Genetics – Mutations

Teacher's Guide

1.0 Summary

The *Mutations* activity is the seventh core Genetics activity and should be run after *XLinkage**.*** It should take students approximately 45 minutes to complete this activity.

2.0 Learning Goals

Driving Question: What happens when you change the DNA? How are mutations inherited?

Mutations and *Mutations II* are two activities that enable students to use BioLogica's DNA model to make changes to the base pair sequences of dragon DNA and investigate the impact of these changes on phenotypes and the inheritance patterns that emerge when dragons with mutated alleles are bred. Because both *Mutations* and *Mutations II* use pedigrees, students should complete *Monohybrid* first.

Mutations introduces students to mutations through the appearance of a novel trait in a pedigree. Students then explore the role of DNA in mutations. They can modify the base pair sequences of particular dragon alleles and examine the impact of these newly created alleles on the appearance of a dragon.

Mutations II builds on **Mutations** and **Monohybrid** by enabling students to investigate how mutations are inherited. It also gives the students more practice in using Punnett squares to determine the probability of inheriting a mutated trait. It should be used after *X-Linkage*.

Learning Goals

- Students will understand that genes are base-pair sequences in DNA which determine traits.
- Students will recognize that the four bases form complementary base pairs (A-T and G-C) that link the two strands of DNA.
- Students will identify the four bases of DNA as adenine, thymine, guanine, and cytosine.
- Students will understand that mutations are changes in the base-pair sequences.
- Students will know that genetic mutations create new alleles.
- Students will understand that not all genetic mutations result in a change of phenotype.
- Students will comprehend that some mutations are dominant and some are recessive.
- Students will be able to differentiate between somatic and inheritable mutations.

Additional Teacher Background

DNA is the nucleic acid that stores and transmits genetic information from one generation to another. The structure of DNA is a double helix in which two strands are wound around each other. Each strand is made up of a chain of nucleotides. The two strands are held together by hydrogen bonds between adenine and thymine and between guanine and cytosine.

Mutations are changes in the DNA sequence that affect how that code is translated. Mutations can range from imperceptible to lethal. Gene mutations result from changes in a single gene. Chromosomal mutations involve changes in whole chromosomes. Somatic mutations occur in body cells such as the skin and cannot be inherited. Germline mutations occur in the germline cells or gametes of organisms and can be inherited.

The *DNA Model* deals with gene mutation. Most gene mutations are point mutations involving the substitution of one nucleotide for another. Substitutions generally change one of the amino acids in a protein. However, when a point mutation also involves the deletion or insertion of a nucleotide the situation is more severe. In this case, frameshift mutation occurs and every amino acid that follows the point of insertion or deletion is affected. The protein can be changed so drastically that it cannot perform normal functions.

Students will be able to make insertions, deletions, and substitutions to the DNA of the Dragon model. They will then evidence the change in the nucleotide sequences as well as the resultant physical changes to the dragon Elvira.

3.0 Standards Alignment

Alignment to National Math and Science Standards (NCTM or NSES)

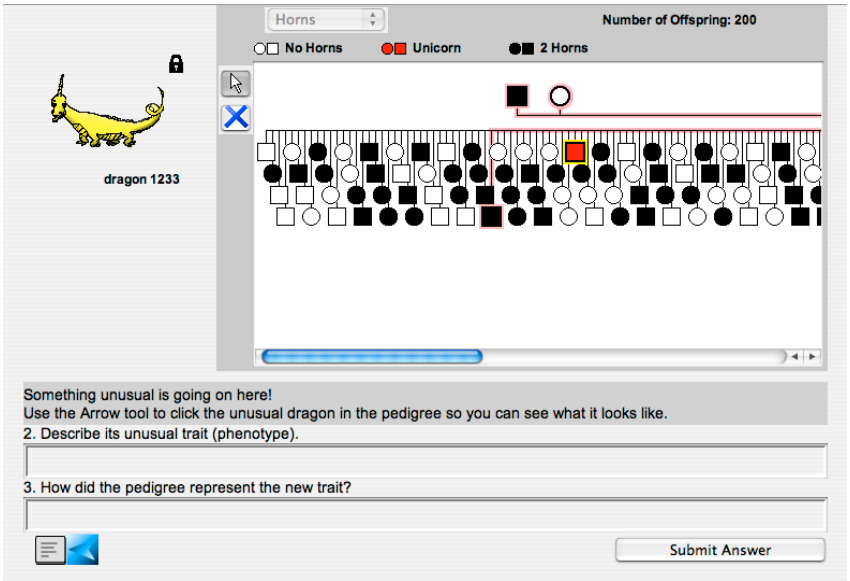
Objective	Standards
Students will learn that DNA is a complex molecule.	Students should know the information passed down from parents to offspring is coded in DNA molecules. Students should know that each DNA molecule in a cell forms a single chromosome.
Students will learn that changes in the DNA of sex cells result in changes in the genotype of the individual.	Students should know that only mutations in germ cells could create the variation that changes cells and organisms.
Students will learn about the modes of inheritance of mutations.	Students should know that in all organisms, the instructions for specifying the characteristics of the organisms are carried in DNA.
Students will further their study of probability.	Students should be able to use simulations to construct empirical probability distributions.

4.0 Activity Sections

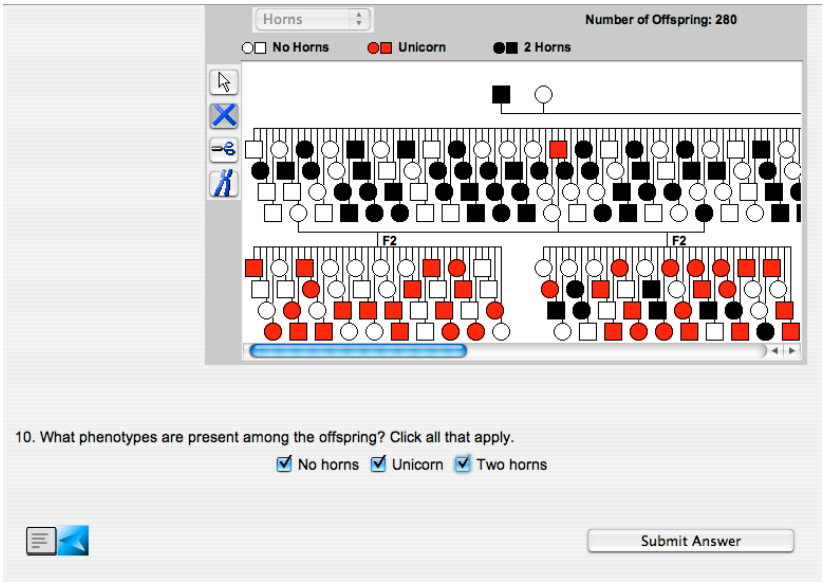
In this activity, students explore the appearance of a novel trait in the pedigree and the types of genetic changes that might be responsible. Students have a chance to view, identify, and modify DNA to produce the new allele and new trait. Students identify the letters ATCG as part of the DNA code. They then match letters as the base pairs A-T and C-G. Students identify the names of the molecules adenine, thymine, cytosine, and guanine. Students create substitution, deletion and insertion mutations to create new alleles. Students investigate how these new traits are inherited through the generations in order to determine dominance relationships among new and existing alleles.

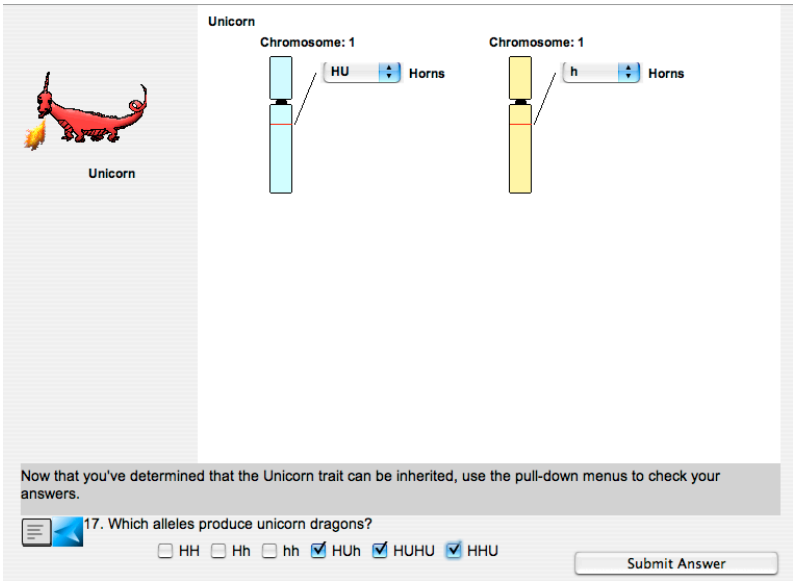
4.1 A New Trait

Students investigate a new trait that appears in a pedigree.

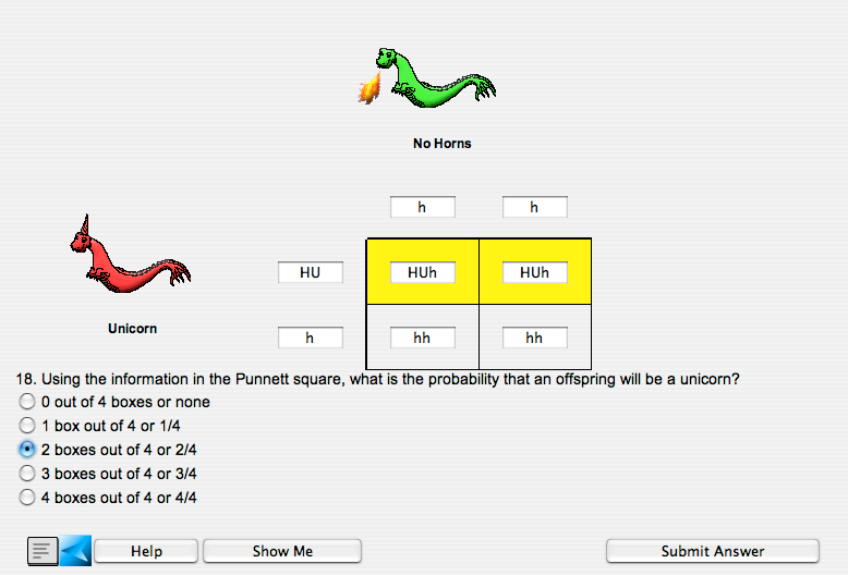


Using their prior knowledge and pedigree tools, students determine that the unicorn trait can be inherited and that the new HU allele is dominant when paired with existing alleles.





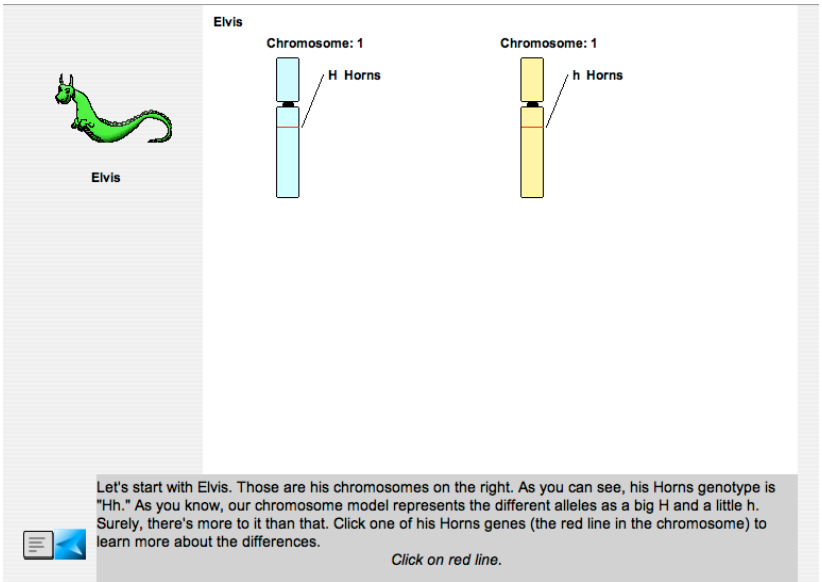
Students explore then predict how likely unicorns are to appear now that the allele is present in the population.



We then stress the rarity of mutations

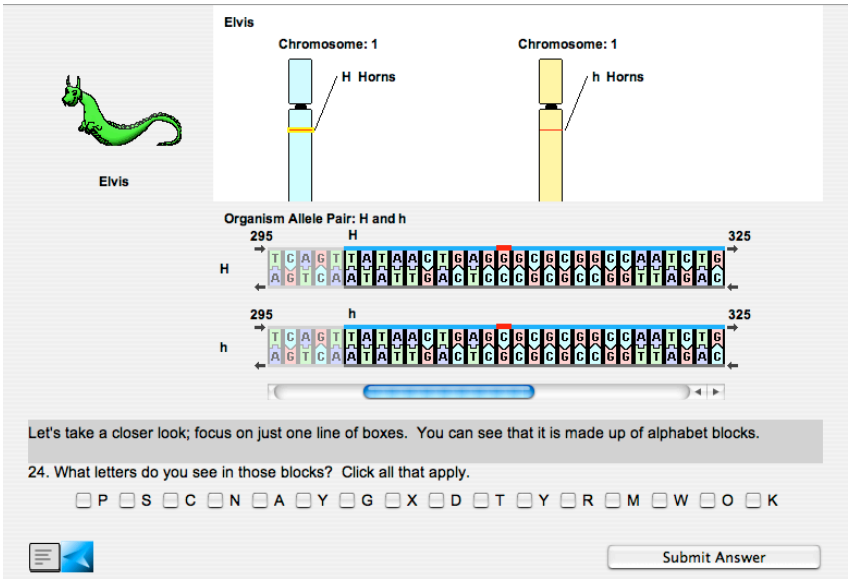
4.2 DNA Model

Students then dive into the DNA model to become familiar with its parts and how they relate to the chromosomes and alleles encountered in Introduction and Meiosis.



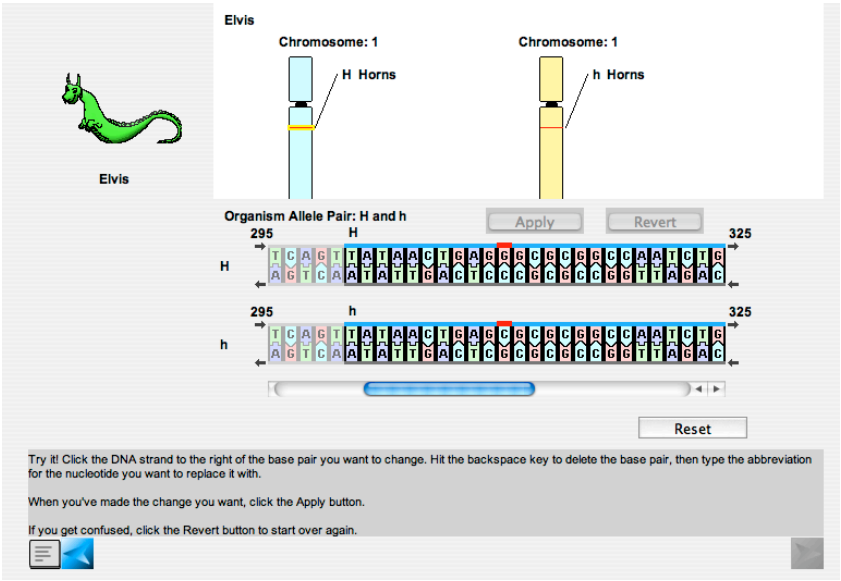
View of Elvis' chromosomes, click on a gene (red line) to view DNA.

A series of screens familiarize students with BioLogica's DNA model. Questions help students focus on the base pairs that form DNA.



View of DNA of Horns alleles. Red bar above base pairs shows where base pairs differ for the different alleles.

Students learn how to make changes in the base pairs and are challenged to change the dominant allele to match the recessive one.



Change the DNA to make Elvis hornless.

Students are asked about the relationships among DNA, chromosomes, genes and alleles and receive scores on their answers.

33. What is the relationship between chromosomes and DNA molecules?
- ○ Chromosomes typically contain more than one DNA molecule.
- ○ DNA molecules typically contain more than one chromosome.
- ◉ The number of chromosomes and DNA molecules in a typical cell nucleus is the same.

34. What is the physical relationship between genes and alleles?
- ○ An allele is a particular part of a gene.
- ○ A gene is a particular part of an allele.
- ◉ An allele is a particular version of a gene.
- ○ A gene is a particular version of an allele.

35. What is the physical relationship between genes and chromosomes?
- ◉ Genes are part of chromosomes.
- ○ Chromosomes are part of genes.
- ○ Genes are on chromosomes.
- ○ Chromosomes are on genes.

Submit Answer

36. What is the numerical relationship between genes and chromosomes in a typical cell nucleus?
- ○ It contains more chromosomes than genes.
- ◉ It contains more genes than chromosomes.
- ○ It contains the same number of genes and chromosomes.
- ○ It doesn't contain chromosomes or genes.

37. What is the physical relationship between genes and DNA?
- ○ Genes and DNA molecules are identical segments of information.
- ○ Genes are segments of information attached to DNA molecules.
- ◉ Genes are segments of information within DNA molecules.

38. What is the numerical relationship between genes and DNA?
- ○ Genes typically contain more than one DNA molecule.
- ◉ DNA molecules typically contain more than one gene.
- ○ The number of genes and DNA molecules in a typical cell nucleus is about the same.

Submit Answer

That completes our exploration of the DNA model. You have explored the base pairs that form the critical information-bearing part of the DNA molecule and learned that:

· Each chromosome is a separate DNA molecule.

· Chromosomes contain regions of coding and non-coding DNA.

·Genes are regions of coding DNA.

·Alleles are particular sequences of base pairs for a gene.

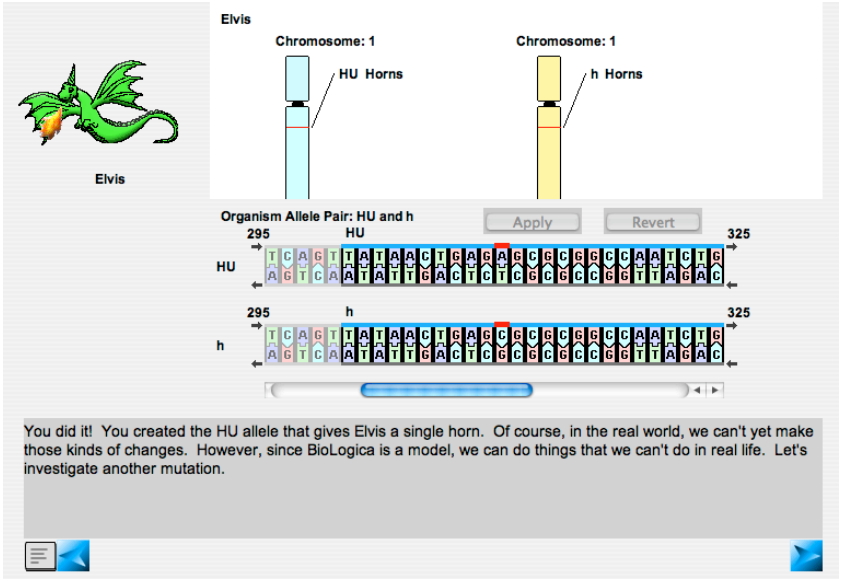
·Different alleles have different sequences.

But what is a mutation? Continue to Part 3 and see!

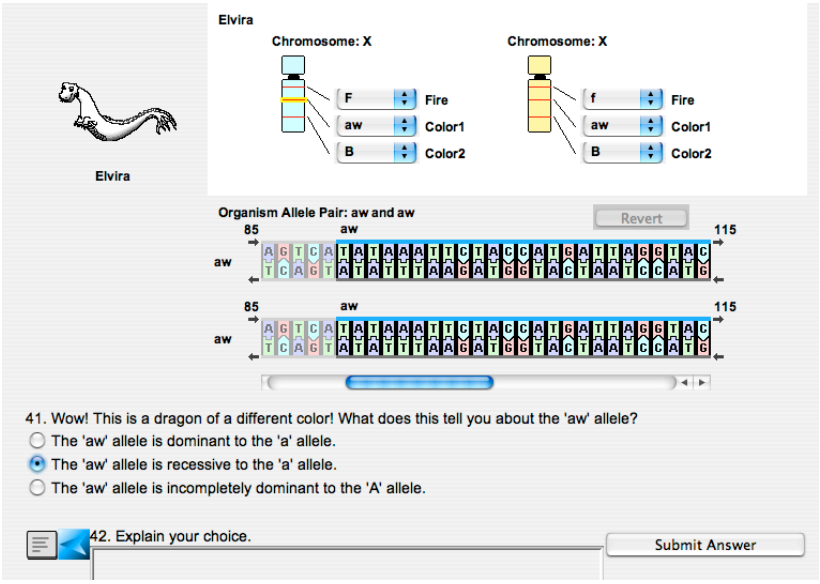
Summary for Part 2

4.3 Change the DNA, Get a Mutation

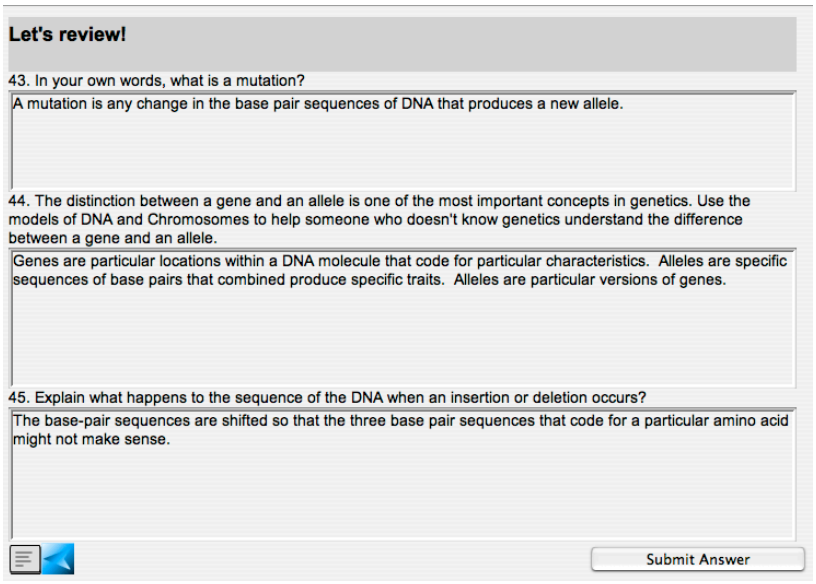
In the following section students explore how the HU allele came to be (a substitution) and investigate other mutations (insertions and deletions).



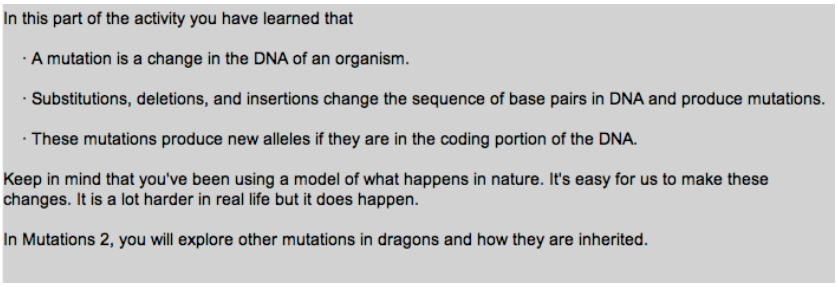
Students substitute a base pair to create the HU allele.



Inserting a base pair into the sequence creates a frameshift and a new allele *aw* that is recessive to both existing Color1 alleles.



Students answer review questions and receive brief summary.



5.0 Student Reports

Your students' work with *Mutations* is logged and viewable on the MAC Project Web Portal at http://mac.concord.org. For each student, you can view a report containing questions and answers.

The next activity that students should use is *Mutations2*, an optional activity in which students explore x-linked and lethal mutations through pedigree analysis.