Cell Division Student Objectives

Enduring understanding 3.A: Heritable information provides for continuity of life.

Essential knowledge 3.A.1: DNA, and in some cases RNA, is the primary source of heritable information.
   a. Genetic information is transmitted from one generation to the next through DNA or RNA.

   Evidence of student learning is a demonstrated understanding of each of the following:
   1. Genetic information is stored in and passed to subsequent generations through DNA molecules and, in
      some cases, RNA molecules.
   2. Noneukaryotic organisms have circular chromosomes, while eukaryotic organisms have multiple linear
      chromosomes, although in biology there are exceptions to this rule.
   3. DNA replication ensures continuity of hereditary information.

   b. Genetic information flows from a sequence of nucleotides in a gene to a sequence of amino acids in a
      protein.
   c. Phenotypes are determined through protein activities.

Student Objectives:
- Explain how DNA allows for the passage of genetic information between generations.
- Compare the structure of prokaryotic and eukaryotic genetic information storage molecules.

Learning Objectives:
- The student is able to describe representations and models that illustrate how genetic information is copied
  for transmission between generations.

Essential knowledge 3.A.2: In eukaryotes, heritable information is passed to the next generation via processes
   that include the cell cycle and mitosis or meiosis plus fertilization.
   a. The cell cycle is a complex set of stages that is highly regulated with checkpoints, which determine the
      ultimate fate of the cell.

   Evidence of student learning is a demonstrated understanding of each of the following:
   1. Interphase consists of three phases: growth, synthesis of DNA, preparation for mitosis.
   2. The cell cycle is directed by internal controls or checkpoints. Internal and external signals provide stop-
      and-go signs at the checkpoints.
      To demonstrate understanding, make sure you can explain examples like:
      - Mitosis-promoting factor (MPF)
      - Action of platelet-derived growth factor (PDGF)
   3. Cancer results from disruptions in cell cycle control
   4. Cyclins and cyclin-dependent kinases control the cell cycle.
   5. Mitosis alternates with interphase in the cell cycle.
   6. When a cell specializes, it often enters into a stage where it no longer divides, but it can reenter the
      cell cycle when given appropriate cues. Nondividing cells may exit the cell cycle; or hold at a particular
      stage in the cell cycle.

Student Objectives:
- Explain the events of all stages of the cell cycle.
- Explain how cell division is controlled in cells, using examples like MPF and PDGF.
- Explain what cancer is and how it develops in an organism

   b. Mitosis passes a complete genome from the parent cell to daughter cells.

   Evidence of student learning is a demonstrated understanding of each of the following:
   1. Mitosis occurs after DNA replication.
   2. Mitosis followed by cytokinesis produces two genetically identical daughter cells.
3. Mitosis plays a role in growth, repair, and asexual reproduction.

4. Mitosis is a continuous process with observable structural features along the mitotic process. Evidence of student learning is demonstrated by knowing the order of the processes (replication, alignment, separation).

Student Objectives:
- Explain the events of all stages of mitosis.
- Track chromosome and chromatid number through all stages of mitosis.
- Demonstrate how and when the processes of DNA replication, chromosomal alignment, and chromosomal separation are accomplished during a mitotic cell cycle.
- Compare the process of mitosis in plant-like and animal-like cells.

c. Meiosis, a reduction division, followed by fertilization ensures genetic diversity in sexually reproducing organisms.

Evidence of student learning is a demonstrated understanding of each of the following:
1. Meiosis ensures that each gamete receives one complete haploid (1n) set of chromosomes.
2. During meiosis, homologous chromosomes are paired, with one homologue originating from the maternal parent and the other from the paternal parent.
3. Orientation of the chromosome pairs is random with respect to the cell poles.
4. Separation of the homologous chromosomes ensures that each gamete receives a haploid (1n) set of chromosomes composed of both maternal and paternal chromosomes.
5. During meiosis, homologous chromatids exchange genetic material via a process called “crossing over,” which increases genetic variation in the resultant gametes.
6. Fertilization involves the fusion of two gametes, increases genetic variation in populations by providing for new combinations of genetic information in the zygote, and restores the diploid number of chromosomes.

Student Objectives:
- Relate meiosis to the processes of sexual life cycles.
- Explain the similarities and differences among sexual life cycles seen in all organisms.
- Explain the events of all stages of meiosis.
- Track chromosome and chromatid number through all stages of meiosis.
- Demonstrate how and when the processes of DNA replication, chromosomal alignment, and chromosomal separation are accomplished during a meiotic cell cycle.
- Compare the process of meiosis to the process of mitosis.
- Explain how the processes of meiosis increase genetic variation in a population and be able to mathematically modify the effects of those processes.

Learning Objectives:
- The student can make predictions about natural phenomena occurring during the cell cycle.
- The student can describe the events that occur in the cell cycle.
- The student is able to construct an explanation, using visual representations or narratives, as to how DNA in chromosomes is transmitted to the next generation via mitosis, or meiosis followed by fertilization.
- The student is able to represent the connection between meiosis and increased genetic diversity necessary for evolution.
- The student is able to evaluate evidence provided by data sets to support the claim that heritable information is passed from one generation to another generation through mitosis, or meiosis followed by fertilization.

Essential knowledge 3.A.3: The chromosomal basis of inheritance provides an understanding of the pattern of passage (transmission) of genes from parent to offspring.

a. Segregation and independent assortment of chromosomes result in genetic variation.

Evidence of student learning is a demonstrated understanding of each of the following:
1. Segregation and independent assortment can be applied to genes that are on different chromosomes.
b. Certain human genetic disorders can be attributed to the inheritance of single gene traits or specific chromosomal changes, such as nondisjunction.

To demonstrate understanding, make sure you can explain examples like:
- Trisomy 21/Down syndrome
- Klinefelter’s syndrome

c. Many ethical, social and medical issues surround human genetic disorders.

Student Objectives:
- Explain the etiology of specific examples of non-disjunction events in humans, including Down Syndrome and Klinefelter’s syndrome.
- Explain why chromosomal disorders involving the sex chromosomes are generally more tolerated than disorders involving autosomes.
- Consider human genetic disorders from ethical, social and medical perspectives.

Enduring understanding 3.C: The processing of genetic information is imperfect and is a source of genetic variation.

Essential knowledge 3.C.1: Changes in genotype can result in changes in phenotype.
- Alterations in a DNA sequence can lead to changes in the type or amount of the protein produced and the consequent phenotype.

Evidence of student learning is a demonstrated understanding of the following:
- DNA mutations can be positive, negative or neutral based on the effect or the lack of effect they have on the resulting nucleic acid or protein and the phenotypes that are conferred by the protein.
- Mutations are the primary source of genetic variation.

Evidence of student learning is a demonstrated understanding of the following:
- Whether or not a mutation is detrimental, beneficial or neutral depends on the environmental context.

Evidence of student learning is a demonstrated understanding of each of the following:
- Changes in chromosome number often result in new phenotypes, including sterility caused by triploidy and increased vigor of other polyploids.
- Changes in chromosome number often result in human disorders with developmental limitations, including Trisomy 21 (Down syndrome) and XO (Turner syndrome).

Student Objectives:
- Discuss the causes of mutations.
- Explain the relationship between mutations, variation, and evolution.
- Explain the relationship between mutations, and cancer.
- Describe why mutations can have a positive, negative, or neutral effect on the physiology of the organism.
- Explain how changes in chromosome number and structure can affect the physiology of the organism.

Essential knowledge 3.C.2: Biological systems have multiple processes that increase genetic variation.
- The imperfect nature of DNA replication and repair increases variation.
- The horizontal acquisitions of genetic information primarily in prokaryotes via transformation (uptake of naked DNA), transduction (viral transmission of genetic information), conjugation (cell-to-cell transfer) and transposition (movement of DNA segments within and between DNA molecules) increase variation.
- Sexual reproduction in eukaryotes involving gamete formation, including crossing-over during meiosis and the random assortment of chromosomes during meiosis, and fertilization serve to increase variation. Reproduction processes that increase genetic variation are evolutionarily conserved and are shared by various organisms.
Learning Objectives:
- The student is able to compare and contrast processes by which genetic variation is produced and maintained in organisms from multiple domains.
- The student is able to construct an explanation of the multiple processes that increase variation within a population.

Student Objectives:
- Explain how cell division can be used to either increase or maintain the amount of genetic variation in a population.
- Consider the evolutionary advantages and disadvantages of asexual and sexual reproduction.