right.

Interactive websites

http://ngm.nationalgeographic.com/2013/07/125-explore/shared-genes *(11/06/15)*
National Geographic game shows you just how much similarity humans have with other organisms at the DNA level, by science writer Carl Zimmer.

http://www.cellsalive.com/howbig.htm *(11/06/15)*
Compare relative sizes of animated cells and organisms like bacteria, dust mites, blood cells and pollen sitting on the head of a pin.

http://www.nobelprize.org/educational/medicine/2001/ *(11/06/15)*
In this game you are the "Cell division supervisor" and have to ensure cell division is completed with the correct steps and checkpoints.

http://school.discoveryeducation.com/lessonplans/interact/vemwindow.html *(11/06/15)*
Virtual electron microscope. Look at specimen, get a clue and guess what it is.

References:
In addition to resources listed above, the following were also used to develop this package:
Recombinant Protein Therapeutics from CHO Cells – 20 Years and Counting. Jayapal, K.P., et al. 2007. CHO Consortium: SBE Special Edition. Pg 40-47.
http://blogs.nature.com/news/2012/05/first-plant-made-drug-on-the-market.html *(09/07/2013)*
http://www.open.edu/openlearn/nature-environment/cells-are-cities *(09/07/2013)*
http://en.wikipedia.org/wiki/Saccharomyces_cerevisiae *(15/07/2013)*
Activity 2: Cellular Respiration http://www.sciencebuddies.org/science-fair-projects/project_ideas/MicroBio_p011.shtml#procedure;http://www.exploratorium.edu/cooking/bread/activity-yeast.html *(09/07/2013)*
Activity 4: Transmission of Disease Simulation "The Transmission of Disease by Microorganisms",Science in the Real World: Microbes in Action. By Teresa Thiel, Department of Biology, University of Missouri-St.Louis. http://www.umsl.edu/~microbes/elem.htm *(09/07/2013)*
Activity 5: Eggs-ploring Osmosis "Osmosis Eggs-Cells". Center for nanoscale science. PennState. http://www.mrsec.psu.edu/education/nano-activities/cells/osmosis_eggs/index.asp *(09/07/2013)*

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Get kids excited about science

Science Education Through Partnership

Scientists in School is a leading science education charity that reaches more Kindergarten to Grade 8 youth than any other science non-profit in Canada – 703,000 in the 2017-18 school year.

Through our hands-on, inquiry-based science, technology, engineering, math (STEM) and environmental classroom and community workshops, we strive to ignite scientific curiosity in children so that they question intelligently; learn through discovery; connect scientific knowledge to their world; get excited about science, technology, engineering and math; and have their interest in careers in those fields piqued.

By making science a verb - something you do - our workshops allow children's natural curiosity to reign, inspire kids to see themselves as scientists and engineers, and make connections between science and the world around them. This sets the stage for a scientifically-literate future generation who will fuel Canada's economic prosperity and think critically about the scientific challenges facing our society.

Scientists in School relies upon corporate, community, government and individual donors, as well as school board partners for support to develop new programs, continuously improve our existing programs, reach new geographic areas, provide complimentary workshops to less-privileged schools, and subsidize the cost of every one of our 25,040 annual classroom workshops.

Our Partners

Catalyst Level:

Natural Sciences and Engineering Research Council (NSERC), TD Friends of the Environment Foundation, Toronto Pearson International Airport

Innovation Level:

Amgen Canada, John and Deborah Harris Family Foundation, Nuclear Waste Management Organization, Ontario Power Generation, RBC

Imagination Level:

ArcelorMittal Dofasco, General Motors Canada, McMillan LLP, Pure Green Earth Fund, Superior Glove Works Ltd., TELUS

Discovery Level:

Ajax Community Fund at Durham Community Foundation, AtlasCare, Bruce Power, Cameco, Hamilton Community Foundation, MilliporeSigma, Ottawa Community Foundation, pharmaKARe consulting, Purdue Pharma, Syngenta, Systematix Inc., The Johansen-Larson Foundation, The McLean Foundation, The Township of Tiny, Waste Management

Exploration Level:

Brampton and Caledon Community Foundation, Brockville and Area Community Foundation, City of Brantford, Guelph Community Foundation, Huronia Community Foundation, Jackman Foundation, Lee Valley Tools, Niagara Community Foundation, Ontario Teachers Insurance Plan (OTIP), Rotary Club of Lethbridge Sunrise, Siemens Milltronics Process Instruments, The Source, Veridian Connections, Whitby Mayor's Community Development Fund, Youngs Insurance Brokers Inc.