uBEATS Teacher's Guide:

Gene Expression

(Grades 9-10)

This teacher guide is a supplementary text to support the use of the uBEATS Gene Expression module for grades 9-10.

To help students develop the knowledge necessary for an incredible future in health care, we created UNMC Building Excellence in Academics Through STEM (uBEATS), an online health science resource for Nebraska students.

UNMC uBEATS modules are short (15 minutes or less), interactive online health science modules to supplement curriculum taught in grades 6 – 12. These do not replace curriculum, but are a supplement for teachers and students incorporating evidence based information and UNMC expert guided material. Each module is chunked into sections with formative and summative assessments with immediate feedback provided.

Tips on how to utilize uBEATS modules:

- Internet access is required to view uBEATS modules.
- For those who have access to one-to-one technology, modules can be used in or outside of the classroom as a topic introduction, extension, or review.
- For classrooms without individual student devices modules can be used in whole group instruction. Formative assessment questions can use the teacher's preferred call and response method and summative assessment questions can be displayed on the board and answered individually by students or printed and distributed to students after viewing the module.

Objectives

- Describe why sexually-reproduced offspring cannot have the exact same genes as either one of the parents.
- Identify reasons why some genes get expressed in the phenotype while other genes do not.
- Give examples of how environmental factors can influence the expression of genes.

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Introduction

Why do individuals of the same species vary in how they look, function, and behave?

Genes carry the code for proteins and proteins dictate cell function. Thousands of genes expressed in a particular cell determine what that cell can do. Each step in the flow of information from DNA to RNA to protein provides the cell with a potential control point for self-regulating its functions by adjusting the amount and type of proteins it manufactures.

Prior Knowledge

Before beginning this module, the student should understand the Grade Band Endpoints for Core Idea LS3.A. A Framework for K-12 Science

- ***By the end of grade 5.*** Many characteristics of organisms are inherited from their parents. Other characteristics result from individuals' interactions with the environment, which can range from diet to learning. Many characteristics involve both inheritance and environment.
- ***By the end of grade 8.*** Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of a specific protein, which in turn affects the traits of the individual (e.g., human skin color results from the actions of proteins that control the production of the pigment melanin). Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits. Sexual reproduction provides for transmission of genetic information to offspring through egg and sperm cells. These cells, which contain only one chromosome of each parent's chromosome pair, unite to form a new individual (offspring). Thus offspring possess one instance of each parent's chromosome pair (forming a new chromosome pair). Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited or (more rarely) from mutations.

Also before beginning this module, the student should understand the Grade Band Endpoints for Core Idea LS3.B. A Framework for K-12 Science Education

- ***By the end of grade 5.*** Offspring acquire a mix of traits from their biological parents. Different organisms vary in how they look and function because they have different inherited information. In each kind of organism there is variation in the traits themselves, and different kinds of organisms may have different versions of the trait. The environment also affects the traits that an organism develops—differences in where they grow or in the food they consume may cause organisms that are related to end up looking or behaving differently.
- ***By the end of grade 8.*** In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other. In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others harmful, and some neutral to the organism.

Key Terms/Vocabulary

Chromosome, DNA, RNA, genes, nucleus, sexual reproduction, meiosis, fertilization, gamete, zygote, transcription, translation, RNA polymerase, amino acid, protein, enzyme, gene expression, genotype, phenotype, traits, differentiation.

Science Standards

Nebraska's College and Career Ready Standards for Science 2024 Nebraska Science Standards

- Heredity. Inheritance and Variation of Traits: SC.HS.9.4.A, SC.HS.9.4.B, SC.HS.9.4.C

Next Generation Science Standards (NGSS) featuring Three-Dimensional Learning

Core Idea LS3.A: Inheritance of Traits A Framework for K-12 Science Education.

- Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function.

Core Idea LS3.B: Variation of Traits A Framework for K-12 Science Education.

- The information passed from parents to offspring is coded in the DNA molecules that form the chromosomes. In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited. Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depend on both genetic and environmental factors.

Science and Engineering Practices NGSS

- Asking Questions and Defining Problems
- Analyzing and Interpreting Data
- Engaging in Argument from Evidence

Crosscutting Concepts NGSS

- Cause and Effect
- Scale, Proportion, and Quantity

Extensions of the lesson

- To help students become more familiar with the Key Terms of this module, the teacher can use the vocabulary list for a classroom Word Wall, or integrate the vocabulary into classroom word games during review sessions.
- To learn more about the pathway from DNA to protein, see the uBEATS module RNA.

- The teacher may need to address student misconceptions by emphasizing these important concepts:
    - Cells receive their DNA only by inheritance. DNA cannot be naturally transmitted by touch, ingestion, or injection. That's why genetic engineering is so incredible, as well as controversial.
    - It is not possible for a sexually-reproduced organism to have a set of DNA that is identical to either of the parents.
    - The "Central Dogma" of genetics describes the flow of information from the DNA molecule which gets transcribed into RNA, which then moves out of the nucleus into the cytoplasm where it is translated into protein. This process is called gene expression.
    - Every cell holds a complete set of DNA containing the total genome for the entire organism. However, most of the genes in each particular cell never get expressed. Only the genes needed by that cell get switched on and off by signals.
    - RNA polymerase is an enzyme that begins the process of transcription.
    - Translation is the code-induced ribosomal process in which amino acids are assembled into chains that become folded into proteins.
    - Environmental factors, both internal and external, have the potential to change an organism's phenotype by turning genes on and off.

Enrichment

- For information about Healthcare Career Opportunities, see the UNMC Health Career Book.
- To make connections in your community, contact local hospitals, healthcare clinics, zoo, nurses, doctors, veterinarians.
- For a classroom activity to demonstrate gene expression, see Ice Cream Sundae Gene Expression.