How Do Cells Divide: Review of Terminology

Lesson Topic
Cellular Reproduction

RIEL Biology Element
Multiple Modalities

Time Required
4 Days

Standards Addressed

- SC.912.L.16.14: Describe the cell cycle, including the process of mitosis. Explain the role of mitosis in the formation of new cells and its importance in maintaining chromosome number during asexual reproduction.
- SC.912.L.16.16: Describe the process of meiosis, including independent assortment and crossing over. Explain how reduction division results in the formation of haploid gametes or spores.
- SC.912.L.16.17: Compare and contrast mitosis and meiosis and relate to the processes of sexual and asexual reproduction and their consequences for genetic variation.

Lesson Summary
Reproduction is a property of life exhibited by all living things. Cellular reproduction occurs when a cell duplicates its genetic material and divides its cellular contents (nucleus and cytoplasm) to produce two daughter cells, and this is part of the cell cycle. In a eukaryotic cell, the cell cycle includes all the cellular processes (such as growth, gene expression, cell transport, cell respiration, and DNA replication) that occur in the cell, from when it is newly formed to its division into daughter cells. It consists of three main phases: interphase, nuclear division, and cytoplasmic division (cytokinesis). Interphase consists of three sub-stages: Gap 1 (G1), S (Synthesis), and Gap 2 (G2) and the longest phase in the cell cycle. Non-dividing cells exit the G1 and carry on their normal function in the G0 stage of interphase.

Cell division occurs after interphase and includes nuclear division and cytokinesis. There are two types of cell division; mitotic cell division and meiotic cell division, and they differ in the type of nuclear division involved. Mitotic cell division produces identical diploid daughter cells. Meiotic cell division creates unique haploid daughter cells called gametes or sex cells. In humans, meiotic cell division occurs only in germ-line cells in the testes and ovaries, while mitotic cell division occurs in somatic cells and produces identical somatic cells. Nuclear division occurs once in mitosis within four distinct phases (prophase, metaphase, anaphase, and telophase). However, in meiosis, nuclear division occurs twice during Meiosis I and Meiosis II, and each stage of meiosis is comprised of four phases: meiosis I (prophase 1, metaphase 1, anaphase 1, and telophase 1) and meiosis II (prophase 2, metaphase 2, anaphase 2, and telophase 2). Mitotic cell division is a form of asexual reproduction, while meiotic cell division produces gametes, a prerequisite for sexual reproduction.

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Understanding the cell cycle is essential to understand how multicellular organisms grow, heal, produce offspring, and the origin of certain diseases.

Summary of RIEL Element in Lesson: Students will have the opportunity to review this concept of cellular reproduction via different modalities, which will expose them to varied ways of expressing the idea; thus facilitating their understanding. With multiple modalities, students will have increased exposure to the concepts, think more about them and remember more. Among the different modalities, students should encounter at least one that is their preferred style of learning.

Summary of Science and Engineering Practice:
Students will review terms related to cellular reproduction and use models to express their understanding. They will construct appropriate explanations using correct and specific terminology for their assigned case study scenarios.

Materials

- 2 long and 2 short red and yellow pop beads or 2 long and 2 short red and yellow pipe cleaners representing maternal and paternal chromosomes (Red = maternal; yellow = paternal)
- Small dry erase board
- Erase markers
- Board erasers
- Stopwatch or cell phone with stopwatch app

Resources

- Word pyramid presentation
- Cell cycle: https://www.youtube.com/watch?v=WaJ8epyEx2Q
- Meiosis: https://www.youtube.com/watch?v=nMEyeKQClqI
- Mitosis: https://www.youtube.com/watch?v=ofjyw7ARP1c

Content Learning Objectives

- Students will be able to use appropriate terminology to explain biological processes related to assigned case study scenarios on cellular reproduction.
  - Students will be able to identify the stages of the cell cycle, mitosis, and meiosis.
  - Students will be able to differentiate between mitosis and meiosis.
  - Students will be able to explain how mitotic cell division produces genetically identical daughter cells.
  - Students will be able to explain how meiosis produces genetically unique cells through the process of crossing-over and independent assortment.
  - Students will be able to determine the cause and effect of abnormal incidents in the cell cycle.

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Before the Activity:

- Preparing 45 red and 45 yellow color pop beas in Ziplock bags for each group. If using pipe cleaners, 4 red and 4 yellow in Ziplock bags with a scissors per group
- Copies of word list for students to review as homework assignment
- Copies of case study scenarios

Lesson Activities

DAY 1

Introduction

Learning about cell division can seem tedious because of several new terms that students must learn. However, being familiar with these terms sets a firm foundation for understanding inheritance and implications of abnormal nuclear division and cell division. How does my knee heal after a soccer injury? Why do keloid scars form after injury or body piercing? How do tumors develop? Why do siblings from the same parents look so different? Why does chemotherapy cause hair loss and anemia in cancer patients? How is it possible for the same parents to have twins with very different skin tones? These are some of the questions students will be able to answer after mastering this concept of cell division.

Activities

1. The students watch a review video on the cell cycle.
2. Students are assigned into groups of two.
3. With the teacher demonstrating the process, groups create two pairs of homologous chromosomes and sister chromatids using pop beads or pipe cleaners.
4. The teacher will use the chromosomes to model how their number changes as a cell goes through mitotic or meiotic division. Images of the cell cycle, and stages of mitosis and meiosis will be projected and referred to as the demonstration occurs.

Homework

The list of words are given to the students as homework assignments. List of words by topic (cell cycle, mitosis, and meiosis) and meanings of root words and suffixes and prefixes are in Google Slide presentation.

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DAYS 2-3

1. A short bell work quiz is given at the beginning of class to assess the completion of the homework assignment.
2. Students in assigned groups of 2 (from the previous day) will complete the word pyramid game (provided on Google Slides). The groups sit face-to-face but only one member can see the board.
3. The teacher explains how the word pyramid game is played. Instructions are included in the Google Slide presentation**.**
4. Each group needs a stopwatch, a dry erase board, a marker, an eraser, and their constructed chromosomes
5. After starting the timer, the group member facing the board will describe the terms on the word pyramid from the starting point to the finish point by moving down each row (left to right) then up the pyramid.
6. The description of a term can be spoken, illustrated on the dry erase board or modeled using chromosomes. Only drawings/illustrations can be on the dry erase board.
7. The other group member must identify the correct term before the group can move on to the next word.
8. The stopwatch is stopped after the pyramid is completed, and the group writes down their completion time.
9. The group members will look at the pyramid together and review any difficult words.
10. The group members will switch places and complete the next word pyramid.
11. The completion times for the two pyramids are averaged, the group with the shortest time wins the game.
12. After two rounds, a group will switch a member with another group to complete another two rounds.
13. There are 2-3 review questions (provided in Google Slides presentation) after the completion of a word pyramid.

DAY 4

1. Teacher completes one case study scenario with the class as an example. Students will solve assigned case study scenarios in their groups. Teacher instructs the students on using appropriate terminology from the word list to construct their scientific explanation for their scenario.

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Word List

Cell cycle terms:

- Cell plate
- Cleavage furrow
- Cytokinesis
- Diploid cell
- Gamete
- Gap 0 (G0) phase
- Gap 1 (G1) phase
- Gap 2 (G2) phase
- Germ-line cell
- Haploid cell
- interphase
- Meiosis
- Mitosis
- Nuclear division
- Somatic cell
- Synthesis (S) phase

Mitosis terms:

- Anaphase
- Centrioles
- Centromere
- Chromatin
- Chromosome
- Daughter cell
- Diploid cell
- DNA
- Homologous chromosomes
- Metaphase
- Prophase
- Sister chromatids
- Somatic or body cell
- Spindle fiber
- Telophase

Meiosis terms:

- Anaphase 1
- Anaphase 2
- Autosome
- Crossing over
- Diploid
- Gamete
- Germ-line cell
- Haploid
- Homologous chromosomes
- Independent assortment
- Metaphase 1
- Metaphase 2
- Prophase 1
- Prophase 2
- Sex chromosome
- Sister chromatids
- Synapsis
- Telophase 1
- Telophase 2
- Tetrad

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Case Study Scenarios

- A strong resemblance is noticeable between the parents and their children. However, there are also significant differences. From your understanding of cellular reproduction, explain the process that is responsible for this resemblance and uniqueness in this family. You are required to use appropriate terminology of the list of terms of the relevant process.

Note: Teacher may provide picture of a family for reference.

- Do you think these siblings are identical or fraternal twins? Construct an explanation for your answer by describing the process responsible for the presence of strong resemblance or lack of.

Note: Teacher must provide students with pictures of identical or fraternal twins.

- In a biological family of 6, you can tell that John, Agnes, Mary and Mark are siblings. There are some uncanny resemblances that if you meet them separately you can always tell that they are related. They share the same shape of their mouth and eyes, and expressive smiles. There is always the discussion of which traits are "from" the mother-side or the father-side of the family. Despite the similarities in many traits, each sibling is still unique with obvious differences. Explain why children resemble their parents and siblings can be so different but share resemblance at the same time. Explain the process responsible for making each sibling so unique. You are required to use appropriate terminology of the list of terms of the relevant process.

- When the word cloning is mentioned, it is usually in reference to animals. Cloning plants is actually more common, less expensive, and can be carried out by anybody, no expertise needed. Plant cloning or vegetative propagation is a technique used to grow new plants from just a part of another plant. Vegetative refers to plants (think of vegetables). It is a form of asexual reproduction such as growing plant from bud, stem, root, or other plant parts.

  Images of types of vegetative propagation:
  https://www.learninsta.com/vegetative-reproduction/

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Case Study Scenarios

- Describe the differences between sexual and asexual reproduction. Explain the process through which plants grow from plant parts to identical clones. Use relevant specific terms from the list.

- In the Fishlake National Forest in Utah, there is a group of Aspen (*Populus tremuloides*) trees that are considered the largest organism because all the trees in the 107-acre Aspen forest grew from a single root system and are genetically identical. Explain how complete genetically identical trees grew from one root system to form this Aspen Forest.

- During an annual check-up visit, Amy's doctor removed some cells from her cervix during pap smear examination and viewed them under the microscope. Cancer cells are associated with an abnormal number of chromosomes, which makes their nuclei visually bigger. In the cell cycle of somatic cells, a cell duplicates its DNA before dividing into two identical daughter cells. Describe the processes responsible for ensuring that two daughter cells are produced with the number of chromosomes at the end of the cell cycle. You are required to use appropriate terminology of the list of terms of the relevant process.

- Cancer has been defined as a disease of the cell cycle because it developed when cells start to divide out of control. Cancer cells divide too frequently with maturing and specializing to carry out specific functions in the body. Leukemia is a cancer of the cells that produce blood cells Blood cells are produced from stem cells in the bone marrow. Since blood travels around the blood, leukemia starting in the bone marrow easily spreads all around the body. The first line of treatment is chemotherapy, which uses drugs to kill fast growing cells by preventing them from dividing. Unfortunately, frequently dividing normal cells are also affected by chemotherapy treatment. Patients lose their hair while undergoing chemotherapy. Explain how the hair follicle cells that produce more hair are replaced after chemotherapy ends and the hair grows back. Use appropriate terminology in your explanation.

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Case Study Scenarios

- Colchicine is a chemical that prevents the formation of the spindle fibers. Spindle fibers are very important during nuclear division. Describe the function of spindle fibers. What effect would treating plant cells with colchicine have on the cell division?

- There are many checkpoints in the cell cycle that determine if and when a cell can move from one stage to the next. One checkpoint is in metaphase and the cell can only pass through this checkpoint if all its chromatids are attached to a spindle fiber. Why do you think this is important?

- If mitosis occurs but cytokinesis does not, what would be the consequence in the cell? Describe what you would see in the cell at the end of the cell cycle.

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