

5E Integrated STEM Lesson Plan

Lesson Title: Baby Dragons

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Topic: Genetics -Describe Mendelian inheritance,
-Differentiate between dominant and recessive alleles and the terms homozygous, heterozygous, genotype, and phenotype
-Discuss Mendel's laws of inheritance
-Diagram to predict the results of monohybrid crosses for P1 and P2 generations

Targeted Grade Level: High School Biology (mostly sophomores)

Time Needed: 2 Weeks (8 60 minute class periods)

Subject Integration: Science, Math, and Literacy to integrate

Justification: Science: Biology-Genetics: this project enhances understanding by hands on learning seeing genetic traits passed from one generation to the next while comparing 45 different offspring.

Math: Percentage and Probability: using percentage to determine ratio outcomes for offspring and calculating probability of each phenotypic outcome

Literacy: Write a summary of parent to offspring phenotype/genotype outcomes. Include the percent chance each outcome was and the overall dominant to recessive traits the offspring possessed.

Standards: 2020 Colorado Standards: HS.LS2.8 - The characteristics of one generation are dependent upon the genetic information inherited from previous generations.

NGSS Performance Expectations:

NGSS: HS-LS3-1. - Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.

NGSS: HS-LS3-3 - Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

2020 Colorado Standards: HS.LS2.8 - The characteristics of one generation are dependent upon the genetic information inherited from previous generations.

- <https://www.cde.state.co.us/coscience/2020cas-sc-hs>

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts:
<p><u>Asking Questions and Defining Problems</u> Asking questions and defining problems in 9-12 builds on K-8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.</p> <ul style="list-style-type: none"> • Ask questions that arise from examining models or a theory to clarify relationships. <p><u>Analyzing and Interpreting Data</u> Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.</p> <ul style="list-style-type: none"> • Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. 	<p><u>LS3.A: Inheritance of Traits</u></p> <ul style="list-style-type: none"> • 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. 	<p><u>Cause and Effect</u></p> <ul style="list-style-type: none"> • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. <p><u>Scale, Proportion, and Quantity</u></p> <ul style="list-style-type: none"> • Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). <p><i>Connections to Nature of Science</i></p> <p>Science is a Human Endeavor</p> <ul style="list-style-type: none"> • Technological advances have influenced the progress of science and science has influenced advances in technology. (HS-LS3-3) • Science and engineering are influenced by society and society is influenced by science and engineering.

Common Core State Standards:

Math: Interpreting Categorical and Quantitative Data S-ID Summarize, represent, and interpret data on a single count or measurement variable

4. Use the mean and standard deviation of a data set to fit it to a normal distribution and to estimate population

percentages. Recognize that there are data sets for which such a procedure is not appropriate. Use calculators, spreadsheets, and tables to estimate areas under the normal curve.

ELA: -Write informative/explanatory texts to examine and convey complex ideas, concepts, and information clearly (W.9-10.2)

-Draw evidence from literary or informational texts to support analysis, reflection, and research (W.9-10.9)

ITEEA Standards

Other Standards

Measurable Student Learning Objectives:

- Scientists will be able to use a Punnett squares to calculate percentages of offspring traits with known heterozygous parents.
- Scientists will be able to conduct the random chance to an offspring receive 1 of the 2 parents alleles for 14 traits.
- Scientists will be able to state if offspring genetic traits are homozygous/heterozygous and state the offspring's phenotypes.
- Scientists will be able to calculate the percentage of the population's phenotypes and compare to the 3:1 ratio.
- Scientists will be able to write an informative paper concluding Mendelian inheritance and the correlation to their baby dragon.

Nature of STEM: This lesson addresses the nature of science when explaining and demonstrating Mendelian Inheritance by taking 2 dragon parents with known genotypes and create baby dragons.

Engaging Context/Phenomena: Hook: Pictures of family member to look nothing alike (with discussion of no family scandals) how is this possible. Watching a movie clip of “Cheaper by the Dozen” where the littlest family member is called “FedEx”. Then showing two parent dragons “Jymbeo the Great” and “Aymirth the Adorable” are expecting their next clutch of offspring. What do you think their babies will look like?

EXTENTION: Nature vs. Nurture Discuss what happens when twins are separated at birth and raised with different families. Discuss NASA Astronaut twins Scott and Mark Kelly that are being studied to determine what happens to a body in space. These twins allow us to observe what physiological, molecular, and cognitive changes could happen when exposed to spaceflight and the effects of gravity on DNA and if these effects can be passed on to offspring.

Data Integration: Students will analyze and collect data about baby dragon genotype and phenotype. Genotype will be calculated with all students' baby dragon data, to calculate if there is a 3:1 ratio of dominant: recessive traits.

Differentiation of Instruction: All students will watch a demonstrating of how the baby dragon genes are chosen. Key vocabulary will be defined prior to and used in the classroom setting. I will confer with students about the process and address individual needs with one on one time. Check ongoing work to insure genotype and phenotype are correctly written and have past baby dragons as examples

Real-life Connection: Our real life connections is that family member with different traits. Why do you look like one sibling more than another sibling or how a cousin can look alike? Discussion about traits that are typical of region of the world.

Possible Misconceptions: Students may associate “recessive” with inferiority or a lesser genotype. There is no genotype that is better than another; each genotype is simply a different arrangement of alleles.

Lesson Procedure:

5E Model	5E Objectives
<p><u>Engage</u></p> <p>Phenomenon: family members looking different, watching Cheaper by the Dozen to explain younger kid “FedEx”. Discussion about our family differences. Introducing parent dragons “Jymbeo the Great” and “Aymirth the Adorable” as they are expecting their next clutch of offspring. What do you think their babies will look like? Discuss the traits dragons have.</p>	<p>Procedure:</p> <ul style="list-style-type: none"> - Teacher: facilitate material to watch, prep questions about family differences and generation traits, and introduce Jymbeo and Aymirth the dragons - Students: watching/listening, participating in discussion, and asking questions <p>Modifications:</p> <ul style="list-style-type: none"> - Address language barriers: picture examples and Google translate when needed and one on one help when needed <p>Standards Addressed</p> <ul style="list-style-type: none"> - NGSS: HS-LS3-1. - Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. <p>Formative/Summative Assessments</p> <ul style="list-style-type: none"> - Are students participating in discussions about family and dragons <p>Resources</p> <ul style="list-style-type: none"> - Picture examples and movie clip - List of family traits that are commonly different in families - “Jymbeo the Great” and “Aymirth the Adorable” Dragon Examples
<p><u>Explore</u></p> <p>Activity of rolling dice to randomly pick alleles from dragon parents</p>	<p>Procedure:</p> <ul style="list-style-type: none"> - Teacher: showing example for rolling dice and deciding allele the offspring received, walking around helping students if confused about which allele baby dragon is to receive. - Students: rolling dice to randomly choose alleles from parents: Even numbers are dominant

	<p>alleles Odd numbers are recessive alleles</p> <p>Modifications: one on one help and shoulder partner help</p> <p>Standards Addressed</p> <ul style="list-style-type: none">- NGSS: HS-LS3-1. - Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.- 2020 Colorado Standards: HS.LS2.8 - The characteristics of one generation are dependent upon the genetic information inherited from previous generations. <p>Formative/Summative Assessments:</p> <ul style="list-style-type: none">- Check all alleles and identification of genotype to phenotype. <p>Resources: Dice</p>
<p><u>Explain</u></p> <p>Use Punnett squares to describe the probability of the outcome your baby dragon received.</p>	<p>Procedure: Correctly fill in Punnett squares for each trait and calculate percentages of dominant and recessive traits the baby dragon received.</p> <ul style="list-style-type: none">- Teacher: demonstrate Punnett squares and how to calculate percentages, discuss the 3:1 ratio for dominant and recessive traits.- Student: correctly complete Punnett squares for all baby dragon traits and calculate percentages for observed traits <p>Modifications: one on one support, completed examples to follow along with</p> <p>Standards Addressed:</p> <ul style="list-style-type: none">- NGSS: HS-LS3-3 - Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.- Math: Interpreting Categorical and Quantitative Data S-ID Summarize, represent, and interpret data on a single count or measurement variable

	<p>4. Use the mean and standard deviation of a data set to fit it to a normal distribution and to estimate population percentages. Recognize that there are data sets for which such a procedure is not appropriate. Use calculators, spreadsheets, and tables to estimate areas under the normal curve.</p> <p>Formative/Summative Assessments: completion of Punnett squares, completion of percentages and ratios</p> <p>Resources: Punnett square examples and Calculation Examples</p>
<p><u>Elaborate</u></p> <p>Compare classroom data of all 2023 baby dragons</p>	<p>Procedure: comparing all baby dragon data</p> <ul style="list-style-type: none">- Teacher: Draw data table on board for students to fill in, discuss how to correctly place tally marks,- Student: complete group data table with tally marks of baby dragons phenotypic characteristics <p>Modifications: one on one support</p> <p>Standards Addressed:</p> <ul style="list-style-type: none">- NGSS: HS-LS3-3 - Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.- 2020 Colorado Standards: HS.LS2.8 - The characteristics of one generation are dependent upon the genetic information inherited from previous generations.- Math: Interpreting Categorical and Quantitative Data S-ID Summarize, represent, and interpret data on a single count or measurement variable- 4. Use the mean and standard deviation of a data set to fit it to a normal distribution and to estimate population percentages. Recognize that there are data sets for which such a procedure is not appropriate. Use calculators, spreadsheets, and tables to estimate areas under the normal curve.

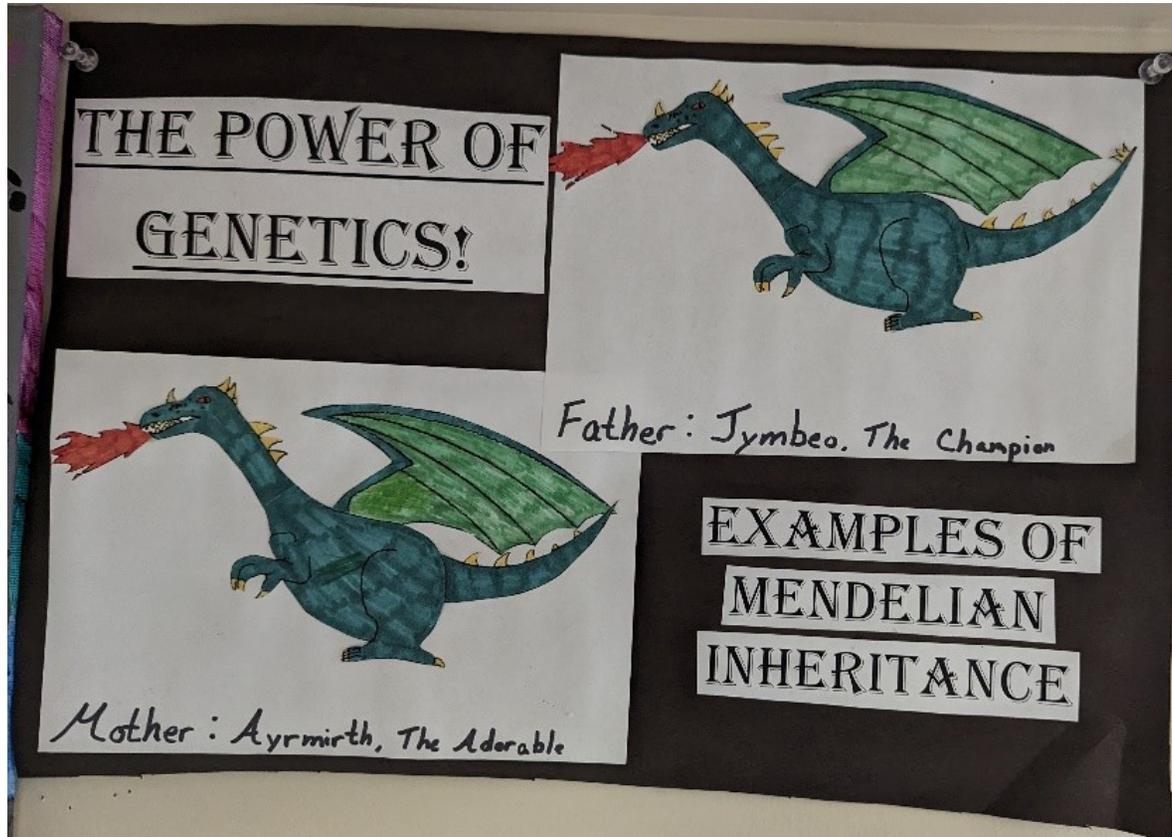
	<p>Formative/Summative Assessments: Correctly place tally marks and decipher class baby dragon data</p> <p>Resources: Completed baby dragon paperwork</p>
<p><u>Evaluate</u></p> <p>Write a summary of parent to offspring phenotype/genotype outcomes. Include the percent chance each outcome was and the overall dominant to recessive traits the offspring possessed.</p>	<p>Procedure: Complete a lab write up summary</p> <ul style="list-style-type: none"> - Teacher: Give students a guide to follow and necessary information to include in write up - Students: Complete a summary/informative write up of their baby dragon <p>Modifications:</p> <ul style="list-style-type: none"> - Sentence stems provided - Structured example for a completed - Help with writing when needed <p>Standards Addressed</p> <ul style="list-style-type: none"> - ELA: -Write informative/explanatory texts to examine and convey complex ideas, concepts, and information clearly (W.9-10.2) - Draw evidence from literary or informational texts to support analysis, reflection, and research (W.9-10.9) <p>Formative/Summative Assessments:</p> <ul style="list-style-type: none"> - Combine the whole project with the informative writing summary. - Complete Baby Dragon with Name <p>Resources:</p> <ul style="list-style-type: none"> - Rubric for students to follow with required information to include in the lab write up

Teacher Background:

- Background knowledge on Mendelian Inheritance, Law of Independent Assortment, dominant/recessive traits, and Punnett squares. Discovery Ed is the online textbook I use in class.

<https://app.discoveryeducation.com/learn/techbook/units/bc1720c7-e9b5-4413-aea3-a514b16c4c3c/concepts/73dc8306-4604-4a7d-b430-ed7ad20140bd/tabs/759da9a7-2edf-4cde-9515-7081ca990764>

- Examples of Baby Dragon Parents:



- Baby Dragon Worksheet

DRAGON GENETICS – Understanding Inheritance¹

INTRODUCTION

In this activity, you and a partner will work together to produce a baby dragon. You will simulate meiosis and fertilization, the biological processes by which the parents' genes are passed on to a baby. To begin, we will review meiosis and fertilization for dragons that have only one chromosome with a single gene.

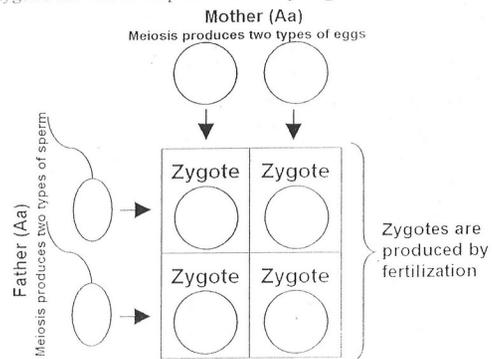
This gene codes for the enzyme that makes the pigment that gives dragon skin its color.

- The dominant allele, **A**, codes for a normal enzyme that results in normal skin color.
- The recessive allele, **a**, codes for a defective enzyme that cannot make skin pigment, so an **aa** dragon is an albino with completely white skin.

★ Suppose that each dragon parent has the pair of homologous chromosomes shown.



Draw the chromosomes of the two types of eggs and the two types of sperm produced by meiosis. Then, draw the chromosomes of the zygotes that are produced when the different types of sperm fertilize the different types of eggs. Next, use an * to indicate any zygote or zygotes that will develop into albino baby dragons.



¹ By Bob Farber, Central High School, Philadelphia, PA and Ingrid Waldrom, Department of Biology, University of Pennsylvania, copyright 2013. Based on the work of Dr. Paul T. Feyerherm, University of North Texas, who developed an earlier version of "Dragon Genetics" described in the January 1999 issue of Science Scope, 29(1): 14-17, and the April 2001 issue of The Science Teacher, pages 52-57. Any other use is prohibited except the Student Handbook for classroom use. A Word file (which can be used to prepare a modified version of desired) Teacher Preparation Guide, permission to use the complete text of our handbook on the web, and a list of links, at <http://www.biology-online.org/bot/edu/waldrom>.

In this activity you will work with a partner to carry out a simulation of meiosis and fertilization and produce a baby dragon. Each student will be a surrogate dragon parent who has the genes indicated on a set of three Popsicle sticks. Each side of a Popsicle stick represents one chromosome, and the two sides together represent a pair of homologous chromosomes. This table explains how the simulation mimics the biological processes of meiosis and fertilization.

Biological Process	Simulation
The parents' diploid cells have pairs of homologous chromosomes. Meiosis separates each pair of homologous chromosomes, so each gamete receives only one from each pair of chromosomes. Thus, the parents' diploid cells have two copies of each gene, but each haploid gamete has only one copy of each gene.	Each dragon parent drops his or her Popsicle sticks on the table or desk, and the side of each Popsicle stick that is facing up indicates which chromosome from each homologous pair is included in the gamete. The alleles from this chromosome are recorded in the Egg or Sperm column in the charts on page 4.
When a haploid sperm fertilizes a haploid egg, this produces a diploid zygote with one copy of each gene from the mother and one copy from the father. These genes determine the phenotypic traits of the baby dragon that develops from this zygote.	The dragon parents record the phenotypic traits of their baby in the Baby's Traits column in the charts on page 4.

SIMULATION PROCEDURE

1. Choose a partner carefully. You and your spouse will share the grade for this lab. Your instructor does not care which partner worked the hardest. This is a no divorce classroom. The lab must be completed on time.
2. Each partner must pick up a bundle of three Popsicle sticks -- one green autosome, one yellow autosome, and one sex chromosome stick. Parent partners must be of the opposite sex; therefore one parent must pick up a bundle with a double X chromosome Popsicle stick (red) and the other must pick up a bundle with an X/Y chromosome Popsicle stick (blue).
3. Record the alleles from both sides of each Popsicle stick for Mom in the first column of the charts on page 4 and the alleles from both sides of each Popsicle stick for Dad in the second column.
4. Use the decoding chart on page 3 to figure out the phenotypic effects of each parent's genes. Record Mom's and Dad's phenotypic traits in the last two columns of the charts on page 4.
5. For each color autosome and then for the sex chromosomes, each parent will randomly drop his or her stick on the table or desk. The side of the stick that is up represents the chromosome that is passed onto the baby via meiosis and fertilization. Record the alleles from this chromosome in the Egg or Sperm columns in the charts

- on page 4.
- Next, you must decode the genes inherited by your *bundle of joy* to determine the phenotype of your baby. Record the trait produced by each pair of alleles in the Baby's Traits column of the charts on page 4. If your baby dragon is aa, be sure to take this into account when assessing the phenotypic effects of the skin color and freckles genes.
 - Using the pictures at the end of this handout, cut out the traits and paste them together to create a picture of your baby. If you prefer, you may trace the traits to produce your baby's picture. If your baby dragon has them, draw in extra toes, freckles and/or skin color (or label the color).

DRAGON GENOME – *DECODING OF THE GENES*

Chromosome	Dominant alleles	Recessive alleles
Green Autosome	W has wings	w no wings
	L long neck and tail	l short neck and tail
	A normal skin pigment	a completely white, including no freckles
	C skin color dark green*	c skin color light green*
Yellow Autosome	F fire breather	f not fire breather
	T and t [see below]	
	R and r [see below]	
X Chromosome	H has horn on nose	h hornless
Y chromosome	M male sex (results in spike on tip of tail)	
Incompletely dominant alleles		
TT five-toed	Tt four-toed	tt three-toed
RR lots of freckles* (draw 10)	Rr some freckles* (draw 5)	rr no freckles

*If a dragon is aa and therefore unable to make skin pigment, it will have white skin and it will not have any freckles (no matter what alleles it has for the skin color and freckles genes).

Our Baby!

Names _____

Green Autosomes

GENOTYPES ALLELES in		PHENOTYPES	Mom's Traits	Dad's Traits
Mom	Dad	Egg	Sperm	Baby's Traits
Ww	Ww			
Ll	Ll			
Aa	Aa			
Cc	Cc			

Yellow Autosomes

GENOTYPES ALLELES in		PHENOTYPES	Mom's Traits	Dad's Traits
Mom	Dad	Egg	Sperm	Baby's Traits

Sex Chromosomes (Use the first line for the alleles on the X chromosomes and the second line for the allele on the Y chromosome. Remember that the sperm will have either an X chromosome or a Y chromosome.)

GENOTYPES ALLELES in		PHENOTYPES	Mom's Traits	Dad's Traits
Mom	Dad	Egg	Sperm	Baby's Traits
None	None	X		
			No spike on tip of tail	

Label the baby's phenotypic traits and the figure on the last page of this handout to make a picture of your baby dragon. If your baby dragon has them, draw in extra toes, freckles and/or skin color (or label the color).

Questions

- 1a. What is one phenotypic trait that is the same in Mom, Dad and baby dragon?
 - 1b. Draw a Punnett square to show how your baby dragon inherited the genes that resulted in this trait. In the Punnett square, circle the genotype of your baby dragon.
 - 1c. Suppose that Mom and Dad had a second baby. Would the second baby necessarily have this same trait? Explain why or why not.
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- 2a. Does your baby dragon have exactly the same phenotypic traits as his or her same-sex parent?
 - 2b. If not, choose one trait that differs between the baby and the same-sex parent, and explain the genetic reason for this difference.
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- 3a. What is Mendel's Law of Segregation?
 - 3b. Explain how Mendel's Law of Segregation is simulated by dropping a Popsicle stick and writing the letters on the side facing up in the egg or sperm column of the charts on page 4.
 - 3c. Use an example from this simulation to demonstrate how segregation of two alleles during meiosis, followed by fertilization, can result in a baby that has a new phenotypic trait that is not observed in either parent.
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- 4a. What is Mendel's Law of Independent Assortment?
 - 4b. Explain how Mendel's Law of Independent Assortment is simulated by dropping the green and yellow autosome Popsicle sticks.
 - 4c. Explain why the Law of Independent Assortment does not apply to genes that are close together on the same chromosome.
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5. This simulation can be thought of as a simplified model of how meiosis and fertilization result in inheritance. Like all models, this simulation is not a completely accurate model of biological reality. For example, in this simulation a gamete receives all of the genes on one chromosome from each homologous pair and none of the genes on the other homologous chromosome. Explain why this is not an accurate model of biological reality. Explain how meiosis can result in a chromosome in the gamete that has parts of both chromosomes in a parent's pair of homologous chromosomes.
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- 6a. For the mom and dad in the simulation, will all of their daughters have horns? Explain why or why not.
 - 6b. For this couple, will all of their sons have horns? Explain why or why not.
 - 6c. Which sex will be more likely to have horns. How might horns be an advantage for this sex? [Be creative in your answer.]

7. Use the decoding chart on page 3 to complete the following table

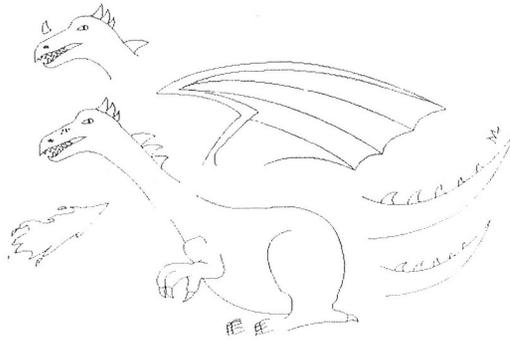
Phenotypic Trait	Can two individuals with this phenotype have different genotypes? If yes, give an example of the different genotypes.
Has wings	
Has 5 toes	
Has no freckles	

8a. What is epistasis?

8b. Describe an example of epistasis in this simulation.

8c. Explain the molecular basis for this example of epistasis. (Hint: Review the top of page 1.)

9. Phenotypic traits are influenced by environment as well as genotype. Propose an environmental factor that might influence phenotypic traits as the baby dragon grows up, e.g. how long the neck and tail grow or how dark the freckles in the skin become.



(Figure from Dr. Pamela Spradell-Daniel: "How a Dragon Grows Its Wings - A fanciful approach to natural selection." The Science Teacher, April 2001, pages 17-18.)