DIFFERENTIATED LESSONS ON ECOLOGY, DEFINING LIVING ORGANISMS, HOMEOSTASIS, & CELL CYCLE

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Fall 2009

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A CELL THEORY LESSON

These lessons were designed to facilitate differentiation in a general classroom that includes students who may struggle, be on grade level, or excel in the content and their learning skills. Each uses a different strategy to adjust questions for the process, product, or content of a lesson. The lessons also include brief rationales for why the lessons were modified in a particular way and a method for assessment. There are also details that help explain how the teacher is able to manage different groups working on different tasks in the classroom.

DIFFERENTIATED LESSON PLAN 1: QUESTIONING

Overview of Course:
This lesson on energy flow within ecosystems will be taught in a 10th grade biology course during a unit on the topic of basic principles in ecology.

Objectives:
As a result of this lesson, students will be able to:
- Demonstrate how all energy that flows in most ecosystems comes from the sun.
- Distinguish between food webs and food chains.
- Analyze the loss of energy through a food chain.

Struggling Learner Directions and Lesson	Grade-Level Learners Directions and Lesson	Advanced Learners Directions and Lesson
Engagement: During a class discussion, the teacher will call on particular students who are struggling with this topic to answer questions which will mostly help these learners RECALL and APPLY their prior knowledge on energy in ecosystems. Exploration: Struggling learners will work in a group to discuss the characteristics of food chains and food webs in deciduous forest habitats, since they will be most familiar with organisms in this environment. The food webs they observe will have relatively few connections. The students will be given a handout with questions to guide their discussion which provides visuals and graphic organizers to help them build connections Explanation: As part of this step in the lesson, the students will summarize and share their experiences with a unique ecosystem with the class. Elaboration: To apply what they have learned, struggling learners will complete an activity that asks how they might create three diagrams that illustrate different aspects of energy flow in an ecosystem of their choice. They should understand the way food chains, webs, and pyramids are used to describe energy transfer in an ecosystem. However, the	Engagement: During a class discussion, the teacher will call on grade-level learners to answer questions which will help particular students mostly APPLY their knowledge of energy in ecosystems to new or more abstract concepts and ANALYZE relationships. Exploration: Grade-level learners will work in a group to discuss the characteristics of food chains and food webs in wetland habitats, since this environment will be less familiar and more abstract for these students. The students will be given a handout with questions designed to encourage them to make comparisons between the food chains and food webs they are studying for this activity and the food webs that exist in the environment in which they live. Explanation: The students will summarize and share their experiences with a unique ecosystem with the class. Elaboration: To apply what they have learned, grade-level learners will complete an activity that asks them how they might create three diagrams that illustrate different aspects of energy flow in an ecosystem of their choice. They should understand the way food chains, webs, and pyramids are used to describe energy transfer in an ecosystem. These students will	Engagement: During a class discussion, the teacher will call on grade-level learners to answer questions which will help particular students mostly APPLY their knowledge of energy in ecosystems to new or more abstract concepts and ANALYZE relationships. Exploration: Advances learners will work in a group to discuss the characteristics of food chains and food webs in coral reef habitats, since this environment will be least familiar and most abstract for these students. The students will observe how complex and diverse these food webs can be. These students will be encouraged to analyze factors which affect the stability of food chains and food webs in this environment and evaluate the role of humans in the food web. Explanation: The students will summarize and share their experiences with a unique ecosystem with the class. Elaboration: To apply what they have learned, advanced learners create three diagrams that illustrate different aspects of energy flow in an ecosystem of their choice. They should understand the way food chains, webs, and pyramids are used to describe energy transfer in an ecosystem. These students will

number of organisms they are required to include in their diagrams will be less depending on how many relationships they are able to conceptualize at one time (about 3 in a food chain and at least 4 in a food web).	be expected to include organisms at all trophic levels and multiple connections between trophic levels (about 5 in a food chain, 8 to 10 in a web).	be expected to include organisms at all trophic levels and multiple connections between trophic levels (about 5 in a food chain, 8 to 10 in a web). Advanced learners should also be able to calculate the exact energy loss at each level of the food pyramid they create.

Differentiation Strategy and Rationale(Justification):

Questioning is a strategy that allows a teacher to continually check for understanding, whether the questions are in a handout or spoken orally. Questions require students to draw on their knowledge, synthesize information into their own words, and evaluate their understanding. However, because answering questions itself requires so many skills, some students may need more support than others. I differentiated the engagement, exploration, and elaboration parts of this lesson so that students could explore each concept at a level that would be both challenging and achievable.

I separated the stations into three groups of students, those who might struggle, those at level, and those who might excel in this particular topic. The students' readiness level could be predetermined through an exit slip or pre-assessment. Each of the students would eventually be exposed to and learn all of the objectives, or content, for this lesson during a whole class instruction following the exploration activities. The questions at each station were differentiated based on readiness using different level blooms, abstract versus concrete examples, and degree of guidance through multiple questions or supportive charts and pictures.

What did I differentiated for?	**What I differentiated?**
This lesson was primarily designed to differentiate for varying readiness levels that could be observed in students. The students' readiness level for this particular topic, energy flow in an ecosystem, could have be determined by their performance on formative assessments, such as exit cards or pre-assessments, given prior to this lesson. The students were given guided questions that varied the amount of critical thinking needed for students to respond. Struggling learners were generally required to use lower level Bloom's thinking levels, more concrete examples of ecosystems, and fewer connected points as they considered the relationships between organisms within ecosystems. Grade-level learners were generally given medium level Bloom's thinking level questions to consider, more concrete examples of ecosystems, and multiple connections points. Advanced learners were given higher level Bloom's thinking level questions to consider, more abstract examples of ecosystems, and many connection points between organisms to relate to one another. Advanced learners were also required to think more mathematically, or abstractly, when considering food pyramids.	I differentiated the product of student learning at three points during the course of this lesson in order to help different students learn new concepts related to energy flow through an ecosystem by planning for a class which would include struggling learners, grade-level learners, and advanced learners for this topic. In the engagement portion of the lesson, questions were targeted at specific students which required them to produce answers using different levels of thinking according to Bloom's taxonomy. In the exploration activity, different groups of students were required to generate answers to questions by providing evidence from examples which varied from familiar to unfamiliar, or more concrete to more abstract. The students were also required to answer questions with regard to varying amounts of complexity found among ecosystems, from describing only a few relationships to many. The final product of this lesson, a written assignment requiring students to create diagrams based on their knowledge of different systems, was also altered by increasing the number of connections and relationships being mentally constructed. More advance students were also asked to consider energy loss in a more complex or abstract way by solving a mathematical equation. In this assignment the students were allowed to choose their own organisms and ecosystems of interest.

There were also points in the lesson in which I hoped to allow students to explore ideas in a way that was more comfortable for them in terms of interest and learning styles. Over the course of the lesson, students are able to discuss, write, and draw their ideas as they uncover more information. Assignments are given in both oral and written formats. The students are also given some choice in the regions, habitats, or particular organisms they study.	I wanted all of the students in the class to reach the same content goals for the lesson. Each of the students examined the source, transfer, and efficiency of energy transfer in an ecosystem. The context in which they studied this content varied slightly, with some students investigating ecosystems found in their own natural environment (concrete examples) and other students considering ecosystems found in distant habitats (abstract examples). The students followed a similar process throughout the lesson. The teacher presented the students with guided questions throughout the lesson, to respond to aloud and in writing, in order to help them construct new meaning about the relationships between organisms in a system.

Topic: Energy Flow within an Ecosystem **Class:** General Biology
Subject: Basics of Ecology **Grade:** 10th

Lesson Content

Virginia Standards of Learning:

Bio 9. The student will investigate and understand dynamic equilibria within populations, communities, and ecosystems. Key concepts include
b) nutrient cycling with energy flow through ecosystems;

Lesson Objectives (UKDs): *As a result of this lesson students will:*

- **Understand that...**

- The complex interactions between organisms in an ecosystem are affected by the efficiency of energy transfer between trophic levels.

- **Know. . .**

- Primary productivity is the total amount of organic material that is produced by autotrophic, or "self-feeding", organisms in an ecosystem. All other organisms in an ecosystem rely on this productivity to sustain life.
- Plants produce chemical energy by absorbing and transforming energy from the sun during the process of photosynthesis. Plants are the basic trophic level of most ecosystems on Earth. Almost all aquatic and organisms rely directly or indirectly on the sun for energy.
- A trophic level is one of the steps in a food chain or food pyramid. Examples of trophic levels include producers and primary, secondary, and tertiary consumers.
- The path of energy through the trophic levels of an ecosystem is called a food chain.
- A food web is a diagram that shows the complex feeding relationships between the organisms in an ecosystem. A food web is made up of multiple complete food chains.
- An energy pyramid is a triangular diagram that shows an ecosystem's loss of energy, which results as energy passes through the ecosystem's food chain. Each row in the pyramid represents a trophic (feeding) level in an ecosystem.
- Energy transfer through a food chain is inefficient. Only about 10 percent of the energy at each trophic level is accessible to the next trophic level. The rest is lost to the environment as heat. Therefore energy flows in one direction, rather than cycling as nutrients do, through an ecosystem.

- **be able to (SWBAT). . .**

- Identify the sun as the source of energy for most ecosystems on Earth.
- Distinguish between food webs and food chains.
- Analyze the loss of energy through a food chain.

Essential Questions:

How does energy enter an ecosystem, what direction does energy flow through an ecosystem, and how efficiently is that energy transferred through the complex interactions of the organisms that make up an ecosystem?

Brief Overview:

Prior to this lesson, the students will explore the basic characteristic of populations, communities, and

ecosystems. The students will be expected to have a basic understanding of the ways in which organisms within each of these groups interact with each other and their environment. They should have an understanding of the different roles organisms fill in the ecosystem with regard to energy production and consumption. Students should be able to differentiate between autotrophs and heterotrophs, consumers and producers, and herbivores omnivores, detritivores, and carnivores. This lesson will encourage students to develop a deeper understanding of how energy connects the organisms within ecosystems. During this lesson, the students will discuss how energy enters an ecosystem. They will explore how the transfer of that energy creates chains and complex webs of interrelatedness and interdependence between different groups of organisms. The students will also learn how inefficient energy transfer is between trophic levels and how energy decreases in an ecosystem over time.

Materials:

- Potted plant and light
- Chalk or dry erase board
- Exploration handouts for each students differentiated for 3 groups based on readiness
- Resources on forest, wetland, and oceanic ecosystems including, bookmarked websites on a computer, books, articles, and photographs
- Computer and projector
- "Energy Flow in an Ecosystem" PowerPoint presentation
- Access to a YouTube video located at http://www.youtube.com/watch?v=TE6wqG4nb3M
- Elaboration handouts for each students differentiated for 3 groups based on readiness
- Rulers, colored pencils, paper, and other materials needed for constructing diagrams

Steps in Lesson:

1. Engage: (15 minutes) **At the beginning of the period, the teacher will ask the class to create a list of things they have eaten in the last day. The teacher will record their responses on the board.** Afterwards, the students will come up to identify and circle all of the plants, or plant derived products, they have eaten (French fries, salad greens, stir fried veggies, wheat based cereals, etc.). **Next, the teacher will show the class a potted plant to help them review what they know about plants, cellular processes, nutrient cycling, and forms of energy through a series of questions. The teacher can target each of the questions, which require various levels of thinking skills, at specific groups of students in the classroom by calling on certain students to share their answers. The teacher will have an idea of the level of challenge each question will present to each student based on the results of a pre-assessment given at the start of the unit. The teacher will ask the students:**
    - **What conditions does this plant need to survive in our classroom?** (The students may answer, "the right temperature, light, humidity, space, soil, protection from predators, and nutrients.") This question can be answered by struggling students because it requires students IDENTIFY factors they can observe in the plant's environment.
    - **Do plants need any living organisms to be present to survive?** (the students may answer, "bacteria in the soil to provide nitrogen and other organisms which breath out carbon dioxide into the air.") This question should be answered by students who excel in this topic because it requires students to APPLY their knowledge of nutrient use and cycling to a situation without making direct observations.
    - **Do these organisms provide the plant with energy or nutrients?** (the students should answer, "Nutrients.") This question can be answered by struggling learners because it requires them to be able to DEFINE items already identified as containing either energy or nutrients.

- **How does this plant obtain energy then?** (The students may answer, "The plant performs photosynthesis.") This question may be answered by students at grade level for this topic because it involves a minimum standard of knowledge about the kingdom Plantae and requires them to be able to GENERALIZE and APPLY this knowledge to the particular plant being used.
- **What do scientists call organisms that do not rely on other living things for energy?** (The students may answer, "Producers or autotrophs.") This question can be answered by any level student, including struggling students, because it requires students to LABEL an organism using a term recently learning in this unit. Asking this low level thinking question to higher achieving students will help switch up the routine of questioning so that shorter answers are not always answered by the same group of students.
- **What type of energy is used by the plant to perform photosynthesis, and what type of energy is produced as a result of this process?** ("The students should answer, "Plants absorb solar energy and convert that energy into chemical energy in the form of sugars/glucose." This question can be answered by struggling students because it requires them to RECALL the inputs and outputs of photosynthesis.

The teacher will refer back to the list on the board highlighting the plant organisms the students have consumed. The teacher will ask the class as a whole, "When you eat these plants, do you obtain energy or nutrients?" (The students should answer, "Both.") The teacher will help the class make connections by pointing out that since they already identified the plants' source of energy as the sun, and we rely on the plants for some of our energy, some of the energy that allows us to live indirectly comes from the sun. The students will then describe what each of the other organisms they consumed had probably eaten most of. On the board the students will write grass beside cows, corn besides chickens, seedlings besides deer, and so on. **Again targeting students at different readiness levels, the teacher will ask:**

- **What do all of these other organisms you ate have in common?** The students may answer, "They consume plants.") This question can be answered by struggling students because it challenges students to make COMPARISIONS and DRAW conclusions, but it also is based on direct observation of the characteristics of these organisms already identified by the class as a whole.
- **If you obtain all of your energy from these living organisms, where does all of the energy you consume originally enter the environment?** (The students should answer, "From the energy found in sunlight.") This question can be asked to students at grade level for this topic because it requires students to ANALYZE the flow of energy from producers to consumers and our relationship to producers whether directly as consumers (herbivores), or as consumers of other consumers (carnivores).
- **Are there other inorganic sources of energy that living organisms can harvest for energy?** (The students should answer, "Yes, chemotrophs produce energy from heat and certain chemical compounds, such as sulfur and ammonium.") This question can be answered by students at grade level for this topic because it requires students to RECALL and STATE information that was learned in previous discussions about the roles of organisms in the ecosystem, but also use terms that are very abstract for students because these organisms and processes can not be observed daily or in habitats where humans can be found normally.
- **Where do chemotropic organisms live? Are these environments common?** (The students may answer, "Chemotrophs are found in deep sea vents where the pressure is very high and there is no sunlight, and in hot springs such as the ones in Yellowstone National Park. They live in extreme environments where only a few highly adapted organisms can live") This question can be answered by students at grade level for this topic because it also requires them to RECALL abstract concepts.
- **What are the most common producers that support oceanic and aquatic ecosystems?** (The students should answer, "Algae and phytoplankton are the most

numerous producers that live in these environments. These organisms live near the surface where they can absorb sunlight and convert that energy to be used by the organisms below the surface.") This question can be answered by students who seem to excel in this topic because it requires them to perform multiple thinking skills including, identifying organisms in unfamiliar habitats, describing how these organisms obtain energy, and evaluating which provides the most energy for other living organisms. They should be able to support their conclusion with information about population size, range of habitat, and ability to transfer energy.

- **What energy source do you think most land and aquatic animals rely on?** (The students should answer, "Solar Energy. Most land and aquatic organisms rely, directly or indirectly, on the chemical energy produced by plants through a process that requires the input of sunlight.") This question can be answered by students who seem to excel in this topic because it requires them to CREATE a hypothesis based on the information reviewed throughout this discussion and SUMMARIZE the "take-away-point" from this activity.

2. Explore: (30 minutes) **The teacher will divide the class into three groups. The groups will be formed based on readiness. The teacher will pass out a handout to each student making sure that each group receives a different handout. The handouts will be differentiated to help guide the groups through a discussion about food chains and food webs in different ecosystems. The teacher will explain that the students might not be able to answer every question by drawing on background knowledge and making inferences. For questions that require further research, the teacher will point out where in the room they have provided additional resources on particular ecosystems. These resources will include bookmarked websites on a computer, books, articles, and photographs.** The students should work together and share their thoughts on each question. If a group finishes early, the students should work individually on their six week forestry projects on leaf identification. Struggling learners will work in one group to explore the characteristics of food chains and food webs in deciduous forest habitats. The food webs they observe will have relatively few connections. They will be able to use their own experiences with and observations of organisms in the environment in which they live to make sense of the relationships between these organisms. The handout given to this group will provide more visuals and graphic organizers to help them build connections. The students in the class who are on grade level for this unit will explore the characteristics of food chains and food webs in wetland environments. These students will be encouraged to make comparisons between the food chains and food webs they are studying for this activity and the food webs that exist in the environment in which they live. The students who have mastered the concepts in this unit well so far will explore the characteristics of food chains and food webs in coral reef environments. The students will observe how complex and diverse these food webs can be. These students will be encouraged to analyze factors that affect the stability of food chains and food webs in this environment and evaluate the role of humans in the food web. **The teacher can divide their time so that they are able to provide help and support to struggling students, answer questions, and ensure that all students are being appropriately challenged.**

3. Explain: (20 minutes) **The class will come together and the teacher will help the students check their understanding of food webs and food chains. The teacher will call on groups to summarize some of the main ideas they learned and record questions they still have. The teacher will then go over a brief PowerPoint that reviews the roles of various organisms in transferring energy within ecosystems and that introduces the concept of a food pyramid. Food pyramids are diagrams that show the amount of energy, in terms of biomass, that are present at each level in the food chain. The teacher will explain how the energy available at each trophic level decreases. The teacher will discuss how people metabolize the food we consume, how some materials are not digestible, and how most of the energy is lost to the**

environment as heat. As a fun review activity, the class will watch a video in which a teacher musically summarizes important concepts about food chains. The video can be found at: http://www.youtube.com/watch?v=TE6wqG4nb3M

4. Elaborate: (15 minutes) **The teacher will pass out a differentiated instructions to each student to help them individually practice applying what they have learned. The teacher will provide rulers, colored pencils, and any other materials needed. The teacher will explain to the class that each student will be asked how to create three diagrams that illustrate different aspects of energy flow in an ecosystem of their choice.** First, the students will create a food chain with various organisms that live in a particular environment. The students will be able to pick an ecosystem based on a region that interests them and choose between drawing or simply labeling organisms. The number of links they are required to include in their food chain will vary based on readiness- how many relationships they are able to conceptualize at one time. Second, the students will be asked to incorporate their food chain into a food web for the particular ecosystem they choose. The number of additional connections they are asked to illustrate will vary. Finally, the students will be asked to convert their food chain into a food pyramid highlighting the energy that is lost in each trophic level. Students who excel in this topic will be asked to calculate the number of calories lost at each level given what the number of calories produced by the producers in their food chain would be.

5. Evaluate: (10 minutes) To check for understanding, the students will complete an exit card with the following questions:
    1. Where does the energy that enters most ecosystems on earth come from? (The sun)
    2. How does energy transfer through an ecosystem? (Through the producer-consumer interactions between organisms)
    3. What is the relationship between a food chain and a food web? (Food chains are composed of a single organism at each trophic level which interact with one another in an area. Food chains make up the individual strands of a food web, which describes the energy relationships between several or all of the organisms in an ecosystem.)
    4. How much energy is lost at each trophic level in a food chain? (90 percent)

   The teacher will also be able to evaluate student learning based on the students' performance on several formative assessment products completed over the course of the lesson. The teacher will be able to check student responses to the group exploration activity and the diagrams they created individually as an elaboration activity. The teacher will also be able to formatively assess the ability of several students to respond to the engagement questions when called upon and their ability to work collaboratively and participate in discussions during several steps in the lesson.

Question Exploration Guide

What is the Critical Question?

How does energy enter an ecosystem, what direction does energy flow through an ecosystem, and how efficiently is that energy transferred through the complex interactions of the organisms that make up an ecosystem?

What are the Key Terms and explanations?

Energy	Energy is the ability to do work or produce change.
Ecosystem	An ecosystem is a system that includes all the living organisms and physical environment in an area interacting with one another and acting as a unit.
Trophic Level	A trophic level is one of the steps in a food chain or food pyramid that describes the interactions between organisms. Examples of trophic levels include producers and primary, secondary, and tertiary consumers.

What are the Supporting Questions and answers?

Where does the energy in an ecosystem come from?	All energy that cycles through ecosystems comes from solar energy from the sun. All of the organisms in an ecosystem rely on primary producers, plants or other autotrophic (self-feeding) organisms to convert that energy into chemical energy.
What roles do different organisms play in the transfer of energy in an ecosystem?	Producers are organisms that can make organic molecules from inorganic molecules. Photosynthetic or chemosynthetic producers serve as the basic food source in an ecosystem. Consumers are organisms that eat other organisms or organic matter instead of producing their own nutrients or obtaining nutrients from inorganic sources. Herbivores (plant-eaters), carnivores (meat-eaters), omnivores (everything-eaters), and detritivores (waste-eaters) are all consumers in an ecosystem. Primary producers and lower level consumers are called pray when they are eaten. Higher level consumers are called predators when they eat other organism. Producers and primary, secondary, ad tertiary consumers are different tropic levels that make up a food chain.
How does the transfer of energy influence which organisms interact with each other and how they interact?	Energy in an ecosystem can only travel between adjacent trophic levels. Consumers rely on primary producers for all energy. However, within consumers there are organisms that can directly metabolize the energy stored in producers and others which rely on these primary consumers for energy, but can not direct access the energy in producers. For example, an owl can eat a chipmunk, but not the nuts and greens the chipmunk eats. Organisms interact most closely with the organisms they receive or give energy to. The ability to obtain enough energy becomes an adaptive pressure. Organisms lower in the food chain have been selected for their ability to protect themselves from predators and animals higher in the food chain thrive when they are better adapted to catching and consuming animals lower in the food chain. This process is known as coevolution.

What are the Supporting Questions and answers?

What defines or limits a system in which energy can be transferred from one organism to another?	The path of energy through the trophic levels of an ecosystem is called a food chain.. A food web is a diagram that shows the complex feeding relationships between organisms in an ecosystem. In order for organisms to be connected in a food web, energy transfer must directly connect each organism to the next in order of organisms. The complex relationships between organisms that are indirectly linked by energy transfer, such as the relationship between multiple herbivores that feed off the same plant source, are food webs. Organisms are organized into food web and food chains based on the ability for energy to be transferred between them. Not all herbivores will be able to eat all plants. For example, a bunny could not eat a cactus. Food chains are limited by the ability for organisms to recognize, consume, and metabolize a particular source of energy. Energy transfer cannot occur between all organisms as a result of geographic, physical, social, and other boundaries which prevent organisms from developing in relation to one another.
How does energy transfer effect the amount of energy available to each level in an ecosystem?	An energy pyramid is a triangular diagram that shows an ecosystem's loss of energy, which results as energy passes through the ecosystem's food chain. Each row in the pyramid represents a trophic (feeding) level in an ecosystem. The energy in an ecosystem is most concentrated at the producer level, where energy comes most directly from energy in the sun. Only 10% of the energy available at each level is consumed by organisms in the next trophic level. Most is lost as heat. As a result, more energy is needed at each lower level to support few organisms at the next level.
How do scientists measure the available energy in an ecosystem?	Biomass, or the dry weight of tissue and other organic matter found in a specific ecosystem, is used by ecologists to determine the amount of energy present in trophic levels. Although there may be a greater number of organisms at higher trophic levels, there is always a greater amount of biomass at each lower level in an ecosystem. There is more biomass found among primary producers than at the primary consumer level.

What is the Main Idea Answer?

Energy loss at each trophic level guides the complex, dynamic interactions between organisms in an ecosystem. Organisms which occupy higher trophic levels rely on the greater amount of energy stored in the lower trophic levels. The interactions between different trophic levels, in which some organisms are consumed for energy, help to maintain a balanced or sustainable amount of energy in a system.

DIFFERENTIATION LESSON PLAN 2: CRITICAL THINKING

Overview of Course:
This lesson will be taught in a 10th grade biology course during a unit on the topic of the structure and function of living cells. In this lesson students will explore the concept of life as they observe it in nature. They will also consider how scientists continue to examine and redefine our understanding of living organisms.

Objectives:

The Virginia Standard of Learning addressed in this lesson:

Bio.5 The student will investigate and understand life functions of archaebacteria, monerans (eubacteria), protists, fungi, plants, and animals including humans. Key concepts include
f) how viruses compare with organisms.

Bo.2 The student will investigate and understand the history of biological concepts. Key concepts include
a) evidence supporting the cell theory

As a result of this lesson, students will be able to…

- Struggling learners: Distinguish between living and non-living organisms based on observations of their physical and behavioral characteristics. (*Analyzing*)
- Grade-level learners: Propose a definition for life, assuming cells are living and viruses are non-living, by comparing the characteristics of each. (*Creating*)
- Evaluate the evidence supporting or rejecting cell theory, which defines cells as the basic unit of living things, based on scientists' research of viruses. (*Evaluating*)

Struggling Learner Directions and Lesson	Grade-Level Learners Directions and Lesson	Advanced Learners Directions and Lesson
In this lesson, struggling learners will work in a small group to complete a Concept Comparison Table to summarize the unique characteristics which distinguish living organisms from non-living material. **The teacher will introduce the two concepts being examined in detail, "Living things" and "Non-living things" and the overall concept, "Classifying the natural world". The teacher will help the students understand why it is important for scientists to distinguish between the two and complete steps 1, 2, and 3 of the concept comparison table. The teacher will give the students directions to help guide them and start them off in completing the next step of the table on their own.**	In this lesson, grade-level learners will work in a small group to complete a Concept Comparison Table to define life, given the assumption that cells are living and viruses are nonliving, based on their research and background knowledge of the characteristics of each. The group will be given a concept comparison table with the steps 1 and 2 completed. There will be a short introduction that will explain how cell theory is used by some scientists to determine that viruses are not living organisms. **After the students have had time to read the introduction and review their knowledge of the topic with each other, the teacher will give the students some directions on how they can complete steps 3 through 7 of the concept comparison table using their notes, reasoning, and resources**	In this lesson, advanced learners will participate in a Socratic Seminar to determine whether viruses are living organism. The discussion will be based on readings they complete prior to the class period. The readings will explore the experiments used to develop cell theory and the current research findings on the nature and behavior of viruses. Each of the students will have read the chapter on the development of cell theory presented in a book by Alvin Silverstein, titled *Cells*: *Science Concepts*, *Second Series*. The students will also have explored the articles and resources found at the Website, *Are Viruses Alive?* The students will not have to go to the website. The teacher will have given each student 2 of the 9 additional resources presented on this Website as well as the main review article. This will allow each student to contribute a unique

Then, the teacher will be able to leave the students to discuss and write down, in step 3 of the concept comparison table, characteristics they can think of which can be observed in each category. The teacher might have labeled examples of each (a plant, fish, soil, water) set out to help the students make observations.

The teacher will return to the group and review with the students their responses for step 3 of the concept comparison table by asking the students to identify each characteristic as unique or shared between both living and non-living organisms. As the students describe the characteristics they listed the teacher can ask the students to explain each trait more by giving examples of living things they have seen before. The students will record the like characteristics in steps 4 and the teacher will help the students identify the overarching categories for step 5. The students will record the unlike characteristics in step 6 and discuss the categories in which living and non-living organisms differ. The teacher will give students directions for completing the next step in the concept comparison table on their own.

The teacher will be able to leave the group as the students work on summarizing what they have learned about each concept through this activity by creating a definition for living and non-living things. The students should first try to formulate a definition on their own, and then discuss their ideas with one another. As they listen to each other's definitions, they should check that they have included all of the necessary characteristics. In each of their definitions, the students should include the unique, or "unlike", characteristics of living and non-living things.

provided in class. The teacher will describe several books, articles, and, if available, bookmarked WebPages which the students can find information related to viruses and cells to include in their tables. The teacher will give an example to illustrate the relationship between characteristics and categories.

The students will be given time to research and discuss in their group characteristics of viruses and cells. Then they will divide these characteristics into like and unlike characteristics. Finally, the students will create overall categories in which viruses and cells are similar and different.

The teacher will return to the group to check their understanding and review their responses for steps 3 through 7 of the concept comparison table. The teacher will then direct the students to create a definition for living things based on the characteristics they listed that were unique to cells, rather than based on the tenets of cell theory. The students should be able to say more than, "Viruses are not living because they are not composed of cells, which are the basic building blocks of living things according to cell theory." The teacher will explain that their definition should distinguish viruses from living things based on multiple characteristics they observed, including appearance and behavior. The teacher will direct the students to first work on their definition individually, then share their ideas with the group, and come to a consensus on the best definition.

The students will individually write their definition of living things in the summary portion, step 8, of their concept comparison table. As a group they will discuss how well each definition summarizes the characteristics they found in their research. The students will test each definition to ensure that cells are defined as living and viruses are defined as non-living, according to how they are viewed by many scientists.

perspective to the discussion and allow the students to share their knowledge with one another as they piece together and argument for whether viruses are living or nonliving. One student will be assigned the role of leader during the Socratic Seminar. While all of the students will be required to take notes during the reading, this student's notes will be modified to include only questions that will guide their thinking during the discussion.

At the beginning of the period, the teacher will ask the students to review the notes they took during their reading so that they will have evidence to support their ideas during the activity. The teacher will direct the students to create a list of questions they have from the readings while the teacher starts the other groups of students on their tasks.

The students will individually highlight the important ideas and questions they found in their readings.

The teacher will return to the group to check that each student has the readings, notes, and questions to show they are prepared to fully participate in the discussion. Students who say they were unable to complete the readings may work with the at grade-level group to investigate the characteristics of viruses and cells during the period. The teacher will remind the students of the important behaviors that will help the Socratic Seminar run more smoothly. The teacher will remind the leader to begin with lower level questions and advance up to higher level thinking questions as the group proceeds through the discussion. The teacher will also assign a "vibes watcher" to help the group monitor the effectiveness of the discussion. This student should help make sure every student has an opportunity to speak and

The teacher will return to the group to review and discuss the definitions they formed after analyzing the similar and contrasting characteristics of living and non-living things. The teacher will use this as a point to check for understanding, ask for questions, and correct any misconceptions. The teacher will use their questions and observations to make suggestions for further ideas they could explore. The teacher will direct the students to brainstorm more questions and suggest ways they could find out more about these topics. At the end of this lesson, the students will individually work on creating a picture that will illustrate their understanding of the distinguishing characteristics of living and non-living things. The students will hand in this drawing along with a short paragraph explaining their reasons for what they depicted in the picture.	**The teacher will review their definitions and ask students where questions, gray areas, and problems came up in their discussion. The teacher will present two questions. First, the teacher will explain that some scientists do consider viruses as having a "borrowed life". The students will discuss whether they think viruses share enough in common with living organisms to be considered living themselves. Second, the teacher will review with students the characteristics of chloroplasts and mitochondria within cells. Both have their own genetic material, specialized parts, a double layered membrane, and other characteristics similar to whole cells. The students will be asked to discuss among themselves whether our knowledge of these organelles today could also challenge the tenets of the cell theory. The students will also be encouraged to think of more questions they could investigate and write those in step 9 of their concept comparison table.** At the end of this lesson, the students will individually work on creating a picture which will illustrate their understanding of living things. They should include the role of viruses and cells in creating their definition of life. The students will hand in this drawing along with a short paragraph explaining their reasons for what they depicted in the picture.	**signal with a yellow card to the teacher when the discussion in dying down or becoming heated.** The students will participate in a Socratic discussion. **The teacher will return to the group when the discussion in dying down and ask the students guided questions to summarize their discussion. The teacher will give students a take away point, "Viruses live between living and nonliving conditions. In their chemically active state, viruses interact with living organisms in ways that influence their movement and development in significant ways. For humans, viruses can cause deadly diseases, but they can also be used as vessels to transfer DNA in important genetic research that may save many lives."** At the end of this lesson, the students will work on creating a picture which will illustrate their own interpretation of viruses as living or nonliving units and the future fate of cell theory (Will it remain the same, will scientists propose new tenets to expand the definition of life, or will it be discarded?). The students will hand in this drawing along with a short paragraph explaining their reasons for what they depicted in the picture.

Differentiation Strategy and Rationale(Justification):
Educators are often encouraged to engage students in thinking critically about the content they are learning. Critical thinking is associated with higher level thinking skills according to Bloom's taxonomy. Students are asked to problem solve, apply, evaluate, make judgments, and analyze the significance of various concepts. While these tasks may seem difficult to incorporate into lessons designed for all learners, including struggling and grade level learners, it is important for all students to experience activities that engage their critical thinking because it requires individual students to consider their prior knowledge and new findings on a topic in both logically and morally meaningful ways. In this lesson, all students were required to confront a question relevant to making decisions both as an individual and as a society – "What is life?" This is a very broad concept in biology, which offered many different levels of exploration. Struggling learners could explore how individuals distinguish between living and non-living things based on observations made in the natural world. Grade-level learners could explore the definitions of life proposed by scientists based on observations of the microscopic world of cells and viruses. Advanced learners could explore in more detail, and with greater independence, the role of viruses in shaping the living world.

What did I differentiated for? **_____ Interest _____ Learning Style ____✓___ Readiness**	**What I differentiated?** **____✓____ Content ____✓____ Process _____ Product**
This lesson was primarily designed to differentiate for varying readiness levels that could be observed in students. The students' readiness level for this particular topic could be determined by their performance on formative assessments, such as exit cards or pre-assessments, given prior to this lesson. Readiness could also be determined for this lesson based on the students reading performance. Struggling students were required to do less reading than the grad-level and advanced learners. The advances learners were required to read extensively and independently before coming to class.	The goal for all students was to reach a higher level of Bloom's taxonomy and to engage in critical thinking about a similar topic. However, each readiness level group had unique objectives for this lesson. Struggling learners were asked to analyze the characteristics of living and non-living things. Grade level learners were asked to create their own definition of living things based on their research around cells and viruses. Advanced learners were asked to judge the strength of different evidenced used by scientists to define viruses as living and non-living, and also evaluate the role of viruses in shaping the development of other living things. The process of this lesson was also differentiated to allow varying amounts of support and independence during the students' exploration of these concepts. Struggling learners were asked to complete a concept comparison table, a type of graphic organizer, with frequent teacher guidance. Grade-level learners were also asked to complete a concept comparison table with less direct teacher assistance and more materials for students to research and discuss their findings as a group. Advanced learners were asked to explore the concept individually and independently and then, as a group, critique the conclusions they read about.

Comparison Table for Grade-level Learners

Living organisms share many common characteristics. Organisms are often distinguished from non-living material in nature by their ability to grow and develop, reproduce, respond to their environment, move, have complex organization, and perform metabolic processes. Viruses share many of these characteristics, however, many scientists argue that viruses are non-living based on the cell theory. By the early 1900's several scientists, who worked both independently and collaboratively, had proposed three tenets that now make up the cell theory.

- Cells are the basic unit of life.
  You cannot break a cell down into smaller parts that are independently living. The cell is the smallest unit that can still exhibit all of the characteristics of life.
- Cells are the building blocks of all living things.
  All living things are composed of cells, from single-celled bacteria, to multicellular animals.
- All cells come from pre-existing cells.
  Cells cannot form spontaneously from non-living material.

Your task is to complete the following comparison table comparing cells and viruses to understand how some scientists distinguish between living organisms and viruses, based on the idea that cells are the basic unit of life.

② Overall Concept:
Defining Characteristics of Living Organisms

①Concept	**①Concept**
Cells	**Viruses**
③Characteristics	**③Characteristics**
Diversity of forms/appearance	Diversity of forms/appearance
Can cause illness in organisms	Can cause illness in organisms
Can be beneficial to organisms	Microscopic/small
Microscopic/small	Function as single units only
Can be singular or function as part of a multicellular organism	Carry hereditary information
Carry hereditary information	DNA or RNA, but never both
Both DNA and RNA	Specialized parts
Specialized parts	No metabolic machinery to replicate outside of a host
Can self-replicate and divide	Always parasitic; rely on and harm a host
Contains specialized organelles	
Contains macromolecules including proteins	

C Communicate targeted concepts
O Obtain the Overall Concept
M Make lists of known characteristics
P Pin down Like Characteristics
A Assemble Like Categories
R Record Unlike Characteristics
I Identify Unlike Categories
N Nail down a Summary
G Go beyond the basics

⑨Extensions

If we instead assumed viruses were living, how would our understanding of the basic components of living things change?

How do mitochondria and chloroplasts compare to whole cells? How could the characteristics of mitochondria and chloroplasts challenge the statement, "Cells are the basic units of living things"?

④ Like Characteristics

Diversity of forms/appearance
Can cause illness in organisms
Microscopic/small
Carry hereditary information
Specialized parts
Contains macromolecules including proteins

⑤ Like Categories

Form/Structure
Environmental Role
Size
Instructions
Materials

⑥ Unlike Characteristics

Can be singular or function as part of a multicellular organism
Can be beneficial to organisms
Both DNA and RNA
Can self-replicate and divide
Contains specialized organelles

⑥ Unlike Characteristics

Function as single units only
DNA or RNA, but never both
No metabolic machinery to replicate outside of a host
Always parasitic; rely on and harm a host

⑦ Unlike Categories

Unit of function
Relationships in an Ecosystem
Type of genetic material

⑧ Summary

Living organisms are composed of cells that contain both DNA and RNA, are able to self-replicate and divide, and contain specialized organelles. Living things can have both beneficial and harmful roles in the environment.

Comparison Table for Struggling Learners

② Overall Concept:
Defining Characteristics of Living Organisms

C Communicate targeted concepts
O Obtain the Overall Concept
M Make lists of known characteristics
P Pin down Like Characteristics
A Assemble Like Categories
R Record Unlike Characteristics
I Identify Unlike Categories
N Nail down a Summary
G Go beyond the basics

①Concept
Living Things

①Concept
Non-living Things

③Characteristics
Are made up of parts
Self-organized
Similar chemical composition
Move
Grow
Respond to their surroundings
Reproduce
Need food
Breathe, transform energy, & secrete waste (Metabolic processes)
Are found in nature

③Characteristics
Are made up of parts
Many possible compositions
Move
Grow
Some need fuel (machines)
Cycle & are transformed
Are found in nature
Are made by people

⑨Extensions
What characteristics allow scientists to distinguish between groups of living organisms?

How do scientists classify viruses which share some of the unlike characteristics of both living and non-living things?

④Like Characteristics
Are made up of parts
Move
Grow
Food/Fuel
Are found in nature

⑤Like Categories
Structure
Movement
Development
Energy
Location

⑥Unlike Characteristics
Self-organized
Similar Composition
Reproduction
Responsiveness
Metabolic Processes

⑥Unlike Characteristics
Many possible compositions
Cycle and are transformed

⑦Unlike Categories
Structure
Formation or Origin
Functions or Processes

⑧Summary
Living organisms describe self-organized things in nature, which share a similar chemical composition and which are able to reproduce, respond to their environment, and perform similar metabolic processes.

Socratic Seminar for Challenging Advanced Learners

Resources and Readings:

Cells: Science Concepts, Second Series, by Alvin Silverstein
Are Viruses Alive Website, retrieved from http://serc.carleton.edu/microbelife/yellowstone/viruslive.html

Sample Discussion Questions:

- What is life? Describe attributes of life that make it distinctive from other parts of the Earth system, such as minerals, water, or light.
- What is a virus, what qualities do viruses possess that are characteristics of life, what qualities set them apart from the classic definitions of life?
- Is a virus a living entity? Why or why not?
- If you define a virus as a living entity, what are the limits of life? Discuss what qualities must be present for something to be considered alive.
- If a virus is not defined as living, what is it? How does it reproduce? How have viruses evolved through time?

DIFFERENTIATION LESSON PLAN 3: CONCEPTUAL LEARNING

Overview of Course:
This is a lesson, on the concept of homeostasis in living systems, which was planned for a 10th grade introductory biology course.

Objective:

The objectives for this lesson align with the following Virginia Standard of Learning:

Bio 5. The student will investigate and understand life functions of archaebacteria, monerans (eubacteria), protists, fungi, plants, and animals including humans. Key concepts include

d) maintenance of homeostasis

Homeostasis is an underlying theme in the study of biology. To carry out life processes efficiently, living organisms require a controlled internal environment. Environmental systems also require relatively stable conditions to support life. Homeostasis is the ability of a living system to control these conditions through response, regulation, and feedback.

As a result of this lesson, students should be able to…

- Recognize the processes by which internal conditions are maintained in living systems despite changes in external conditions. (*Understanding*)

Struggling Learner Directions and Lesson	Grade-Level Learners Directions and Lesson	Advanced Learners Directions and Lesson
In this lesson, struggling learners will participate in a concept mastery activity to explore the concept of homeostasis. **The teacher spend the majority of the class period leading the discussion taking place with this group of students.** However, when there will be breaks when the teacher will start the students on a portion of the activity with an example, and leave to guide and check on the other groups working in the class. One student in the group will be assigned the role of "Caller". This student will signal to the teacher with a flag if the group has completed a section and is ready to move on, or if there are any questions or concerns.	In this lesson, grade-level learners will participate in a concept attainment activity, the "Example/Non-example Game", to explore the concept of homeostasis. These students will work in two small groups, each with access to a computer and a prepared PowerPoint. This activity will be divided into sections indicated by bright blue slides in the PowerPoint. One student in the group will be assigned the role of "Caller". This student will signal to the teacher with a flag if the group has completed a section and is ready to move on, or if there are any questions or concerns within the groups.	In this lesson, a group of advanced learners will participate in a concept development activity, the "Category Game", to explore the concept of homeostasis. These students will be working independently with little teacher supervision for most of the period. A student in the group will be assigned as a "Caller", and given a flag to raise when the group as completed one part of the activity and is ready to call the teacher over for their next instructions. **The teacher will introduce the concept of homeostasis to the group, speaking quietly and**

The teacher will introduce the topic of homeostasis to the class as part of the overall concept of life processes. The students will record these in the bottom of their diagrams in the space provided and underlying ideas on which they will base the rest of the activity. **The teacher will then ask the students to brainstorm key words they already associate with this concept from prior experiences and lessons. The teacher will provide the examples of a "response", "feedback", "exothermic animals", or "internal conditions" as needed to help prompt the students. The teacher may then leave the students to continue brainstorming to work with other groups.** The students will suggest additional key terms and record these in their diagrams. **The teacher will then explain that as a group they should discuss the relation of each of the terms they brainstormed, as well as additional terms they discover, to the concept of homeostasis by completing the following sections of the concept mastery diagram one at a time. The teacher will begin with the "Exmples" section and explain how endothermic animals would represent an example of homeostasis in that these animals regulate their body temperature as temperatures in their environment change.** The students will continue to identify examples of homeostasis. **The teacher will check their understanding and ask the students to explain the connection of each example to the concept of homeostasis. Then the**	**The teacher will explain that the aim of this activity is to describe the concept that is common to all things in one category, and not common to all non-examples. The teacher will read the focus statement and answer any questions.** In each group, the students will go through and discuss the fist positive example. They will then examine a five more images of examples of the concept and non-examples that do not fit into the concept. **The teacher explain that in the next few slides the students will encounter mixed unlabeled images that could represent examples or non-examples. As a group, the students should determine which images could represent which. Images that are indeterminate can be classified separately from the examples and non-examples.** The students will observe and identify 8 more images. **The teacher will review how the students identified each of the unlabeled images. Then, the teacher will go over the instructions provided for the next portion of the activity.** The students will write down the common characteristics they observed in each example and non-example. The students will describe what criteria they used to distinguish examples from non-examples. The students will then observe 8 more images and test each of the images against their list of attributes. The students should label the images that have all of the common characteristics as examples and others as non-examples. **The teacher will review the student's list of**	**having the actual topic written on an index card so that other groups will not overhear. The teacher will give each student in the groups a few sticky note cards and tell the students they should work together to produce a list of about 25 words related to the concept. The students should be as broad as possible. The teacher will leave the students to brainstorm ideas.** **The teacher will review the lists the students developed and divide the group of advanced learners in the class into two smaller teams of about 4 students. The teacher will give the students their next set of directions on an index card for each group.** The students will be asked to group the items in their list into 4 to 5 groups. The students should look for words or phrases that go together or that have some connections. The groups they create should be about equal in number. **The teacher will return to direct the students to label each group they created and record their groupings. The students will be given only a couple of minutes (about 2) to finish labeling their groups. Then, the teacher will listen to each team explain their groupings to the other team and discuss how the ideas in their list are related. The teacher will give the students their next directions on an index card and leave the team to begin regrouping their items.** The students will regroup the items in their list into 4 or 5 distinctly new groups. The students should be able to explain the new relationships they saw and

teacher will start the students on a discussion of non-examples by providing an example. On their own, the group will continue to identify non-examples of homeostasis. **The teacher will review the students' responses for non-examples and lead the students through a discussion of characteristics that are always present, sometimes present, and never present in the situations they described as examples. The teacher will provide examples for each category if needed to help the students identify these characteristics.** The students will then continue to identify words from their key words list that fall into these 3 categories. **The teacher will review the students' responses and guide the students in how to use the diagram to develop a definition for the concept.** The students should individually record a definition based on the characteristics that are always present. **Then the teacher will provide an item for the students to practice with.** The students will discuss whether the item is an example or non-example based on the definition they constructed. As the groups finished, the students will be instructed to work on their Ecosystem Journals. As the students progressed through each unit during the year, new concepts will be incorporated into their journals through writing prompts where the students will apply a new process to their ecosystems or individuals found within the ecosystems they choose at the beginning of the year.	**attributes and encourage students to consider where problems occurred in using those attributes to classify future images. The teacher will instruct the students to continue on to the next part of the activity.** Here the students will revise their list of traits, if necessary, to make them more predictive. Next, the PowerPoint will indicate that the students should work within their groups to name the concept being described. The students should also create a rule for what conditions must be met to fit this category or concept based on their list of traits. **The teacher will check the students understanding of the concept and make sure that the students were able to accurately define a rule for Homeostasis based on their knowledge of examples and non-examples. The teacher will guide the students on how they will continue.** Each group member will create at least one positive example. Then the group will use guided questions to discuss the process they used to name the concept being examined through examples and non-examples. As the groups finished, the students will be instructed to work on their Ecosystem Journals. As the students progressed through each unit during the year, new concepts will be incorporated into their journals through writing prompts where the students will apply a new process to their ecosystems or individuals found within the ecosystems they choose at the beginning of the year.	how items fit into each new group. The students should discuss in their small teams why some items can fit into more than one group. **The teacher will give the students their next set of directions on an index card and leave the group.** The students will look for a group that can be completely taken apart and all of its members distributed to the other groups. This will be called subsuming a category. When each team is done, the students should again share their results between teams. **The teacher will review the combining, regrouping, and subsuming recorded by each group and give the students their next set of directions on an index card. The teacher will stress that the students should work individually.** The students will individually work to put together and summarize their listing, grouping, and observations, to form generalizations about homeostasis. The students will be asked to make a single sentence statement about all of the items in their list. As the groups finished, the students will be instructed to work on their Ecosystem Journals. As the students progressed through each unit during the year, new concepts will be incorporated into their journals through writing prompts where the students will apply a new process to their ecosystems or individuals found within the ecosystems they choose at the beginning of the year.

Differentiation Strategy(ies) and Rationale(Justification):

For this lesson on the concept of homeostasis, I differentiated the lesson based on student readiness, as determined by previous formative assessments in the unit. Each readiness level was divided into groups that approached the concept of homeostasis in different ways through three different activities dealing with concept development, attainment, and mastery. The groups were given varying amounts of teacher support throughout the lesson.

The concept development activity will allow advance learners to explore and organize their knowledge of the concept of homeostasis. The students are asked to list, combine, label, subsume, and recombine ideas related to the topic of homeostasis until they have explored multiple characteristics that describe each connected idea. The activity will help advanced students demonstrate that they are able to link and connect the different pieces of homeostasis together to form an abstract statement or generalization about the concept. Advanced learners are challenged to create their own connections and look at a concept from different perspectives.

The concept attainment activity allows grad-level learners to identify characteristics that can be used to distinguish examples of a concept from non-examples. Students are required to figure out defining traits of homeostasis in living organisms and living systems by comparing examples with certain traits and lacking certain traits selected by the teacher. This strategy allows students to consider the concept of homeostasis in terms of a category which things they can observe either fit into or do not fit. In this way, the students can see how different aspects of homeostasis – the regulation of temperature, saturation, or nutrients in living organisms and the regulation of biodiversity, nutrients, and energy in living systems – are related to one another. As the students progress through the PowerPoint and group discussion, they will gain a better understanding by building on previous experiences and encounters.

The concept mastery activity allows struggling learners to explore a given concept with a greater amount of guidance from the teacher. The visual organizer focuses students thinking on the overall concept through identifying examples, non-examples, and criteria for characteristics that are present, sometimes present, or never present. The students are able to start with their prior knowledge, by brainstorming key terms, and then elaborating on how those terms fit into the overall picture. Once the concept map is completed, the students can use it as a template for practicing identifying new items as examples or non-examples of the concept. The students could also begin with more familiar homeostatic processes in individual organisms and then move on to consider what mechanisms maintain internal stability in ecosystems in the face of environmental disruption. In this lesson, the teacher provided specific examples of terms to fit into each category to support the student's thinking while the teacher directed other groups.

What did I differentiate for?	**What I differentiated?**
_____ **Interest** _____ **Learning Style** ____✓___ **Readiness**	_____ **Content** ____✓____ **Process** _____ **Product**

Concept Attainment PowerPoint

This protects people from change.

1

Positive Example

2

Negative Example

3

Positive Example

4

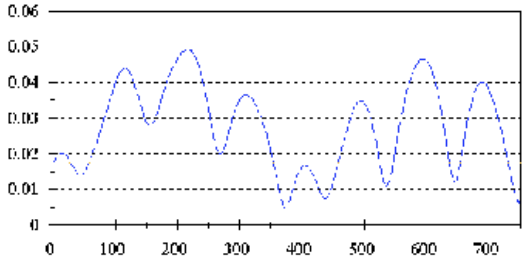
Positive Example

5

Negative Example

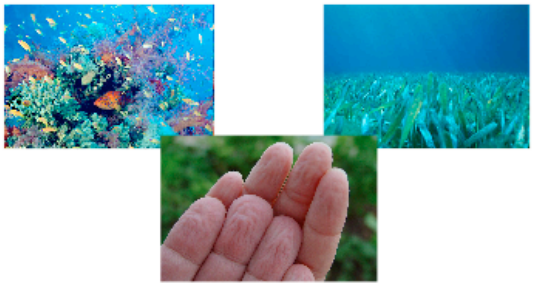
6

Negative Example



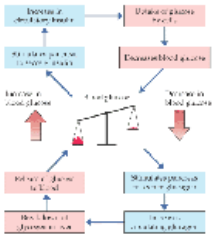
7

What Am I?
Example or Non-example



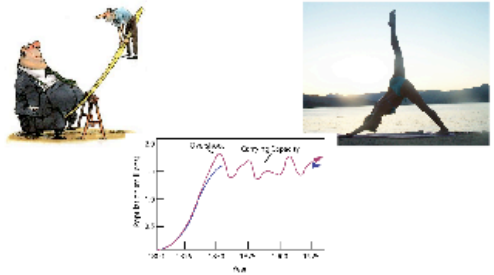
8

What Am I?
Example or Non-example



9

What Am I?
Example or Non-example



10

What do all the positive examples have in common?

Make a list of the characteristics you see?

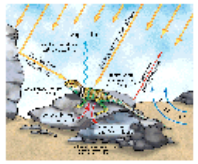
Complete this list FIRST, then continue through the next three slides to test several images against this list and classify each image accordingly.

11

Test These
Based on Your Attribute List

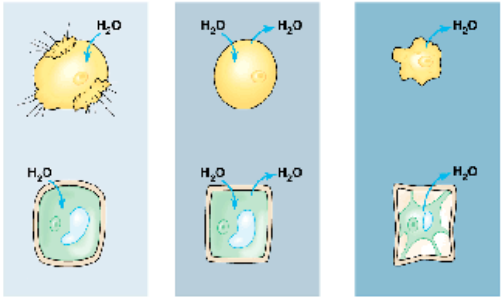
12

Test These



13

Test These



14

Do you want to revise your attributes list?

15

Within your groups, name the concept illustrated by the examples and non-examples

Then, state a rule that connects this concept to the list of criteria you identified.

Each group member, create examples of your own that fit into the concept you named as a group and share your ideas.

Discussion:

Did anyone have to change his/her thinking?

What made you change your mind?

When did you begin to see this attribute?

Concept Development for Homeostasis

Listing:

In this part of the concept development model, the students will work in small groups to brainstorm and list words or phrases related to what they know about the topic provided by the teacher. The teacher should encourage the students to reach about 25 items in their list and allow these items to be as broad as possible. Below is an example of the list the students might develop.

metabolism	carrying capacity	equilibrium	energy flux
temperature	receptor	nutrient cycling	straight line
counter weight	system response	sustainability	control center
stimulus	signal	trophic levels	extinction
succession climax	endothermic	blood glucose	urine
blood clotting	biodiversity	saturation	scarcity
balance			

Grouping:

In this part of the concept development model, the students will be asked to group the items in their list into 4 to 5 groups. The students should look for words or phrases that go together or that have some connections. The groups they create should be about equal in number. Below is an example of how the students might group the list above.

1 – equilibrium, balance, straight line, counter weight, sustainability
2 – receptor, control center, stimulus, signal, system response
3 – trophic levels, succession climax, biodiversity, nutrient cycling, carrying capacity
4 – endothermic, blood glucose, urine, blood clotting, metabolism
5 – temperature, saturation, scarcity, extinction, energy flux

Labeling:

In this part of the concept development model. The students will be asked to give a name to each of the groups or categories they created. The students will explain their reasons for their grouping and labeling. The students will discuss how the items are related and how their label describes their common characteristics. Below is a description of the labels the students might develop for the list and groups above.

1 = Definitions – These words each serve as synonyms of homeostasis or describe some fundamental characteristic of homeostasis in living systems. Homeostasis creates a state of *balance* or *equilibrium* in a system by maintaining consistent internal conditions even when external conditions are changing. The mechanisms in living organisms that are used in homeostasis serve as *counterweights*, they counteract changes. Homeostasis can describe a *straight line* on a graph where the temperature of an organism remains constant or where the number of species in an ecosystem remain constant. By keeping conditions favorable for life, homeostasis allows for *sustainability*.
2 = Process – These words describe part of the process by which living systems regulate their internal conditions. They describe what is done in homeostasis. For example, a *receptor* picks up information about a *stimulus*, or change in the external environment, which is interpreted by the *control center*, which then sends a *signal* to the part of the system that needs to enact a *system response*.

3 = Environmental Examples – These are examples of homeostasis in ecological systems. *Trophic level* interactions maintain stability in the amount of energy in a system by ensuring that lower level organisms are not overeaten, because these are the organisms that supply energy for the rest of the system. *Succession climax* is the point when an ecosystem is fully recovered and is at a stable number of species and populations. For example, after a fire a forest would grow through a series of intermediate communities until the point where the populations in it could be sustained and further growth would slow until another fire or externally caused change in the system. An ecosystem with greater *biodiversity* is more likely to recover from changes or damage. For example, if there is a diversity of crops on a farm, the farm is more likely to recover from a sudden disease at a faster rate. Nutrient cycling causes a constant supply of materials to be available in a system and used by multiple organisms. For example, the water cycle helps to restore an area form drought or flooding. *Carrying capacity* describes the point where energy and nutrients limit the size of a population's growth in an ecosystem, allowing the population to thrive sustainably creating a state of homeostasis where the populations neither increases or decreases.
4 = Internal Examples – These are each examples of systems within an organisms that can be used to create homeostasis. *Endothermic* animals maintain a constant internal body temperature. Insulin is used to maintain a certain amount of *glucose* in *blood* cells. *Urine* is a product of the kidneys that allow animals to remove excess and maintain the amount of water in the body. *Blood clotting* helps the body maintain its blood pressure level when an accident occurs so that this blood can be used to heal the damage. . *Metabolism* includes all of the processes that allow living things to regulate the chemical components needed to support life including what comes in, out, and is produced by cells.
5 = Triggers – These are each components of the external environment that can change and which living systems can respond to in order to maintain their homeostasis.

Regrouping:

In this part of the concept development activity, the students will be asked to regroup the items in their list into 4 or 5 distinctly new groups. The students should be able to explain the new relationships they saw and how items fit into each new group. The students might discover that, and should be able to discuss why, some items could fit into more than one group. Below is one possible way the students could regroup the items in the list above.

1 – temperature, balance, metabolism, endothermic, straight line,
2 – extinction, counter weight, carrying capacity, control center, signal
3 – energy flux, trophic levels, succession climax, blood glucose, receptor
4 – scarcity, sustainability, biodiversity, nutrient cycling, system response
5 – saturation, equilibrium, urine, blood clotting, stimulus

Subsuming:

In this part of the concept development activity, the students will look for a group that can be completely taken apart and all of its members distributed to the other groups.

Synthesizing:

In this part of the concept development activity, the students will put together and summarize their listing, grouping, and observations, to form generalizations about the concept they are studying. The students will be asked to make a single sentence statement about all of the items in their list.

Concept Mastery for Homeostasis

Key Words

response
balance
change
feedback
signals
organisms
ecosystems
temperature change
dehydration
nutrient cycling
endothermic animals
exothermic animals
living systems
mechanisms
internal conditions
external environment

EXPLORE EXAMPLES

Examples:

- endothermic animals
- nutrient cycling
- **excreting waste**
-

Nonexamples:

- exothermic animals
- energy loss
- **dehydration**
-

NOTE KEY WORDS

CLASSIFY CHARACTERISTICS

Always Present	Sometimes Present	Never Present
balance	ecosystems	constant external conditions
living systems	organisms	non-living systems
response	feedback	passive feedback
changing external conditions	signals	disequilibrium
constant internal conditions		

CONVEY CONCEPT

OFFER OVERALL CONCEPT

Homeostasis — **Life Processes**

TIE DOWN A DEFINITION

Homeostasis is the process in which living systems create balance by maintaining constant internal conditions in response to changing external conditions.

biodiversity

PRACTICE WITH NEW EXAMPLE

DIFFERENTIATION LESSON PLAN 4: ROLE PLAY/SIMULATION

Overview of Course: (topic, grade level, course title)
This is a lesson, on the concept cell cycle, which was planned for a 10th grade introductory biology course.

Objective:

In this lesson, the students will discuss the role of cell division and the cell cycle. The students will have the opportunity to explore the different phases and processes involved in mitosis using compound light microscopes. The class will discuss what they observed, the various roles of cell organelles in the process, the points where error can be introduced, and the mechanisms used in eukaryotic cells to ensure identical replication of genetic material during mitosis.

Cell processes are often difficult for students to conceptualize. Many lessons limit students to the motionless snapshots of cells in action pictured in their textbooks. In this lesson, the students will use simulations to represent the fluid, dynamic processes related to cell division. Three simulations will help different groups of students, both as participants and observers, gain a better understanding of the key concepts presented in the full class discussions – the role of cell organelles during mitosis, the cell processes that occur as the cell is transferring from one stage to the next, and the problems that can occur for a cell undergoing division.

The Virginia Standard of Learning addressed in this lesson is Bio 6. The student will investigate and understand common mechanics of inheritance and protein synthesis. Key concepts include:

a) Cell growth and division

As a result of this lesson, students should be able to…

- Discuss the role of cell division in single celled and multicellular eukaryotic organisms.
- *Identify the characteristics of chromosomes during the cell cycle.* (Struggling Learners)
- *Describe the four phases of the mitosis.* (Grade-Level Learners)
- *Evaluate the problems that can occur during cell division.* (Advanced Learners)
- Identify the checkpoints and mechanisms used to control the cell cycle in eukaryotic cells.
- Analyze how errors in mitosis can lead to cancer growth.

The *italicized* objectives relate specifically to the simulation portions of this lesson. All students will be responsible for each of the lesson objectives.

All students in the class will participate in an "engage", "explore", "elaborate", and "evaluate activities during this lesson. These are described in more detail in the attached lesson plan for mitosis. Below I have described the steps which fall mostly into the "explain" segment which was differentiated for this lesson. At this point the students have already reviewed the reasons for and important roles of cell division (repair, growth, renewal, & reproduction) and explored what different stages of the cell life cycle look like under a light microscope, taking notes on what they observed. At this point I will divide the class into three groups based on readiness level. The students will sit in different areas of the classroom, but in a position where they can still see the board and easily participate in whole class discussions. As a class we will begin to understand the complex processes behind the changes in cell structure they observed as a cell undergoes cell division.

Struggling Learner Directions and Lesson	Grade-Level Learners Directions and Lesson	Advanced Learners Directions and Lesson
I will give this group of students, who are struggling with concepts related to cell processes, a handout to write notes on as we walk through each of the phases of the cell cycle as a class. This handout will provide support for these learners by including diagrams, vocabulary, and partially completed notes. Part of the notes that will be important for their particular group to return to later in the lesson will be highlighted in red. The students will share their observations of the appearance and structure changes during six stages of the cell cycle (interphase, 4 mitosis steps, and cytokinesis) that they observed under the microscope. **The teacher will explain to the class the cell processes that are occurring and the role of various organelles in the process.** The class as a whole will discuss related topics including the difference between the cell cycle in plants and animals, problems that can occur, and the mechanisms used by the cell to prevent problems. **I will explain to the class that each group will now work to act out, or simulate, a different aspect of the cell cycle in a clear and fluid way. I will briefly review the common rules for positive participation in the simulations.** The students will focus their simulation activity on the characteristics of chromosomes in the cell cycle, particularly during interphase where DNA is replicated. **The teacher will give the group another guided handout that will explain the scenario.** It will help students in the brainstorming process by providing possible roles they will need (DNA stands, nuclear envelope, etc.) and "plays" to act.. It will provide support for students through notes describing the key characteristics of chromosomes that may be followed or read aloud as the students are re-enacting the cell cycle.	**I will give this group of students, who are performing at grade level on objectives related to cell processes, a handout to write notes on as we walk through each of the phases of the cell cycle as a class**. This handout will provide support for these learners by including detailed diagrams and section headings to help with organization. Part of the notes that will be important for their particular group to return to later in the lesson will be highlighted in green. The students will share with the class their observations of the appearance and structure changes during six stages of the cell cycle (interphase, 4 mitosis steps, and cytokinesis) that they observed under the microscope. **The teacher will explain to the class the cell processes that are occurring and the role of various organelles in the process.** The class as a whole will discuss related topics including the difference between the cell cycle in plants and animals, problems that can occur, and the mechanisms used by the cell to prevent problems. **I will explain to the class that each group will now work to act out, or simulate, a different aspect of the cell cycle in a clear and fluid way. I will briefly review the common rules for positive participation in the simulations.** The students will focus their simulation activity on four sages of mitosis in which multiple organelles participate in the distribution of identical chromosomes into two daughter cells. **The teacher will give the group another guided handout that will explain the scenario.** It will help students in the brainstorming process providing places for students to list roles they will need (centrioles, Golgi bodies, spindle fibers, etc.) and "plays" to act.. It will provide support for students through notes	**I will give this group of students, who are advanced learners in concepts related to cell processes, a handout to write notes on as we walk through each of the phases of the cell cycle as a class**. This handout will have diagrams to help save students time in note taking, and will also include suggestions for additional resources on engaging topics which students may explore for enrichment. Part of the notes that will be important for their particular group to return to later in the lesson will be highlighted in blue. The students will share their observations of the appearance and structure changes during six stages of the cell cycle (interphase, 4 mitosis steps, and cytokinesis) that they observed under the microscope. **The teacher will explain to the class the cell processes that are occurring and the role of various organelles in the process.** The class as a whole will discuss related topics including the difference between the cell cycle in plants and animals, problems that can occur, and the mechanisms used by the cell to prevent problems. **I will explain to the class that each group will now work to act out, or simulate, a different aspect of the cell cycle in a clear and fluid way. I will briefly review the common rules for positive participation in the simulations.** The students will focus their simulation activity on sources of error in cell division and checkpoints in the cell cycle for correcting mistakes or abandoning cell division. **The teacher will give the group another guided handout that will explain the scenario.** It will help students in the brainstorming process assign roles they will need (signaling proteins, DNA stands, etc.) and "plays" to act.. It will provide only a general questions that require students to consider the purpose of cell division and what consequences

Although I will be able to circulate the room during this time to ask questions and check on various students' understanding, I will spend a majority of the time working with this group through the brainstorming process. I will give some key adjectives that may help students picture the movement of human chromosomes, for example, "coil" and "elongate" and "pair up". The students will be also be able to reference their textbooks, notes, and other materials provided. When the students have completed their brainstorming activity, a student will be instructed to flip a card to indicate that the group is ready for the instructor. **I will check that the students have an appropriate roles assignments and behaviors.** Every group member will be required to participate. The group will then work together to act out their process. The students will have to defend how each of their movements represents a process in cell division. When the students have practiced and are confident in their understanding, they will signal for the instructor again. **I will check that their simulation is coherent, well planned, and that the students are able to narrate the processes that are occurring as they assume their different rolls.** **As the students wait for other groups to finish, the teacher will give the students a computer and tell them how to watch a sort animation on mitosis for review.** They will also be asked to work on a reflection in their class journals until all the groups are ready to move on. The students should reflect on their performance and evaluate, compared to the movie, how well their model could be used to explain the cell cycle. When all the groups are ready, the students will share their simulations with the class. On an index card they	bulleting the key steps that occur in each phase leading up to full nuclear division . **I will be able to circulate the room during this time to ask questions and check on various students' understanding. For this group I will ensure they understand the importance of spindle fibers in directing chromosome movement.** The students will be also be able to reference their textbooks, notes, and other materials provided. When the students have completed their brainstorming activity, a student will be instructed to flip a card to indicate that the group is ready for the instructor. **I will check that the students have an appropriate roles assignments and behaviors.** Every group member will be required to participate. The group will then work together to act out their process. The students will have to defend how each of their movements represents a process in cell division. When the students have practiced and are confident in their understanding, they will signal for the instructor again. **I will check that their simulation is coherent, well planned, and that the students are able to narrate the processes that are occurring as they assume their different rolls.** **As the students wait for other groups to finish, the teacher will give the students a computer and tell them how to watch a sort animation on mitosis for review.** They will also be asked to work on a reflection in their class journals until all the groups are ready to move on. The students should reflect on their performance and evaluate, compared to the movie, how well their model could be used to explain the cell cycle. When all the groups are ready, the students will	mistakes could have on living organisms and depict these in their simulation. **I will be able to circulate the room at during this time to ask questions and check on various students' understanding. I will give these students examples they can research or explore to help them think of ideas for consequences of errors in mitosis beyond what was mentioned in the lecture, such as the appearance of Trisomy X.** The students will be able to reference their textbooks, notes, and other materials provided. When the students have completed their brainstorming activity, a student will be instructed to flip a card to indicate that the group is ready for the instructor. **I will check that the students have an appropriate roles assignments and behaviors.** Every group member will be required to participate. The group will then work together to act out their process. The students will have to defend how each of their movements represents a process in cell division. When the students have practiced and are confident in their understanding, they will signal for the instructor again. **I will check that their simulation is coherent, well planned, and that the students are able to narrate the processes that are occurring as they assume their different rolls.** **As the students wait for other groups to finish, the teacher will give the students a computer and tell them how to watch a sort animation on mitosis for review.** They will also be asked to work on a reflection in their class journals until all the groups are ready to move on. The students should reflect on their performance and evaluate, compared to the movie, how well their model could be used to explain the cell cycle. When all the groups are ready, the students will share

will write one thing they noticed while viewing the other two simulations as audience members and at least two questions they still have about cells and cellular division.	share their simulations with the class. On an index card they will write one thing they noticed while viewing the other two simulations as audience members and at least two questions they still have about cells and cellular division.	their simulations with the class. On an index card they will write one thing they noticed while viewing the other two simulations as audience members and at least two questions they still have about cells and cellular division.

Differentiation Strategy(ies) and Rationale(Justification):

Molecular biology becomes very abstract for many students when there are really very concrete structures and functions that scientists can observe. Part of the problem is that students struggle to see these materials "in action" in their environment. Digital video is making that easier, but they don't allow students to experiment with the way parts interact or with the problems that could occur. Simulations allow learners to experience the world of cells from the perspective of different organelles. In this "life-size" microscopic world, they begin to get a sense of organelles as living material composed of parts and designed to carry out very specific work. Just as builder carefully lay stones to support a building, they can get a sense of the way different parts of the cell support life through very specific, prescribed behaviors.

The students were challenged to review and master the different roles and behaviors involved in different parts of the cell cycle through simulations. These simulations were perfected into final performances that were presented to their classmates. I differentiated the portion of the cell cycle used for this product based on readiness because I have seen students who fail to learn the concept of mitosis, and also those who learn it to different degrees of detail, but with comparable success. The most fundamental concept students must grasp is that mitosis results in two nuclei with identical genetic material. This happens through a process where DNA is replicated and equally distributed between two new cells. If students can hold onto this idea, they can continue to build on it through the study of meiosis, genetics, and heredity. Students on grade level are often expected to learn the four stages of mitosis. This helps students tie in information they have previously learned about cells – their structure and organelles – to a life process where these part are actively performing various functions. Advanced learners can explore in more depth the ways cells correct for and respond to problems in the completion of life processes. The mechanisms that allow organisms to respond to changes and maintain stability are underlying themes in biology.

Struggling learners may often have difficulty being self-motivated. This lesson helps provide keep students focused and provides structure for activities through oral and written instructions and peer interaction. Guided notes helped struggling learners practice and account for weaker study skills. Advanced learners, who can make their own predictions and set their own goals for learning, were given supplemental materials for exploration and further study. They were also given less structure and more opportunities for critical thinking. All learners were given the opportunity to synthesize information and display their achievement to their peers.

What did I differentiate for?	**What I differentiated?**
---------Interest ----------Learning Style ----X----Readiness	**----------Content ----------Process -------X-------Product**

Topic: Mitosis
Subject: Genomics

Class: Biology
Grade: 10th

Lesson Content

Virginia Standards of Learning:

Bio 6. The student will investigate and understand common mechanics of inheritance and protein synthesis. Key concepts include:
a) Cell growth and division

Bio 1. The student will plan and conduct investigations in which
a) Observations of living organisms are recorded in the lab and in the field

Lesson Objectives (UKDs): *As a result of this lesson students will:*

- **Understand that...**

- Cell division results in genetically identical daughter cells.
- The mitotic phase is only part of the cell cycle in which cells grow and divide.
- The eukaryotic cell cycle is regulated by a molecular control system.

- **Know. . .**

- The role of mitosis in the reproduction, growth, development, repair, and renewal of eukaryotic organisms.
- The phases of the cell cycle, including interphase (G1, S, G2), mitosis (prophase, metaphase, anaphase, telophase), and cytokinesis.
- The characteristics, movement, and assortment of chromosomes during the cell cycle.
- The mechanisms by which eukaryotic organisms control and check the cell cycle.
- The possible result of errors in the replication and division of nuclear materials during the cell cycle.

- **be able to (SWBAT). . .**

- Discuss the role of cell division in single celled and multicellular eukaryotic organisms.
- *Identify the characteristics of chromosomes during the cell cycle.* (Struggling Learners)
- *Describe the four phases of the mitosis.* (Grade-Level Learners)
- *Evaluate the problems that can occur during cell division.* (Advanced Learners)
- Identify the checkpoints and mechanisms used to control the cell cycle in eukaryotic cells.
- Analyze how errors in mitosis can lead to cancer growth.

Essential Question:

What is the role of the cell cycle in Eukaryotic organisms? How are the phases of mitosis carried out and regulated by cells to produce genetically identical daughter cells? How can scientists use knowledge of the cell cycle to improve our understanding of human health (tissue maintenance, growth, and disorders)?

Brief Overview:

In this lesson, the students will discuss the role of cell division and the cell cycle. The students will have the opportunity to explore the different phases and processes involved in mitosis using compound light microscopes. The class will discuss what they observed, the various roles of cell organelles in the process, the points where error can be introduced, and the mechanisms used in eukaryotic cells to ensure identical replication of genetic material during mitosis.

Cell processes are often difficult for students to conceptualize. Many lessons limit students to the motionless snapshots of cells in action pictured in their textbooks. In this lesson, the students will use simulations to represent the fluid, dynamic processes related to cell division. Three simulations will help different groups of students, both as participants and observers, gain a better understanding of the key concepts presented in the full class discussions – the role of cell organelles during mitosis, the cell processes that occur as the cell is transferring from one stage to the next, and the problems that can occur for a cell undergoing division.

Materials:

- Single eukaryotic cell labels for the human body
- Onion root tip slides, compound light microscopes, and photographs
- Handout for onion root tip exploration
- 3 Differentiated handouts for notes on the stages of the cell cycle and checkpoints
- 3 Different handouts for brainstorm activity adapted from "Genes in Motion"
- Computer with animation link
- Student Journals
- Index Cards
- Rubric for simulation participation

Steps in Lesson:

6. Engage: (15 minutes) I will introduce the topic the class will be exploring during the block – Mitosis and the cell cycle. To review what the students already know about cells and genes, and to engage student interest in the topic, I will ask for a student assistant in the class to be a model human being. The student will come to the front of the room and I will give them directions to tape one different piece of paper on each of their feet, hands, arms, legs, stomach, and head which will represent single eukaryotic cells. Then I will ask the class, "Suppose that your hand or your arm or your leg was made up of only one cell. What would happen if that cell stopped working or died?" I will draw an X over the hand cell. Possible answers might be that you would loose your entire hand, the body part would no longer function, or the cell would fall off. I will then ask the students to predict how many cells are in the human body. (It is impossible to count, but scientists estimate about 50 to 100 trillion cells – 100,000,000,000,000). What happens if just one cell in your hand or body dies, either from an accident or normal wear and tear? Will you loose your whole hand? (No). What does the body do to replace cells that die? Do wounds heal from the outside in or inside out? (Outside in because other cells divide to fill in the space left by the cell that died). I will write on the board "*Omnis cellula e cellula"* (Every cell from a cell) and ask students, thinking back to cell theory, what scientist stated this. (Rudolf Virchow). So when we talk about mitosis today, we are going to be talking about a process of cell division that allows us to make new cells from pre-existing cells. I will give the students a definition of mitosis to write in their notes. Mitosis is a process of cell division in eukaryotes that produces two new nucli that have the

same number of chromosomes. I will explain that today we are going to look at what happens in a cell during mitosis and what can happen when mitosis goes wrong. First, we will think about "Why mitosis?". We will try to come up with a list of where we use mitosis in our bodies and where other organisms can use this process. Students should include this in their notes.

- Tissue repair or renewal: We already mentioned one in thinking about how wounds heal. Cells can divide to heal, repair, or create new tissue. It is important to think about how most of the time division occurs cells of the same cell type to produce replacement cells – that is why stem cell research is so fascinating.

- Growth and development: Thinking back to where we came from, I can ask students how many cells they had when they were born? (Probably still in the trillions) and how many cells they had when they were only a few days conceived? Although a different process produces that first fertilized egg cell, mitosis is how we get to be multicellular organisms.
- Reproduction: Thinking back to when the students were studying single celled eukaryotic organisms (protists), I can ask the students to explain what would happen if their single cell divides. (Two new protists are formed). Going back to the definition I gave them, I can ask why we say archaea and bacteria do not undergo mitosis even though they also reproduce asexually, with one parent dividing to produce two. (Bacteria and Archaea do not have a defined nucleus to divide) Then I can explain how some multicellular organisms can also reproduce through mitosis. (Hydra go through budding, strawberries go through vegetative reproduction, and sea stars can grow from a fragment of the old one)

7. Explore: (30 minutes) I will have set up at 6 tables a microscope pin pointing a particular cell of an onion root tip undergoing the different stages of the cell cycle. (There will be one for interphase, prophase, metaphase, anaphase, telophase, and cytokinesis). Before encouraging the students to explore these stations, I will give a brief overview of the characteristics of chromosomes and the importance of their activity during the cell cycle. I will tell the students to look carefully for what is happening at each stage and start to think about how the stages fit together with one another. The stations are just snapshots of a process cells are continually undergoing. I will give each student a handout to guide their observations at each station. The students will work in pairs to rotate through each of the 6 stations. I'm going to give each group about five minutes to work on each station, but they can switch before that if you see one open. The students should talk to each other about what they are seeing and what they think is happening to the cell.

8. Explain: (40 minutes) The class will come together I will divide the students into three separate groups based on readiness level. Then, I will hand each group of students different handouts to write notes on as we walk through each of the phases of the cell cycle. The handouts will provide varying amounts of support for learners and will highlight portions of the notes that will be important for their particular group to return to later in the lesson. Addressing the class as a whole, I will encourage the students to share their observations and describe what they saw at each station by calling on particular students. I will draw a picture of what they tell me they saw on the board and then tell them the name scientists have given each of the processes and structures they described. I will write down the main points and terms on the board as we go along. I will elaborate on certain stages where the processes which were occurring in the cells were not visible in under the microscope. . I will also discuss topics such as the difference between cytokinesis in animal and plant cells due to the cell wall. We will then discuss where problems can go wrong in the cell cycle and have individual students right in stop signs on a diagram on the board to indicate where cells pause

in the cell cycle to check that everything is ok before continuing to divide. Students will be introduced to cell signaling and self-regulating mechanisms.

9. Explore (as needed) I will explain to the class that each group will now work to act out, or simulate, a different aspect of the cell cycle in a clear and fluid way. The teacher will briefly review the common rules for positive participation in the simulations. Their group assignment will be the portion of the cell cycle which was highlighted in the handout they received for taking notes during the lecture/group discussion. As they turn to work within their individual groups, the students will be given another handout, one per group, that will explain in more depth the simulation they will participate. The handout will help guide their brainstorming before they begin the simulation. It will provide varying levels of support for the different groups and will encourage all of the students to think creatively. The students will be able to reference their textbooks and other materials provided. After brainstorming, the groups will work together to act out their part. They will have to determine, or will be given suggestion for, the players they will need, the actions, and the overall structure of their simulation. The students will have to defend how each of their movements represents a process in cell division. When the students have practiced and are confident in their understanding, they will be able to watch a sort animation on mitosis for review. They will also be asked to work on a reflection in their class journals until all the groups are ready to move on. The students should reflect on their performance and evaluate, compared to the movie, how well their model could be used to explain the cell cycle.

10. Elaborate (10 minutes) When all the groups are ready, the students will share their simulations with one another, so that two groups are the audience at all times. The audience will be asked to write one thing they noticed while viewing the cell life cycle in this new format and at least questions they still have about cells and cellular division. As a class we will discuss each of their ideas. While considering their questions, I will ask students to think about how the topics we discussed today relate to the development of cancer. I will explain to the students two methods the cell can use to prevent damaged DNA from becoming cancerous. (Repair the DNA or force the cell with damaged DNA to die – aptosis).

11. Evaluate: (5 minutes) To check for understanding, I will ask the students before leaving to spend a couple minutes answering the following questions, without looking back at their notes, on an index card:
    1. The life of a eukaryotic cell includes three main phases, _____, _____, and _____. (interphase, mitosis, cytokinesis)
    2. Mitosis divides a cell's _____ equally between two daughter cells, while cytokinesis divides _____. (chromosomes, the cytoplasm)
    3. The cell has many proteins and feedback mechanisms that act like stoplights at the _____, _____, and _____ checkpoints to inspect whether the cell is ready to continue to the next phase in the cell cycle. (Cell growth/G1, DNA synthesis/G2, Mitosis)
    4. Think about: (students will not have to write an answer for this question) What would happen if mitosis was used produce entirely new individuals in humans the way it does for single-celled eukaryotic organisms?

The Cell Theory – Example of a completed handout

Scientists & Their Observations

Mid 1600's

- Anton van Leeuwenhoek – 1600s – Observed cells created microscopes capable of 500x
- Robert Hooke – 1665 – Observed the cell walls of cork cells

Early 1800's

- Robert Brown – 1833 – Examined the nucleus of cells
- Matthias Schleiden– 1838 – Observed that all plants are made of cells
- Theodore Schwann – 1839 – Observed the nucleus and found that all animals are made of cells
- Rudolf Virchow – 1858 – Proposed that cells must come from pre-existing cells

The Main Ideas of Cell Theory:

1. All Living Things are Composed of Cells
2. Cells are the Basic Units of Structure and Function in Living Things
3. All Cells Only Arise from Pre-Existing Cells

**(Students may not include these, but they will be discussed in class)*

Modern Cell Theory also states:

4. Cells Contain Hereditary Information which is Passed from Cell to Cell During Cell Division,
5. All Cells have a Similar Chemical Composition, and,
6. All Energy Flow (metabolism & biochemistry) of Life Occurs within Cells

Notes on the Cell Cycle and Mitosis

Why Divide?

Mitosis:

Cytokinesis:

Reasons for Mitosis in Eukaryotic Cells…

Examples → Humans, Onions, Mushrooms, Amoeba

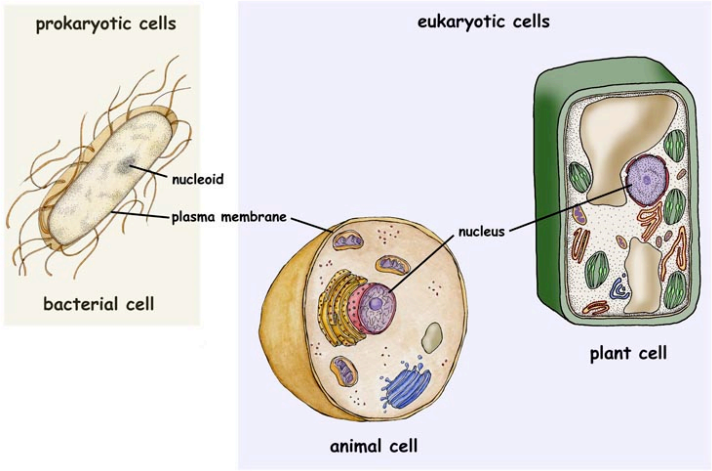
1.

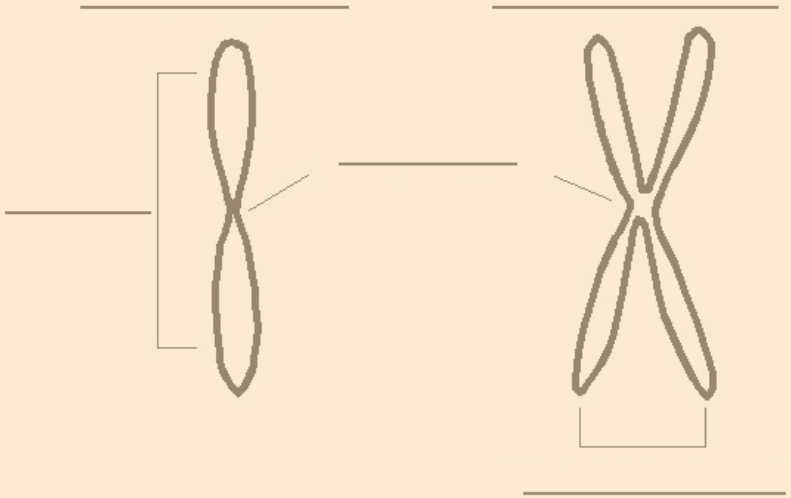
2.

3.

Cellular Division in Prokaryotic Cells…

Examples → Bifidus, Salmonella





Double the DNA ➧

Gene:

Genome:

Chromosome: A cellular structure carrying genetic material, found in the nucleus of eukaryotic cells; each chromosome consists of one very long DNA molecule and associated proteins

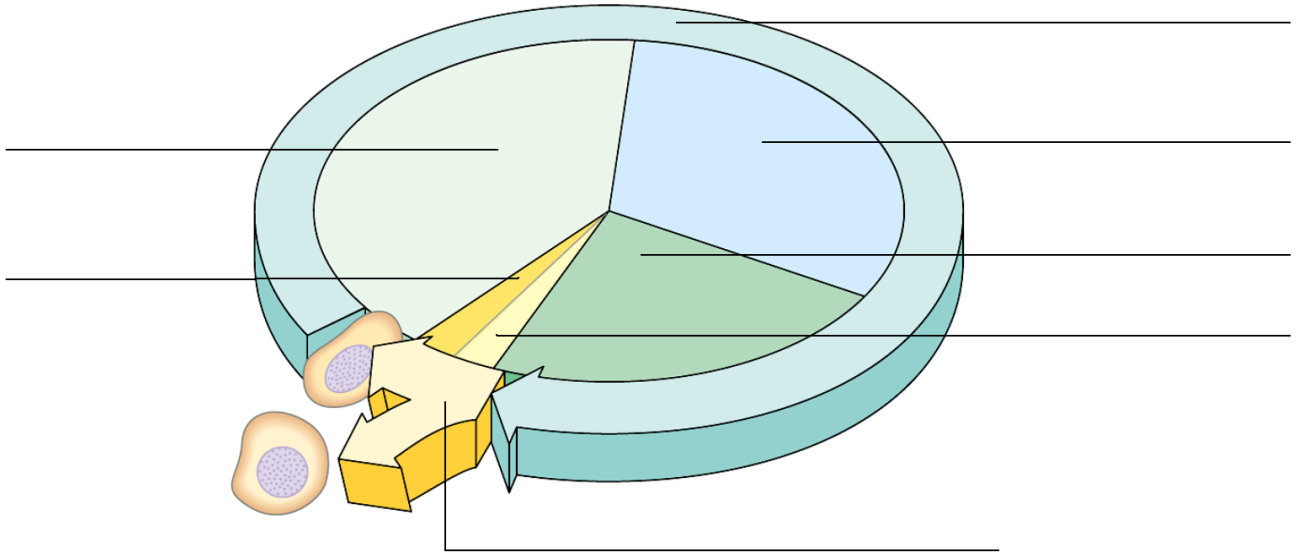
Chromatin: One of the two exact strands of replicated (copied) DNA that make up a eukaryotic chromosome

- **When the cell is not dividing, chromatin exists in its dispersed form, as a mass of very long, thin fibers that are not visible with a light microscope**
- **During mitosis, chromatids become coiled and visible**

Sister Chromatid: Either of two copies of a duplicated chromosome attached to each other by proteins at the Centromere and, sometimes, along the arms. Sister Chromatids are eventually separated during mitosis

Centromere:

The cell cycle is the process by which Genetic Material replicates, condenses, and separates into two new cells. Describe the general movement of Chromosomes during the Cell cycle:



Stages of Life

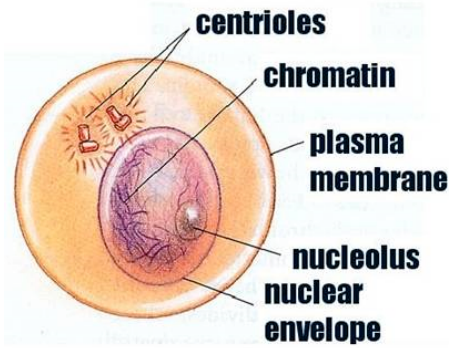
Interphase: The period during the cell cycle when the cell is not dividing and which accounts for 90% of the cell cycle

- **G1:**
- **S:**
- **G2:**

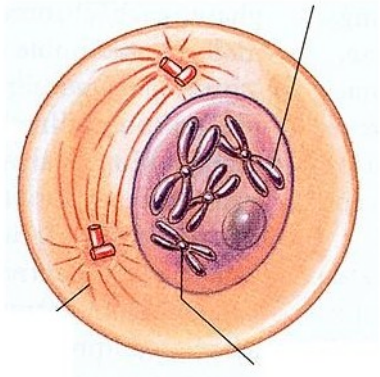
Mitotic Phase (M): The period during the cell cycle where the parent cell divides into two identical daughter cells.

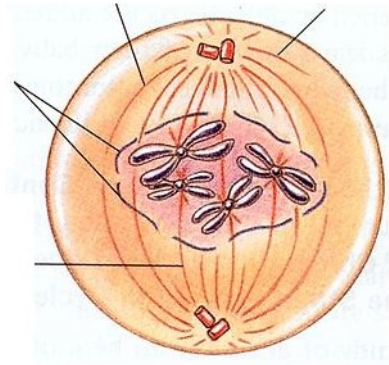
Mitosis:

Cytokinesis:

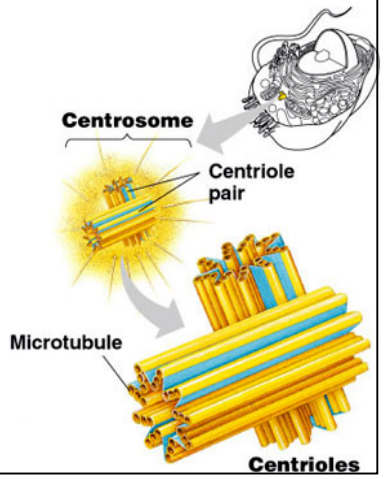


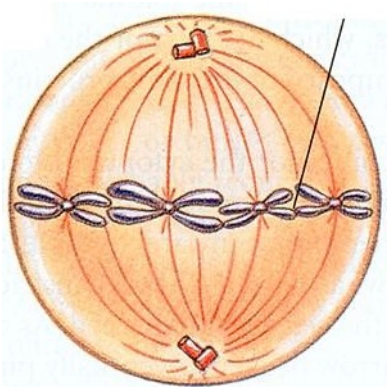
First Stage of the Cell Cycle ➧



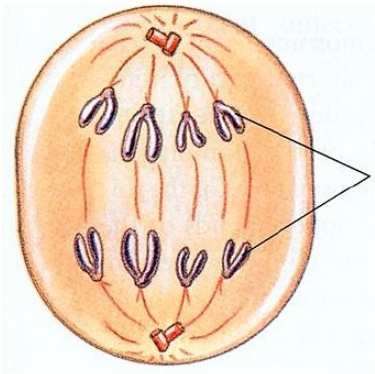


First Phase of Mitosis ➧

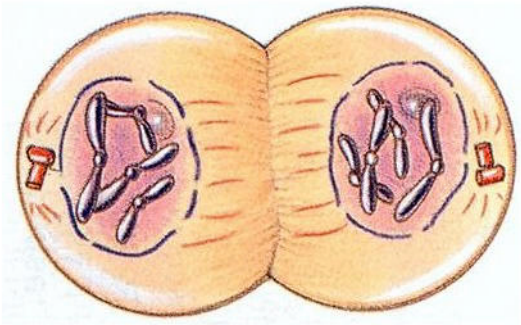




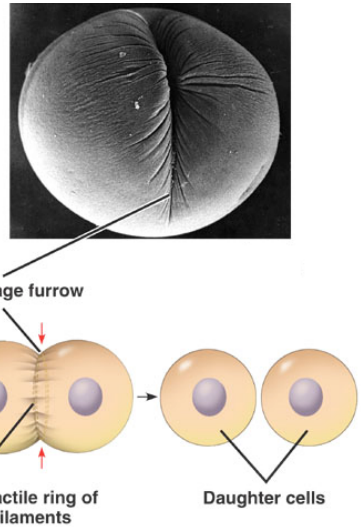
Second Phase of Mitosis ➧

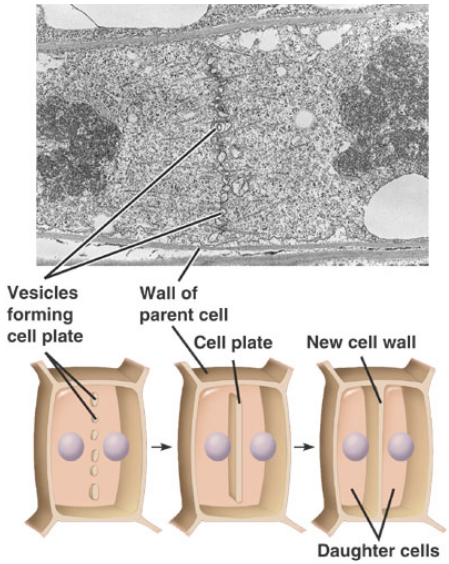


Third Phase of Mitosis ➧



Fourth Phase of Mitosis ➧





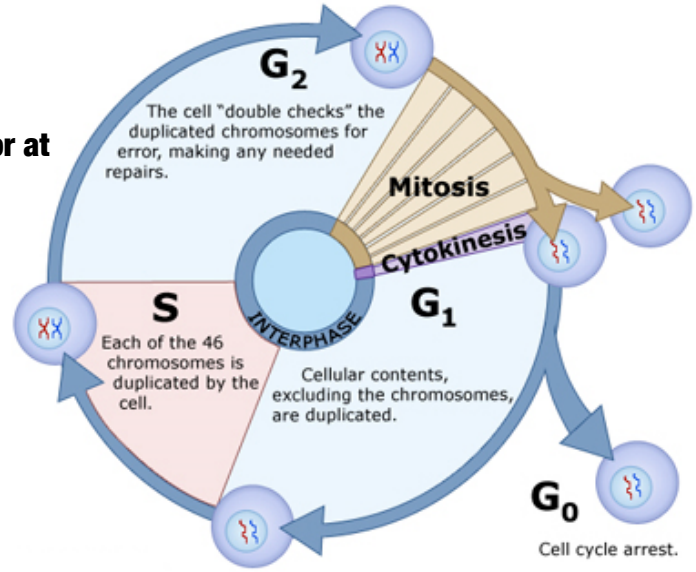
Final Stage of the Cell Cycle ♦

Animals:

Plants:

Errors & Checkpoints in the Cell Cycle

Eukaryotic Cells have developed three checkpoints for ensuring they are ready to divide and all is going well. Describe what the cell is checking for at each point and draw these checkpoints as stoplights in the diagram.



G1:

G2:

Mitosis:

Why is it important that are cells can undergo Aptosis, programmed cell death?

How is cancer related to the process of cellular dividsion?