WHAT A WHALE OF A CHANGE!

GRADES 7-12

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TIME ALLOTMENT:

Two 45-minute class periods

OVERVIEW:

NOTE: Students should be acquainted with protein synthesis, in particular the translation process (incorporation of amino acids into polypeptides) prior to participation in this unit.

The genetic code carries the instructions for production of amino acid chains (proteins or polypeptide chains). On occasion, a gene is altered— this may result from an error in copying during replication or could result from damage to a gene. Such a change, known as a mutation, could result in changes in the recipe for a protein or group of proteins. While alteration of a chromosome can result in dramatic, observable changes, in this unit, **point mutations** (mutations affecting a single gene) and the implications of the affect single genes can have on development of characteristics are considered.

Through the activities in this lesson, students will become familiar with the basic types of point mutation and the impacts each might have on the amino acid sequence of a protein and hence upon the characteristics of individuals exhibiting these mutations. After examining the web sites and video clips and participating in class discussion of mutations, students will "translate" mRNA codons to determine the amino acid sequence in a polypeptide chain of an origami whale. After translating the "wild type" sequence, students will translate four sequences each exhibiting a mutation, translate each sequence, and relate the changes in the sequences to alterations in the protein structure (paper folds) in the origami whales.

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SUBJECT MATTER: Biology

LEARNING OBJECTIVES:

Students will be able to:

- **Discuss the relationships among DNA, mRNA, mutations, and protein synthesis**
- **Define and be able to identify: point mutation, Missense mutation, nonsense mutation, silent mutation, frame-shift mutations (insertion and deletion)**
- **"Translate" amino acid sequences**
- **Infer the general affect particular point mutations might have on synthesis of a polypeptide chain**
- **Model (through use of an origami whale) and discuss possible implications of mutations with regard to point mutations**

STANDARDS:

National Science Education Standards
http://bob.nap.edu/html/nses/html
Content Standard C:
The Cell
Biological evolution

Louisiana Science Framework: State Standards for Curriculum Development
www.doe.state.la.us/doe/assessment/standards/SCIENCE.pdf

LS-H-B1: Explaining the relationship among chromosomes, DNA, genes, RNA, and proteins
LS-H-C2: Recognizing the evidence for evolution
LS-H-C3: Discussing the patterns, mechanisms, and rate of evolution

MEDIA COMPONENTS:

Video clips:

1. **Learning and Teaching Evolution**
   Evolving Ideas: Videos for Students
   Segment 5-Did Humans Evolve?
   (Learning and Teaching Evolution, a compilation of 7 video clips for students and case study videos for teachers is a part of the PBS *Evolution* project. A VHS cassette of these clips (taken from the 8 hour series) is available for purchase from WGBH Boston at 1-800-949-8670 for $19.95. Streamlined versions of the videos are available at the website: www.pbs.org/evolution)

2. **Evolution: A Journey into Where We're From and Where We're Headed**
   Great Transformations
   The segment to be viewed opens with a view of flies being observed via a microscope and with the phrase, "By the 1940s, scientists working with fruit flies…" (This is approximately 37½ minutes into the video.) It ends about 6 minutes later with "If one of these genes turned on in the wrong place, striking changes in the body could take place. The visual is a multicolored fly whose body parts are colored coordinated to the gene coding for that trait.

Web Sites:

Mutation and Protein Synthesis:

Biology ClassONline
www.mccsc.edu/~jracy/A3231.html
This includes biology course class notes. The material is written on a level appropriate for most high school students.

Evolution:

Evolution Project
www.pbs.org/evolution
This site is packed with interactive features that allow users to test the evolutionary principals in action. It includes inquiry-based, teacher-assigned lessons for students, streamlined versions of the Videos for Students: Evolving Ideas, and direct web access to hundreds of other multimedia evolution resources.

Evolution –Teacher's Guide Web Resources: Unit 5-Chromosome Clues
www.pbs.org/evolution
This activity uses photos of real chromosomes to compare chromosomes from three species and to introduce the concept of chromosome inversion.

mRNA Codons and Amino Acid Sequences
www.ship.edu/~bmushe/codons.html
Chart listing the amino acids coded by each mRNA codon.

Whales (optional):

Introduction to Cetacea
www.ucmp.berkeley.edu/mammal/cetacea/cetacean.html
This site discusses general characteristics of whales and dolphins and evolution of the cetaceans.

MATERIALS:

For each student:

- Focus for Video Interaction 1 (Changes in the Genetic Code)
- Focus for Video Interaction 2 (Whale of a Change)
- Changes in Gene Sequence worksheet (Culminating Activity)

For each student or small group of students:

- One copy of the origami whale worksheet
- One copy of the whale origami instructions (with picture instructions)

PREP FOR TEACHER:

1. Prior to teaching the unit, bookmark the Web sites used (as reference).
2. Prepare copies of the Focus for Video Interaction and Changes in a Gene Sequence worksheets and the origami whale instructions.
3. **CUE** video segments.

INTRODUCTORY ACTIVITY:

Students should be acquainted with DNA, RNA and protein synthesis, including the translation process (incorporation of amino acids into polypeptides) prior to participation in this unit. Biology texts generally include a chart which students can use in "reading" the codons and determining amino acid placement in a polypeptide (protein) chain.

LEARNING ACTIVITIES:

1. a. Provide a **FOCUS FOR MEDIA INTERACTION** by instructing students to listen closely for new terms and their meanings. **START** video clip 1.
   b. **PAUSE**: after the narrator says, "you will arrive at the common ancestor we share with today's apes." Ask the students to differentiate in their own words the difference between related to and descended from.
   c. **RESUME** the video.
   d. **PAUSE** when the narrator says, "we can establish how closely related they are related one to another." Discuss with students the following question: What do we learn by comparing the DNA sequences of organisms. Instruct the students to
      - listen for any comparisons made between humans and other animals and for any identification of common ancestors and humans in the next section of the program
      - study what is meant by making note of spelling changes.

   e. **RESUME** the video and play until the end of segment 5. At the conclusion ask the students the importance of spelling changes. Have the students discuss **Focus** of **Video** Interaction problems 1 and 2.
2. Discuss the concept of mutations. Introduce the concept of point mutations and have students complete the Class Notes section of the first worksheet. If available biology texts include a discussion on point mutations, assign students to read the section.

   A point mutation is a change in the genetic material that affects only one gene. Point mutations are frequently classified as:

   - ***Silent mutations*** *in which the change in the codon does not result in a change in the amino acid coded for and, therefore no change occurs in the protein chain. For example, CUU, CUC, CUA and CUG all code for leucine; therefore, a change in the third position of the codon would not affect the amino acid in a chain.*
   - ***Nonsense mutations*** *are those in which the affected codon no longer codes for an amino acid but for a "stop" or "termination " codon. (For example, if UGC is altered to UGA) This will result in incomplete production of the polypeptide chain.*
   - ***Missense mutations*** *are those in which the change results in a change in an amino acid added to the sequence. This change could result in a minor change in the protein or in a protein with dramatically different characteristics. (For example, the difference in the structure of "normal" hemoglobin and that of hemoglobin resulting in sickle-cell anemia is a difference of one amino acid in each of two matching strands of the molecule composed of approximately 2800 amino acids.)*

   In addition, changes in genetic sequences can result from changes classified as frame-shift mutations.

   - ***Frame-shift mutations*** *are those in which nucleotides are inserted or deleted (as a result of an error in copying or damage to the chromosome). This modifies the previous grouping of nucleotides in the codons and causes a new sequence of codons to be read. (For example. If the" original" code read AUG GGA AGA CCG… and the first nucleotide in the second codon were deleted, the new code would be AUG GAA GAC CG… which would produce a different protein chain.*

   Chromosome inversions could also be introduced at this time through use of the **evolution Teacher's Guide Web Resource** activity**, Chromosome Clues**.

3. a. Provide a **FOCUS FOR MEDIA INTERACTION** by asking students to consider the shape and composition of DNA and to listen to identify how researchers would trigger developmental change.
   b. **START** the second video clip.
   c. **PAUSE** after the words "Scientists were just beginning to grasp the fact that DNA itself was made up of up Segments." Prompt the students to report on the important terms and allow time for students to share comments and ask questions. Provide wait time before answering to allow students to reflect on one another's questions and offer their own answers.
   d. **RESUME** play and run until the end of the clip with "If one of these genes turned on in the wrong place, striking changes in the body could take place. The visual is a multicolored -fly whose body parts are colored coordinated to the gene coding for that trait. After viewing the video, have students discuss the meaning of the statement, "If one of the genes turned on in the wrong place, striking changes to the body could take place", and relate the quote to point mutations.
4. Distribute the CHANGES IN A GENE SEQUENCE. Tell students that researches have noted differences in the codon sequences for a particular origami whale protein. Have them use textbook copies of the mRNA/amino acid tables to determine the sequence of amino acids coded for by each of the chains illustrated. If the table is not available in class texts, one is available at Web site, www.ship.edu/~bmushe/codons.html.
5. Have students label each of the mutated sequences by the type of mutation it illustrates. It is not necessary to review each amino acid in each of the chains unless you wish to do so but do have students infer possible effects of the mutations on protein production.
   Type 2 illustrates a silent mutation, type 3 a nonsense mutation, type 4 is a frame-shift resulting from a deletion and type 5 is an example of a frame-shift due to an insertion.
6. Guide students through the experimental design portion of the lab activity.

Problem: While these may vary, a possible problem might be, "What affect do various point mutations have on origami whale development?"
Hypothesis and justification: *Have students develop and justify their hypotheses and discuss these with the class.*
Independent Variable: *the mutation*
Dependent Variable: *changes in the amino acid sequence*
Control Group: *the "wild type" sequence*
Collect data (make, compare, and discuss the whale variations) Assign each student lab group one or more of the whale gene sequence *variations.* Following instructions on the "Whale" sheet, they should make compare, and discuss the origami whale variation(s) assigned)
Draw conclusions based on the data collected. Answers may vary but will make for interesting class discussions and may serve to identify student misconceptions and to introduce concepts of adaptation and natural selection (This may be a good time to discuss adaptation and to stress that adaptation occurs within populations not individuals).

CROSS-CURRICULUM EXTENSIONS:

Mathematics: Research and calculate mutation rates in bacteria and relate these to the rates at which drug resistance develops in these organisms.
Art and Science: Relate the techniques of paper folding to protein synthesis. Discuss mutations and evolution in terms of the history of origami art forms.

STUDENT MATERIALS:

- Focus for Video Interaction 1 (Changes in the Genetic Code)
- Focus for Video Interaction 2 (Whale of a Change)
- Changes in Gene Sequence worksheet
- Whale origami variations sheets
- Whale origami instruction sheet (with diagram instructions)

COMMUNITY CONNECTIONS:

- Invite a medical researcher to discuss mutation rate in pathogenic organisms and discuss their affect on medical treatment.
- Invite a wildlife biologist to discuss variations within a species of organism and the implications of these on survival rate of the species.
- Visit an arboretum, forest research center, or horticultural research lab. Observe science at work utilizing mutations to create "improved" strains of organism (for example, grafting of seedless orange tree boughs to hardy rootstock)

FOCUS FOR VIDEO INTERACTION 1

CHANGES IN THE GENETIC CODE

- View the 5 ½ -minute video clip (**PBS evolution**-Video 5 for Students).
- While viewing the video, listen for and record the definition of "mutation" and discuss the meaning of the statement, "We are related to them, not descended from them".
- After viewing the video clip, participate in discussion of the material it covered.
- Participate in discussion of point mutations and complete the "Class notes" problems.
- Watch the second video clip (from **PBS evolution- Great Transformations)**
- After viewing the video, discuss the meaning of the statement, "If one of the genes turned on in the wrong place, striking changes to the body could take place", and relate the quote to point mutations.
- Participate in the lab activity

1. Define "mutation".

2. What does "We are related to them not descended from them" mean?

Class Notes:

1. Define point mutation. Discuss the 3 general types of point mutation and how each affects protein synthesis.

2. Describe what is meant by "frame-shift mutations"? How do insertions and deletions affect protein synthesis?

FOCUS FOR VIDEO INTERACTION 2

WHALE OF A CHANGE

Discuss the meaning of the statement, "If one of the genes turned on in the wrong place, striking changes to the body could take place", and relate the quote to point mutations.

CULMINATING ACTIVITY: CHANGES IN A GENE SEQUENCE

- Follow your teacher's instructions in completing the activity.
  Next to the type number (2-5) indicate the type of mutation exhibited.

"wild-type"

AUG AUC UUU UUU CGU GGU ACG UGC UAU AUG AGG GGU GAG UAG

Type 2

AUG AUC UUC UUU CGU GGU ACG UGC UAU AUG AGG GGU GAG UAG

Type 3

AUG AUC UUU UUU CGU GGU ACG UGC UAA AUG AGG GGU GAG UAG

Type 4

AUG AUC UUU UUU _GU GGU ACG UGC UAA AUG AGG GGU GAG UAG

Type 5

AUG AAUC UUU UUU CGU GGU ACG UGC UAA AUG AGG GGU GAG UAG

- Discuss, with your classmates, the possible implications of each of the mutations above.

LAB NOTES—Following verbal instructions, participate in the "whole-class" group activities.

Problem:

Hypothesis and justification:

Independent Variable:

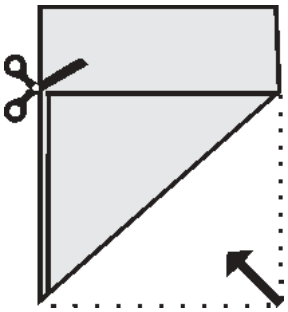
Dependent Variable:

Control:

Collect data
(Following instructions on the "Whale" sheet, make, compare, and discuss the origami whale variation(s) assigned)

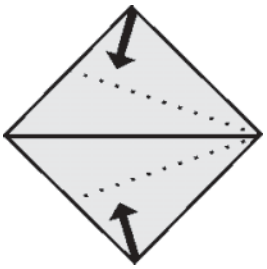
Draw conclusions based on the data collected.

ORIGAMI WHALE



1. Make a square sheet of paper by cutting off the directions.
2. Fold on the lines indicated for your assigned whale type.
   Use the picture guide instructions to assist you.

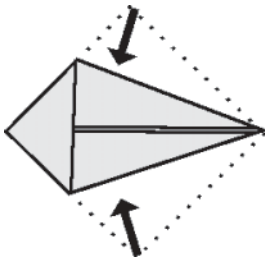
Wild type—Follow all instructions
Type 2—Follow all instructions.
Type 3—Do NOT make fold B.
Type 4—Do NOT make fold D.
Type 5—Do NOT make the short cut through the end of the fold in the tail.

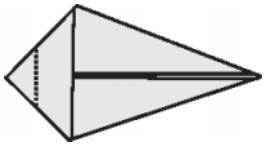


Fold to center fold.

Fold two opposite side so that they meet at the fold.

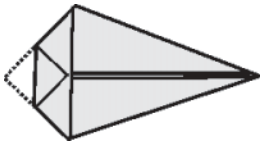
FOLD A

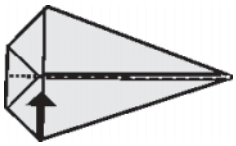




Fold the tip over to just meet the other folds.

FOLD B





Fold the piece in half along the central axis.

FOLD C

Fold the tail up.

FOLD D

Make a short cut through the end of the fold in the tail. Fold the edges of the tail outwards.

Draw eyes, fins, and any other patterns you like, and enjoy your whale.

ORIGAMI WHALE

1. Make a square sheet of paper by cutting off the directions.
2. Fold on the lines indicated for your assigned whale type.
   Use the picture guide instructions to assist you.

Wild type—Follow all instructions
Type 2—Follow all instructions.
Type 3—Do NOT make fold B.
Type 4—Do NOT make fold D.
Type 5—Do NOT make the short cut through the end of the fold in the tail.

Fold here.
FOLD B
FOLD A Fold here.
Fold here. FOLD C
FOLD A Fold here.
FOLD D
Fold tail up
Cut for tail.

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