Modeling and the Three Dimensions of the NGSS in Middle School Genetics

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Next Generation Science Standards

Performance Expectations

- Science and Engineering Practices
- Disciplinary Core Ideas
- Crosscutting Concepts

Links to Common Core

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NGSS MS-LS3-2

- PE: Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation.
- (Clarification: Emphasis is on using models such as Punnett squares, diagrams, and simulations to describe the cause and effect relationship of gene transmission from parent(s) to offspring and the resulting genetic variation.)

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MS-LS3 Heredity: Inheritance and Variation of Traits

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Students who demonstrate understanding can:

MS-LS3-1. Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism. [Clarification Statement: Emphasis is on conceptual understanding that changes in genetic material may result in making different proteins.] [Assessment Boundary: Assessment does not include specific changes at the molecular level, mechanisms for protein synthesis, or specific types of mutations.]

MS-LS3-2. Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation. [Clarification Statement: Emphasis is on using models such as Punnett squares, diagrams, and simulations to describe the cause and effect relationship of gene transmission from parent(s) to offspring and resulting genetic variation.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Developing and Using Models

Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

- Develop and use a model to describe phenomena. (MS-LS3-1),(MS-LS3-2)

Disciplinary Core Ideas

LS1.B: Growth and Development of Organisms

- Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. *(secondary to MS-LS3-2)*

LS3.A: Inheritance of Traits

- 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 specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits. (MS-LS3-1)
- Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. (MS-LS3-2)

LS3.B: Variation of Traits

- 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. (MS-LS3-2)
- 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. (MS-LS3-1)

Crosscutting Concepts

Cause and Effect

- Cause and effect relationships may be used to predict phenomena in natural systems. (MS-LS3-2)

Structure and Function

- Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function. (MS-LS3-1)

Connections to other DCIs in this grade-band: **MS.LS1.A** (MS-LS3-1); **MS.LS4.A** (MS-LS3-1)

Articulation across grade-bands: **3.LS3.A** (MS-LS3-1),(MS-LS3-2); **3.LS3.B** (MS-LS3-1),(MS-LS3-2); **HS.LS1.A** (MS-LS3-1); **HS.LS1.B** (MS-LS3-1),(MS-LS3-2); **HS.LS3.A** (MS-LS3-1),(MS-LS3-2); **HS.LS3-B** (MS-LS3-1),(MS-LS3-2)

Common Core State Standards Connections:

NGSS MS-LS3-2

- PE: Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation.
- DCI:LS1.B: Growth and Development of Organisms: Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. (secondary to 3-2)
- LS3.A: Inheritance of Traits: Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited.
- LS3.B: Variation of Traits: 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.

NGSS MS-LS3-2

- PE: Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation.
- SEP: Developing and Using Models: Develop and use a model to describe phenomena.
- CCC: Cause and Effect: Cause and effect relationships may be used to predict phenomena in natural systems.

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What would a 3-D assessment look like for this PE?

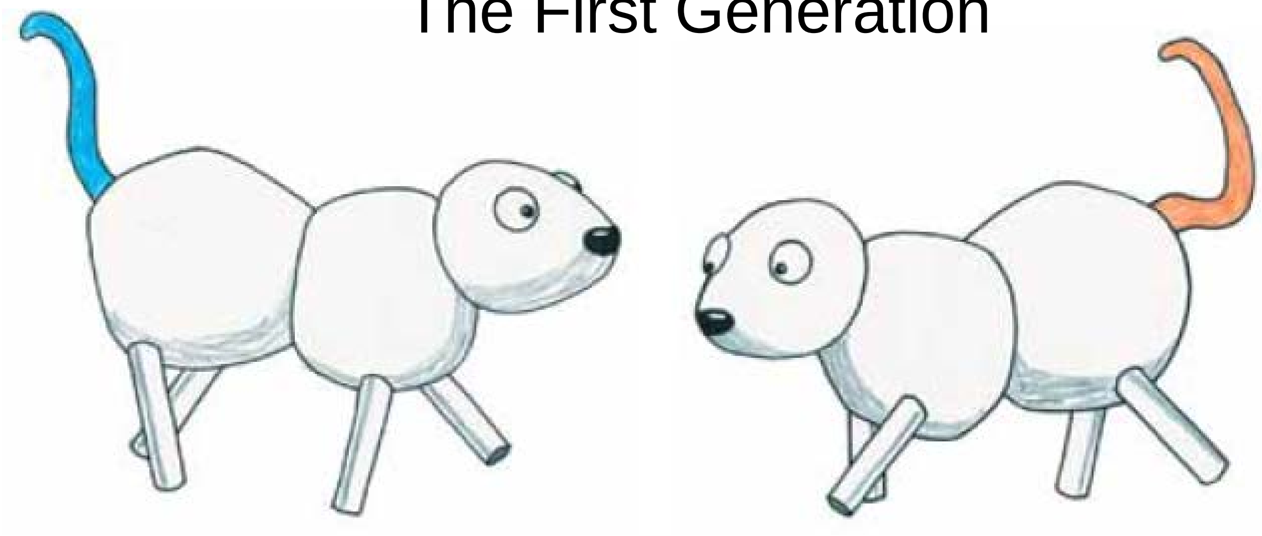
What question(s) or performance assessment(s) would you ask students to respond to?

What kind(s) of responses would you want students to produce?

Activity 2: Creature Features

- Previous (first) Activity in Unit:
  - Marfan Syndrome introduced.
  - Elicit students ideas about genetic conditions and other causes of health concerns (and clarify basic differences)
- Intro to this Activity:
  - Why do some brothers and/or sisters with the same parents not look alike?
  - Read the Introduction

The First Generation



Skye is a rare blue-tailed critter *Poppy is a rare orange-tailed critter.*

STOP TO THINK 1

Discuss this question with your group: What do you think the tails of Skye and Poppy's offspring will look like?

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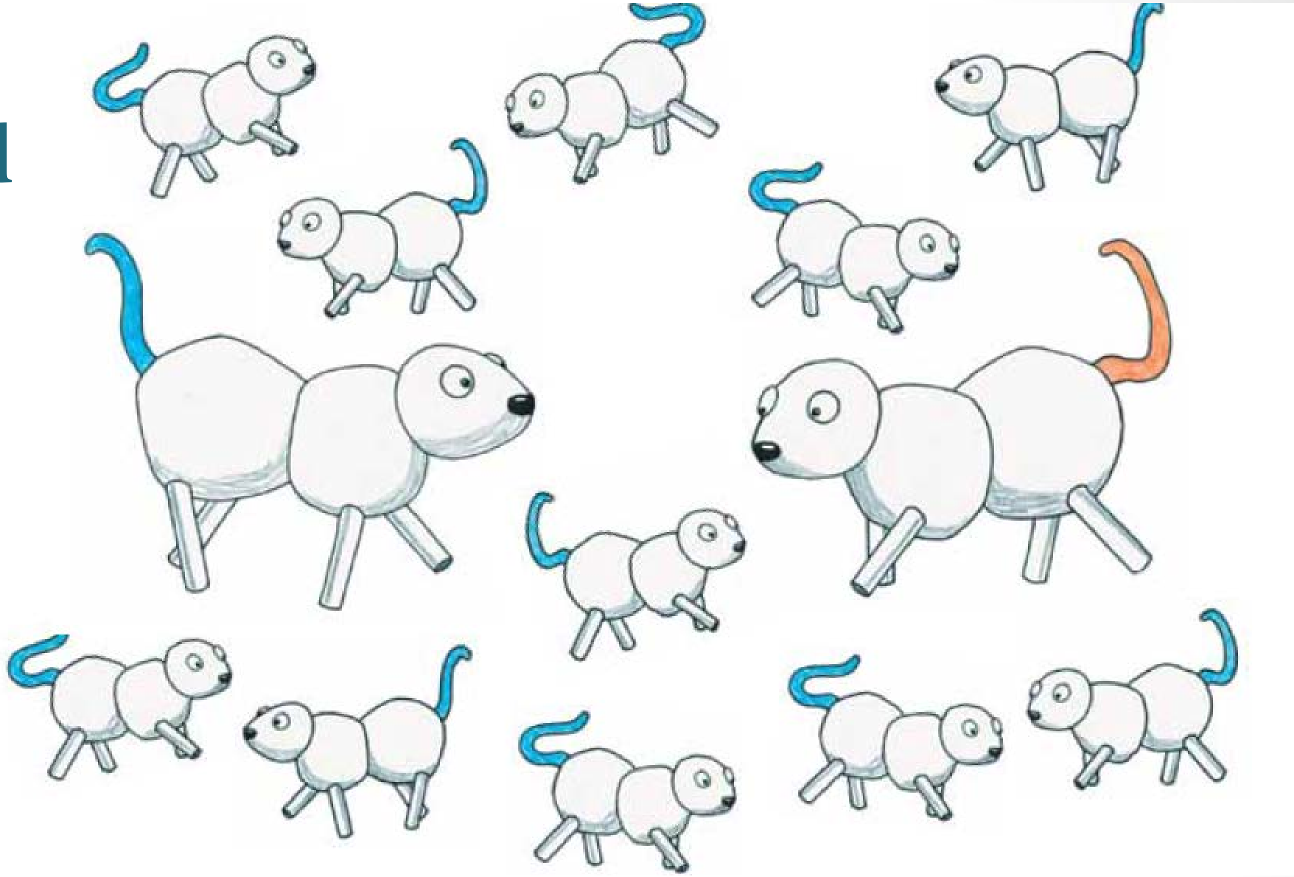
The Second Generation



STOP TO THINK 2

Discuss this question with your group: Why do all of the offspring have blue tails? Develop one or more hypotheses. Be prepared to share one of your hypotheses with the class.

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Alternative Hypotheses

After a lengthy discussion, the scientists decide that they have three different ideas for what happened when the blue- and orange-tailed critters were bred.

Hypothesis A:

Each critter pup got most of its tail-color genes from the parent with a blue tail and only a little genetic information from the parent with an orange tail.

Hypothesis B:

Each critter pup got all of its tail-color genes from the parent with the blue tail. (None came from the parent with the orange tail.)

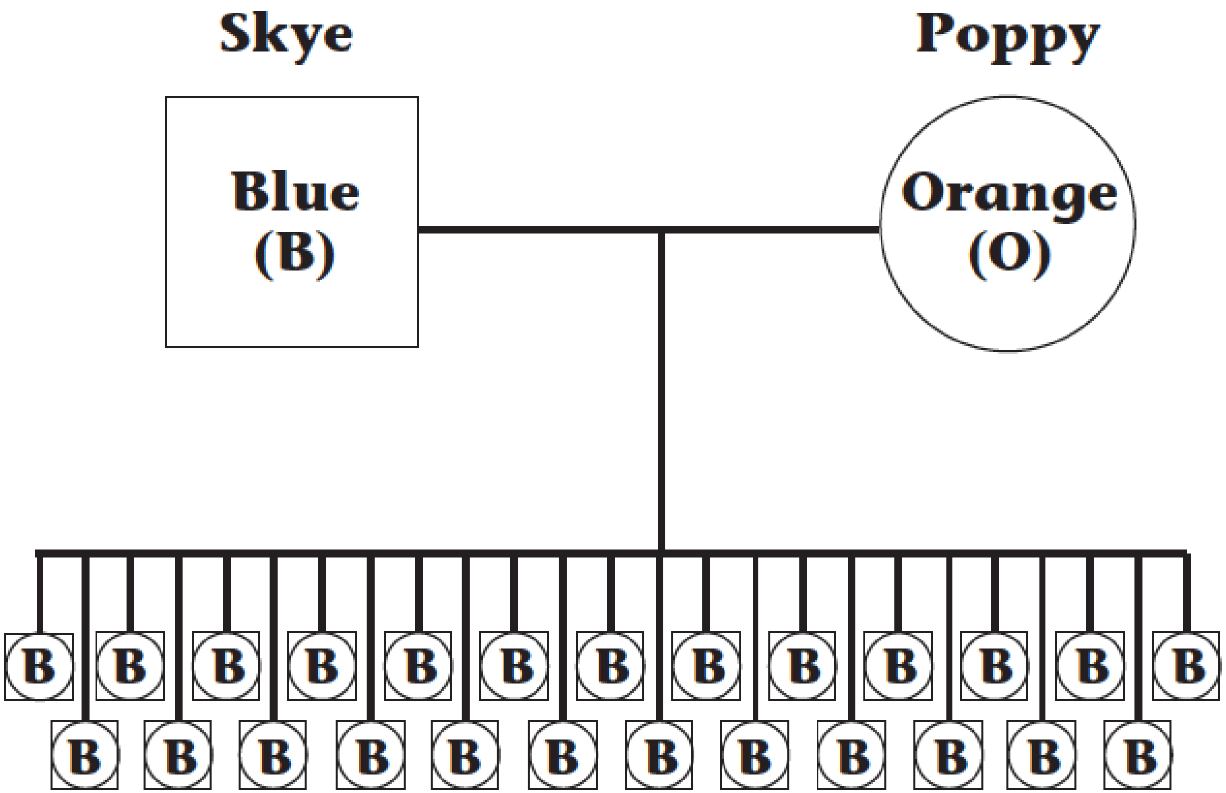
Hypothesis C:

Each critter pup got half of its tail-color information from each parent, but the information from the blue-tailed parent overwhelms the information from the orange-tailed parent.

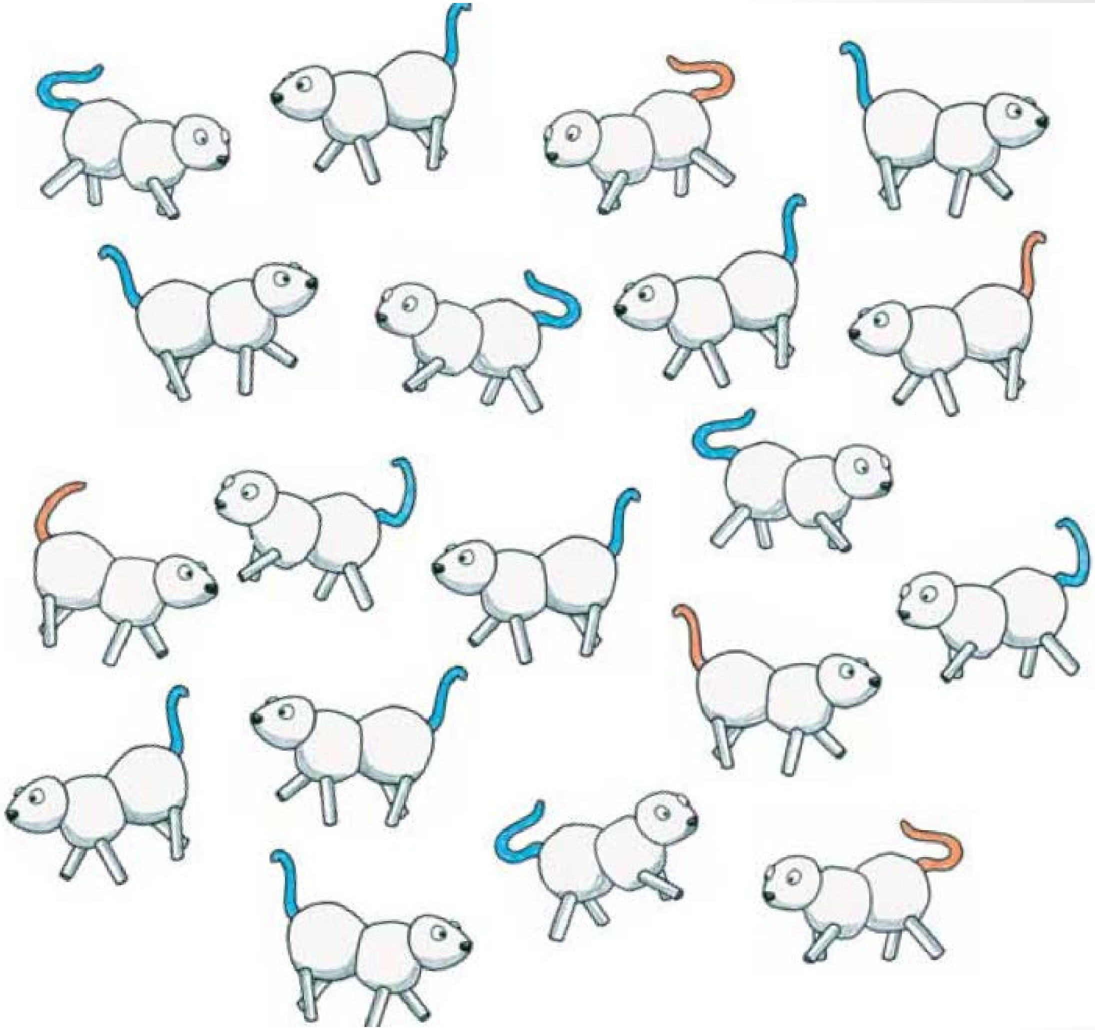
ANALYSIS

Discuss with your group: Which hypothesis is most like your original hypothesis? Explain.

Critters Breed 2



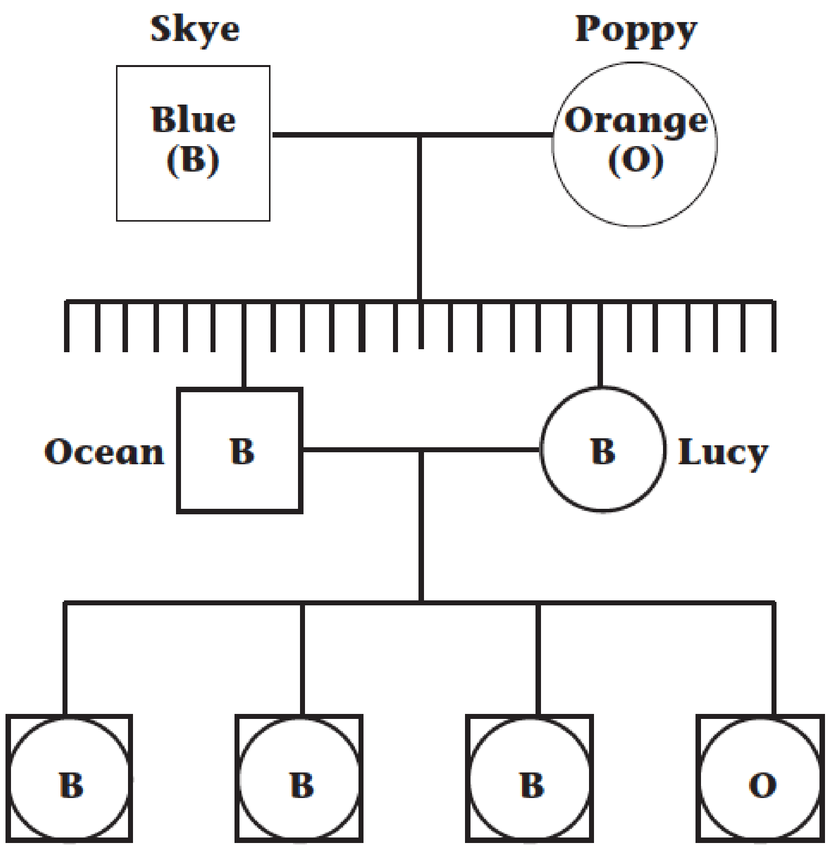
The Third Generation



STOP TO THINK 3

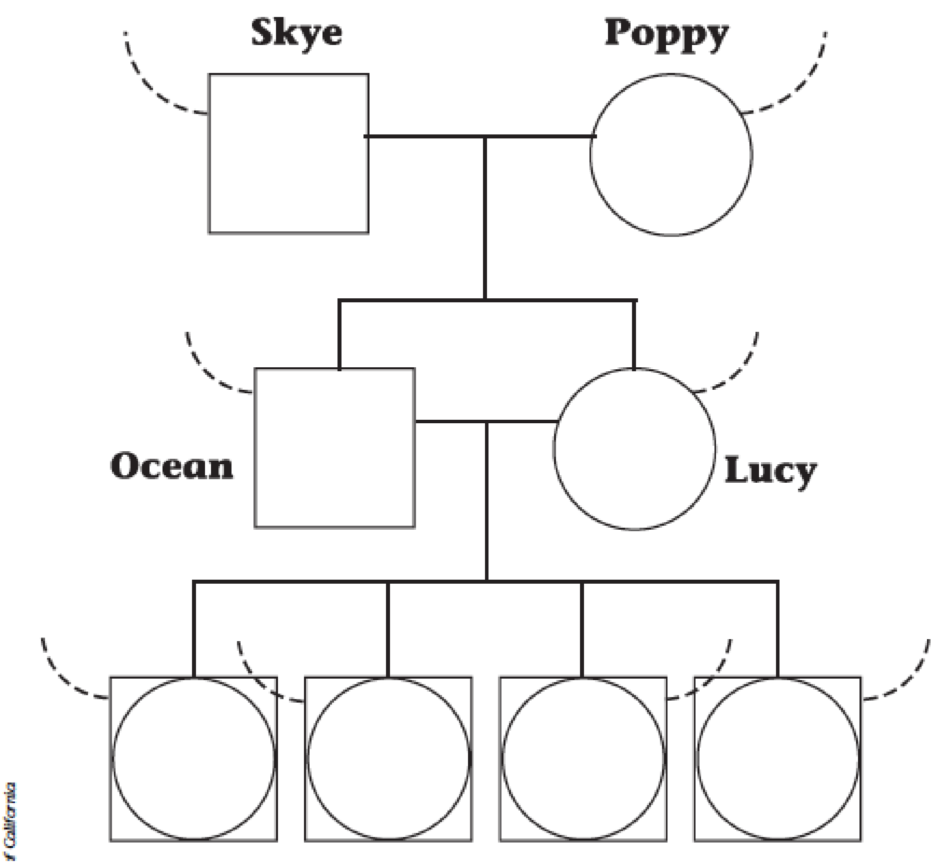
Discuss this question with your group: Does the evidence so far from the second and third generations help you decide which hypothesis or hypotheses might be correct? Explain.

Critters Breed 3



The ratio of blue-tailed to orange-tailed offspring is approximately 3:1

Critters Template



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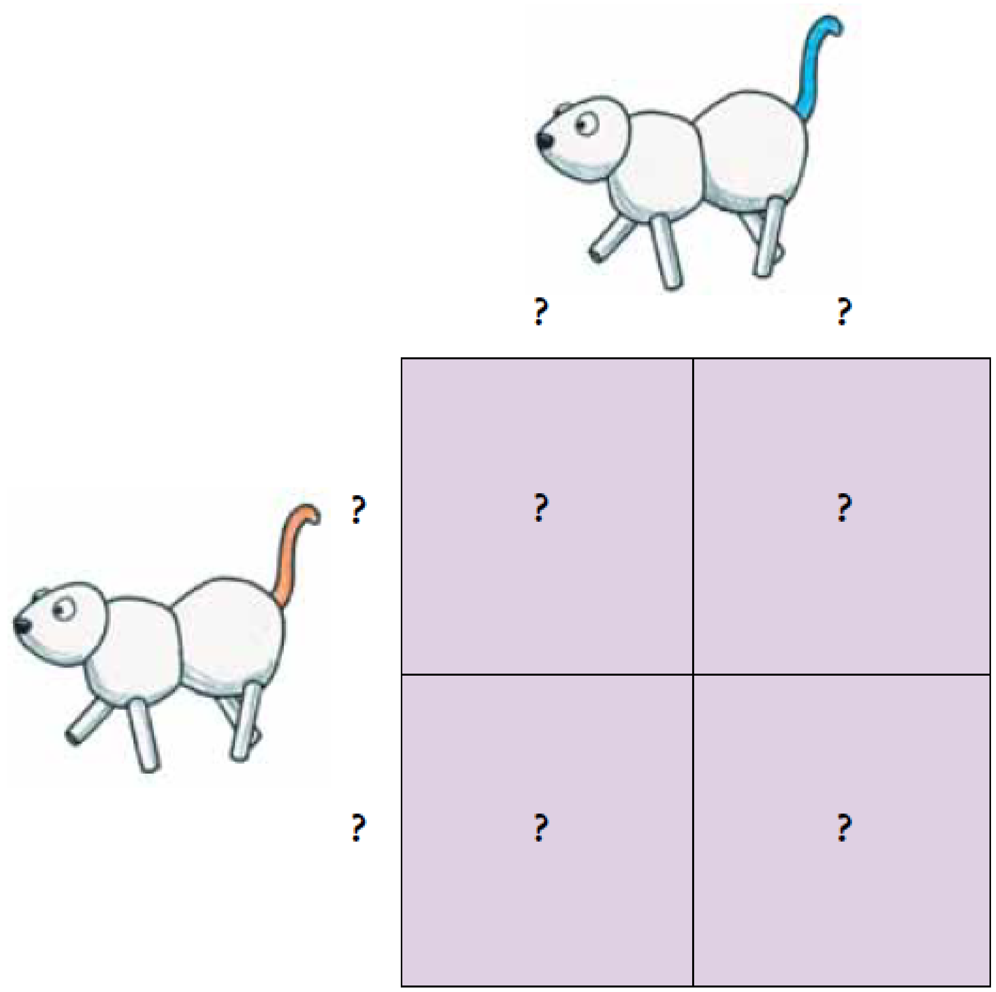
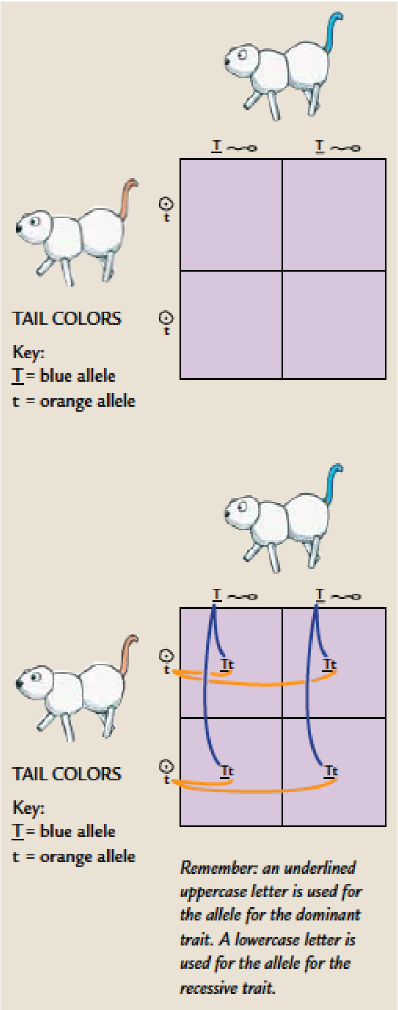
Punnett squares



Punnett squares and coin tosses



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Punnett squares model likely outcomes

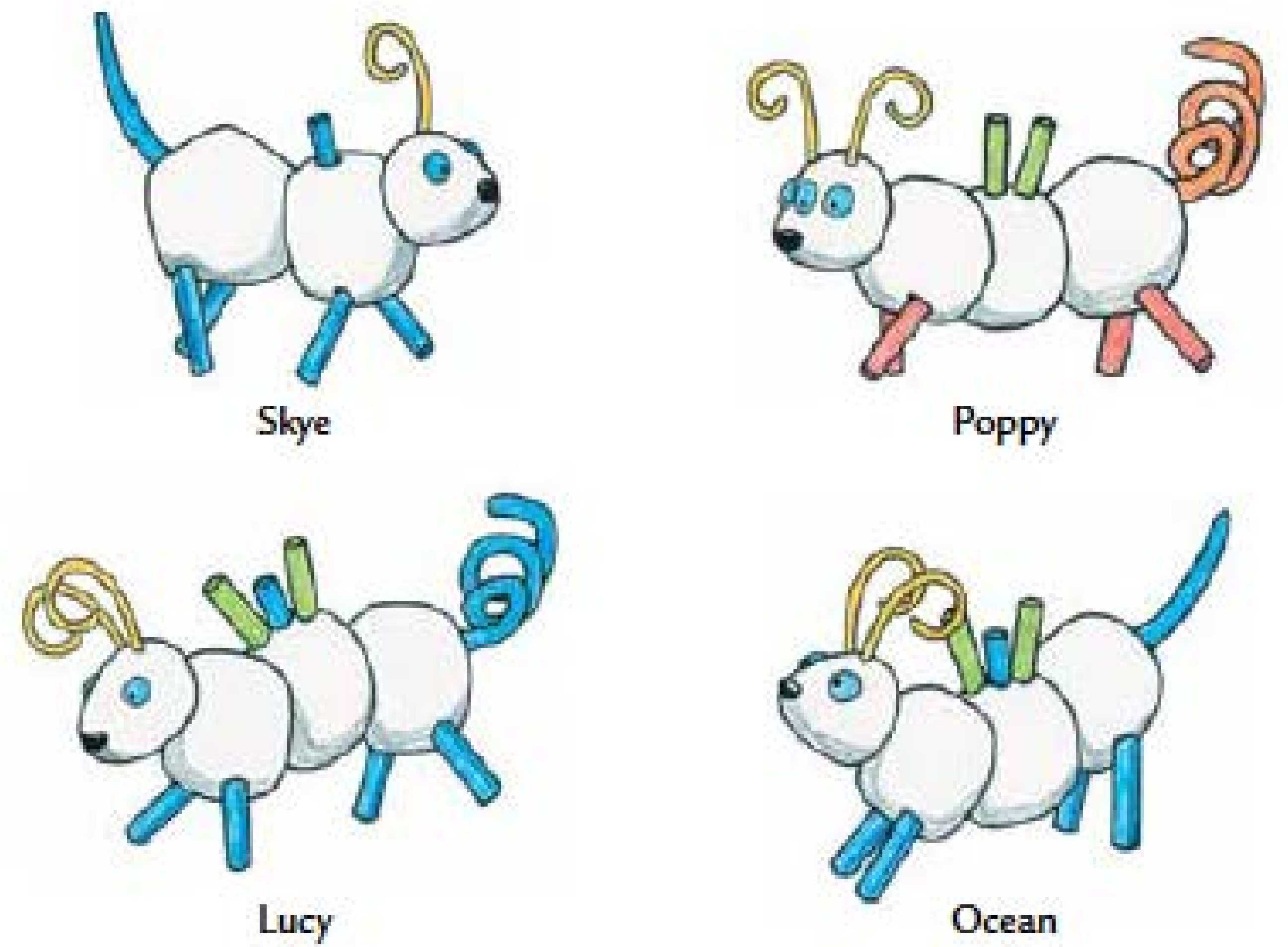
- How can we model actual outcomes of crosses?

How would the story be different if Skye and Poppy and their offspring could only reproduce asexually?

How would you change one of the models to show the difference in what happens at Generations 2 and 3?

There's more to the story

There's more to the story



Let's focus on two traits

- Tail Color: Blue or orange
- Leg Color: Blue or red

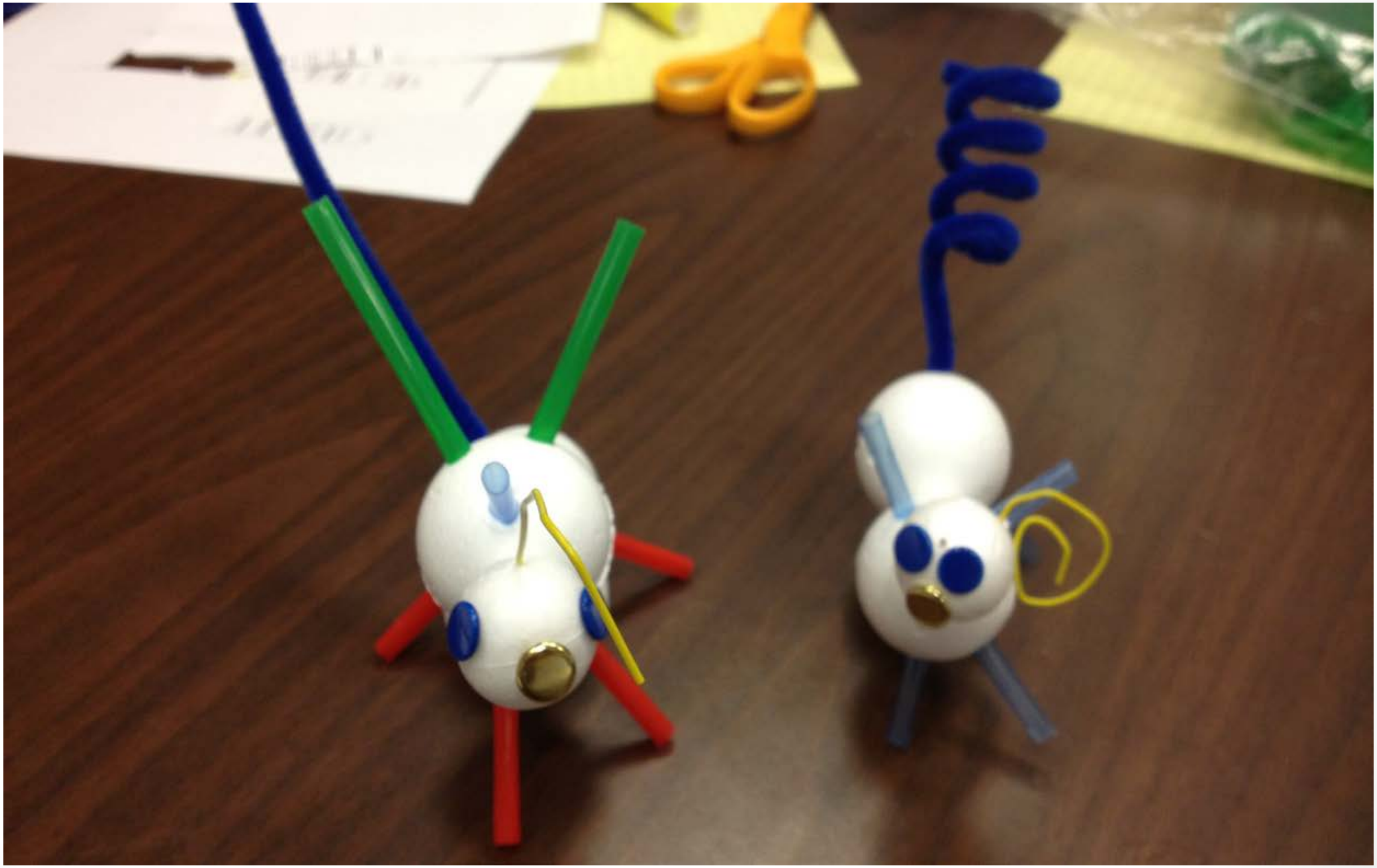
- Create a model to predict the possible appearances of the next generation offspring for tail and leg colors. How many variations are possible in Generation 1? In Generation 2?

Asexual reproduction

- What if Skye (blue tail and blue legs) and Poppy (orange tail and red legs) could only reproduce asexually? Create a model to explain the appearance of their second generation offspring. (Model can be physical or a diagram.)

- What causes the greater variation observed in the sexually reproduced offspring? Use your model to explain your answer.

Two variants produced by sexual reproduction



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What models have we used to understand the outcomes of sexual and asexual reproduction?

What additional learning experience and/or models are needed?

Summary

- In order for students to be successful on assessments that require development and use of models, they will need exposure to multiple models scientists use to describe phenomena.
- Modeling as a practice in genetics can be related to the cross-cutting concept of cause and effect, and models should be used whenever possible to predict likely results.
- Students should be involved in co-creation of models and have multiple opportunities to apply models to new situations.
- PE are assessment targets, not the curriculum. Curriculum should be guided by DCI and SEP and CCC that support learning.

Contact information

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