Biology, Quarter 3, Unit 3.1

Reproduction and Genetics: DNA Replication

Overview

Number of instructional days: 12 (1 day = 53 minutes)

Content to be learned

- Describe the structure of DNA.
- Relate how DNA sequence determines the genetic code.
- Describe the relationship between the specialized structure of DNA and protein production.
- Explain the different types of mutations that occur in a DNA strand.
- Explain how mutations affect genes/heredity.

Processes to be used

- Make and interpret models.
- Make inferences.
- Make claims and use supporting evidence.
- Predict outcomes.
- Use data and observations to make connections.

Essential questions

- How does complementary base pairing impact the transfer of information from parent to offspring?
- What are the opportunities for variation among the offspring of organisms that reproduce asexually and sexually?

Written Curriculum

Grade Span Expectations

LS1 - All living organisms have identifiable structures and characteristics that allow for survival (organisms, populations, & species).

LS1 (9-11) INQ+SAE+FAF -1

Use data and observation to make connections between, to explain, or to justify how specific cell organelles produce/regulate what the cell needs or what a unicellular or multi-cellular organism needs for survival (e.g. protein synthesis, DNA, replication, nerve cells)

LS1 (9-11)-1 Students demonstrate understanding of structure and function-survival requirements by…

1a explaining the relationships between and amongst the specialized structures of the cell and their functions (e.g. ~~transport of materials, energy transfer~~, protein building, ~~waste disposal~~, information feedback~~, and even movement~~).

LS1 (9-11) FAF+ POC -2

Explain or justify with evidence how the alteration of the DNA sequence may produce new gene combinations that make little difference, enhance capabilities, or can be harmful to the organism (e.g., selective breeding, genetic engineering, mutations).

LS1 (9-11) –2 Students demonstrate an understanding of the molecular basis for heredity by …

2a describing the DNA structure and relating the DNA sequence to the genetic code.

2b explaining how DNA may be altered and how this affects genes/heredity (e.g. substitution, insertion, or deletion)

Clarifying the Standards

Prior Learning

Students in grades K–4 examined the physical characteristics of organisms and learned that plants and animals have life cycles.

In grades 5–6, students defined reproduction as the process through which organisms produce offspring. They described reproduction as essential for the continuation of a species. Students differentiated between inherited and acquired traits; they also observed and recorded differences in inherited traits.

Students in grades 7–8 learned that the cell is the basic unit of life and that it has the same survival needs as an organism, including reproduction. Students learned that genetic material is located in the cell's nucleus and they explained reproduction as a fundamental process by which a new individual receives genetic information from its parents. They also described forms of asexual reproduction (genetic contribution of one parent) and sexual reproduction (genetic contribution of two parents). Students should be able to explain that genetic variations/traits of organisms are passed on through reproduction and random genetic changes. They should also be able to differentiate between acquired and inherited

characteristics and give examples of each. They learned how to recognize whether an organism's characteristics were inherited from parents or resulted from interactions with the environment. Students followed a characteristic through a given pedigree.

Current Learning

Students learn the components of a DNA nucleotide and how complementary base pairing occurs. They model the structure of DNA and DNA replication; they also explain the importance of complementary base pairing in the accurate transfer of information during DNA replication (This occurs during the *S* phase of interphase.) prior to cell division. Students describe how DNA nucleotides and RNA nucleotides differ (sugar and nitrogen base). Students explain that a gene is a chain of nucleotides with a specific sequence of nitrogen bases. They describe gene mutations as changes in the specific sequence of bases and identify specific types of mutations (substitution, insertion, deletion). Students also learn that mutations can be beneficial, harmful, or have no effect on the individual. They relate genes and mutations to continuity and variation in inherited characteristics of offspring.

Students learn that, as a result of complementary base pairing during DNA replication, information contained in the genetic code (DNA) is conserved. This information is passed to future generations through the process of cell division (Mitosis and meiosis are the names of these processes.). Random changes in the base sequence of genes (mutations) can result in new variations in traits of offspring, which can prove to be beneficial, detrimental, or have no effect.

As an extension, students could be introduced to the phases of mitosis and meiosis (and the behavior of chromosomes in those processes) in order to understand differences in opportunities for variation.

During this unit of study, students will build and manipulate models of DNA base sequences. They also analyze DNA sequences for various types of mutations. In order to be successful when studying these concepts, students need to be able to accurately compare and contrast information; make detailed and accurate descriptions; use, manipulate, and evaluate models; and make inferences.

Examining heredity at the molecular level is new to students. They learn that parents contribute specific base sequences in genes, which make up the molecular basis of variation. Students also study the link between harmful mutations and disease.

Future Learning

In future units and courses, the information from this unit will be used in the study of protein synthesis through transcription and translation. Students will learn that changes in DNA can cause structural alterations to the resulting protein (DNA → RNA → Protein), which may alter the function of the protein. Students will learn the technology involved in DNA analysis. They will also learn patterns of inheritance (Punnett squares, pedigrees, autosomal, sex-linkage, and polygenes). In addition, they study the relationship between genetic change in populations and evolution.

Additional Research Findings

According to *Making Sense of Secondary Science*, students recognize variation between species, but think it's due to environmental conditions rather than inheritance. Students have a tendency to believe that they "favor" or inherit more traits from their father if they are male and from their mother if they are female. (p. 51). The book also states that students fail to make the connection between variation and reproduction or the impact of environment on gene expression and resulting phenotype (pp. 52–53).

The *Atlas for Science Literacy* states, "Students may think that inheritance only happens in observable features (p. 68). Students may think that whole organisms can "mutate" in their own lifetime. They fail to understand that it is only mutations in the sex cells that affect offspring (p. 70).

Students incorrectly assume that all DNA bases code for proteins when, in fact, much of our DNA has no known function at this time. Students carry many misconceptions about reproduction and inheritance into their biology class. These errors can be difficult to overcome. Students often struggle to understand the relationship between observable traits and the processes that occur at the molecular level, such as replication or transcription errors.

Biology, Quarter 3, Unit 3.2

Transcription/Translation

Overview

Number of instructional days: 8 (1 day = 53 minutes)

Content to be learned

- Describe how DNA codes for the production of specific proteins.
- Describe how alterations in the DNA code may produce changes in the resulting protein.

Processes to be used

- Make and interpret models.
- Make inferences.
- Make claims and use supporting evidence.
- Predict outcomes.
- Use data and observations to make connections.

Essential questions

- How does the nucleus control cell processes?
- How does DNA provide a genetic code for specific proteins?
- In what ways do alterations in the sequence of nucleotide bases in the gene sequence impact protein production?

Written Curriculum

Grade Span Expectations

LS1 - All living organisms have identifiable structures and characteristics that allow for survival (organisms, populations, & species).

LS1 (9-11) FAF+ POC -2

Explain or justify with evidence how the alteration of the DNA sequence may produce new gene combinations that make little difference, enhance capabilities, or can be harmful to the organism (e.g., selective breeding, genetic engineering, mutations).

LS1 (9-11) –2 Students demonstrate an understanding of the molecular basis for heredity by …

2c describing how DNA contains the code for the production of specific proteins.

Clarifying the Standards

Prior Learning

In grades 5–6, students differentiated between inherited and acquired traits and they observed and recorded differences in inherited traits. In grades 7–8, students identified that genetic material is located in the cell's nucleus. Students explained that genetic variations and traits are passed on through reproduction and random genetic changes.

Current Learning

Students describe the flow of the central dogma of biology (DNA→RNA→ Proteins). They describe the location and events of transcription of mRNA from the DNA template strand of a gene. Students describe the location and events of translation from mRNA to protein. They take a DNA gene sequence and interpret the code for the production of a specific protein segment. They should also be able to explain and supply examples of how changes in the base sequence of the DNA (mutation) can change the amino acid sequence of the resulting protein. Students relate changes in amino acid sequences to changes in the three-dimensional structure of the protein, which may alter its function.

Students interpret charts and graphs, make scientific drawings, and label scientific diagrams. Students use a section of DNA code to transcribe a short mRNA molecule. They then use a codon chart to translate the code into the specific amino acid sequence found in the protein for which the DNA is coded.

Students have very little entering knowledge about transcription and translation. In this unit of study, students learn that proteins determine traits (DNA→RNA→Protein →Traits). It is important for students to understand that changes in DNA that alter protein structure can produce variations of a trait. These variations may have important evolutionary consequences.

Future Learning

Students will learn the technology involved in DNA and protein analysis. They will also learn patterns of inheritance (Punnett squares, pedigrees, autosomal, sex-linkage, and polygenes). In addition, they will study the relationship between changes in the gene pools of populations and evolution–speciation through the process of natural selection.

Additional Research Findings

See the National Science Digital Library's science literary maps (< http://strandmaps.nsdl.org/?d=SMS-MAP-1381>) for the following research:

Some research indicates that in 2nd grade there is a shift in children's understanding of organisms from representations based on perceptual and behavioral features to representations in which central principles of biological theory are most important. Children at this age can begin to understand that animals of the same species have similar internal parts and offspring.

By the end of 2nd grade, students know that children resemble their parents and realize that reproduction underlies this resemblance. Students at this age can also begin to understand the difference between learned resemblance and inherited resemblance.

When asked to explain how physical traits are passed from parents to offspring, elementary-school, middle-school, and some high-school students express the following misconceptions: Some students believe that traits are inherited from only one of the parents (for example, the traits are inherited from the mother, because she gives birth or has most contact as children grow up; or the same-sex parent will be the determiner). Other students believe that certain characteristics are always inherited from the mother and others come from the father. Some students believe in a "blending of characteristics." It may not be until the end of 5th grade that some students can use arguments based on chance to predict the outcome of inherited characteristics of offspring from observing those characteristics in the parents.

Early middle-school students explain inheritance only in observable features, but upper middle-school and high-school students have some understanding that characteristics are determined by a particular genetic entity, which carries information translatable by the cell. Students of all ages believe that some environmentally produced characteristics can be inherited, especially over several generations.

By the end of 5th grade, students know that babies result from the fusion of sperm and eggs. However, they often don't understand how the fusion brings new life. Before students have an early understanding of genetics, they may believe that the baby exists in the sperm but requires the egg for food and protection, or that the baby exists in the egg and requires the sperm as trigger to growth.

Biology, Quarter 3, Unit 3.3

Biotechnology

Overview

Number of instructional days: 10 (1 day = 53 minutes)

Content to be learned

- Explain the processes used in biotechnology to analyze DNA and proteins.
- Explain how technological advances produce evidence of genetic relationships among groups of organisms.
- Explain how biotechnology provides evidence for the ways that human (and other organisms') heredity is affected by environmental factors.
- Research how some environmental factors cause gene mutations.

Processes to be used

- Use tools and technology.
- Interpret models, diagrams, charts, and narratives.
- Make inferences.
- Make claims and use supporting evidence.
- Predict outcomes.
- Use data and observations to make connections.

Essential questions

- How have technological advances in the study of DNA and proteins increased understanding of relationships among organisms?
- How have advances in biotechnology impacted humans and the environment?
- How do irritants in the environment—such as radiation and some chemicals—cause genetic mutations that can lead to disease?

Written Curriculum

Grade Span Expectations

LS3 - Groups of organisms show evidence of change over time (structures, behaviors, and biochemistry).

LS3 (9-11) NOS -6

Explain how evidence from technological advances supports or refutes the genetic relationships among groups of organisms (e.g., DNA analysis, protein analysis.

LS3 (9-11)-6 Students will demonstrate their understanding of the degree of genetic relationships among organisms by …

6a using given data (diagrams, charts, narratives, etc.) and advances in technology to explain how our understanding of genetic variation has developed over time.

LS 4 - Humans are similar to other species in many ways, and yet are unique among Earth's life forms.

LS4 (9-11) NOS+INQ -9

Use evidence to make and support conclusions about the ways that humans or other organisms are affected by environmental factors or heredity (e.g., pathogens, diseases, medical advances, pollution, mutations).

LS4 (9-11) –9 Students demonstrate an understanding of how humans are affected by environmental factors and/or heredity by …

9a researching scientific information to explain how such things as radiation, chemicals, and other factors can cause gene mutations or disease.

Clarifying the Standards

Prior Learning

In grades 5–6, students learned that species with similar evolutionary histories and characteristics are classified more closely together than species with different histories and characteristics.

By grades 7–8, students were able to explain that genetic variations/traits of organisms are passed on through reproduction and random genetic changes. Students gathered evidence to demonstrate evolutionary relationships among organisms such as similarities in traits, body structure, and early development.

Current Learning

Students examine evidence collected using various biotechnological techniques to support or refute claims about genetic relationships. These techniques may include: gel electrophoresis for separating DNA and proteins, amino acid sequencing, RFLPs, gene amplification (PCR) and DNA fingerprinting. Topics of discussion may include genetically modified organisms (GMOs) for agricultural (food) and pharmaceutical uses; production of transgenic species using plasmids; paternity testing and gene therapy prospects. Environmental mutagens such as radiation, chemicals, and viruses and their effects are

addressed. Bioethical issues surrounding genetic engineering applications are discussed. Students also conduct research to examine how environmental factors can lead to some diseases and harmful mutations in the DNA sequence.

Students examine charts, graphs, autorads, and other diagrams and images for the purpose of analysis and interpretation, and to support claims. They also distinguish among facts, reasoned judgment based on research findings, and speculation in a text as they conduct a short research project to answer questions about the relationship between genetic mutations, disease, and specific environmental factors.

Students analyze and interpret biotechnology data and conduct labs and/or simulations. In order to be successful when studying these concepts, students will need to accurately compare and contrast information; make detailed and accurate descriptions; use, manipulate, and evaluate models; and make inferences.

Different from what they learned in previous grades, students examine heredity at the molecular level. They learn that the genetic contribution of parents consists of specific base sequences in genes, which make up the molecular basis of variation. They also study the link between harmful mutations and disease.

Future Learning

This is the final required biology course, therefore the information in this unit will only be used again if students take an advanced biology course.

Additional Research Findings

According to *Benchmarks for Science Literacy*, students have trouble thinking of the human body as a chemical system (p. 342). High school and college students mainly use obvious criteria to distinguish between living and nonliving things; they rarely mention structural or biochemical characteristics (DNA) (p. 341).

See the National Science Digital Library's science literary map (Strand map: The Human Organism / Disease 9–12; < http://strandmaps.nsdl.org/?id=SMS-MAP-1446>) for the following research:

Elementary-school students may have the following ideas about germs: Germs are microorganisms causing illness; germs enter the body through the mouth while eating and leave the body through the mouth; every illness is caused by germs; all diseases are caused by the same kind of germ; the process of infection is automatic; any infection in the body necessarily makes it ill; and when medicine is administered, healing takes place immediately.

Lower elementary-school children may think that illness is the result of misbehavior and realize that they are ill only when they are told that they are by others or when illness has a behavioral impact such as having to stay in bed or go to the doctor. Upper elementary-school children may believe that all illnesses are caused by germs and are contagious. As students grow older, their beliefs about the causes of illness begin to include the malfunctioning of internal organs and systems, poor health habits, and genetics. Upper elementary students can understand that a change in internal body state or the experience of symptoms is the consequence of illness.