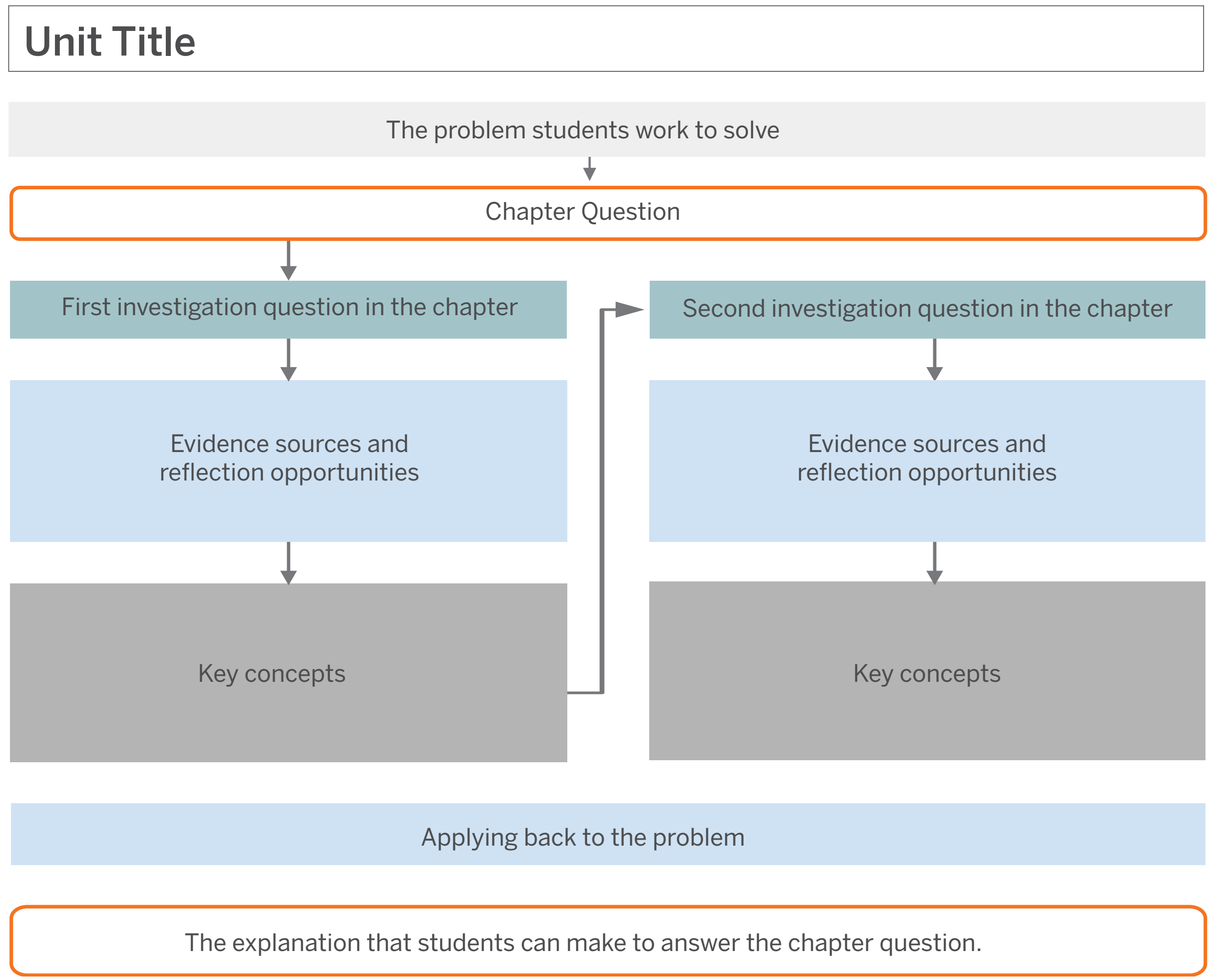
# *Traits and Reproduction* Coherence Flowchart

## The storyline of the unit

In each Amplify Science unit, students figure out a phenomenon by asking questions, gathering evidence, and coming up with an explanation of how the phenomenon works. The Coherence Flowchart visually represents the storyline of the unit, showing the coherent flow of questions, evidence, and ideas that support students as they build complex explanations of the unit's anchor phenomenon. The Coherence Flowchart on the following pages (one chapter per page) can be used to see the connections between the questions that drive students' experiences, the evidence they gather, the ideas they figure out, and the new questions that those ideas generate. The diagram to the right explains the structure of a chapter in the Coherence Flowchart.

Note: The Coherence Flowchart is a tool for teachers and is not meant to be distributed to students.

**Typical structure of one chapter in a Coherence Flowchart**




Instruction is framed by questions about the unit's anchor phenomenon and the related problem students are solving. Chapter Questions then guide students in figuring out the phenomenon, piece by piece. Within each chapter, Investigation Questions focus students on a manageable piece of content that will help them figure out the Chapter Question. Each question motivates activities, and each activity provides specific evidence related to the Investigation Question. Students synthesize the understanding constructed over multiple activities, and this understanding is formalized through key concepts. Often a key concept leads students to an additional Investigation Question students need to pursue to answer the Chapter Question. At the end of the chapter, students' new understanding is applied back to the unit's anchor phenomenon and leads students to a new Chapter Question or a final explanation.

AmplifyScience

# Traits and Reproduction: The Genetics of Spider Silk

**Problem students work to solve**

Why do Darwin's bark spider offspring have different silk flexibility traits even though they have the same parents?

**Chapter 1 Question**

Why do traits for silk flexibility vary within this family of Darwin's bark spiders?

**Investigation Question**

What determines an organism's traits at the molecular scale? (1.3-1.5)

**Evidence sources and reflection opportunities**

- Compare spider traits in the Sim (1.2)
- Read "Surprising Spider Silk" (1.3)
- Build physical models of spider silk protein molecules (1.3)
- Use the Sim to observe protein molecules of spiders with different traits for silk flexibility (1.4)

**Key concepts**

The function of a protein molecule depends on its structure and how it interacts with other protein molecules. (1.3)

Differences in the structure of protein molecules affect how they connect to other protein molecules. This can result in different traits. (1.4)

Organisms can have different proteins in their cells for a particular feature. (1.5)

**Application of key concepts to problem**

- Model what determines silk flexibility using the paper Modeling Tool (1.4)
- Use the Sim to make and test predictions about the effects of changing protein shapes (1.5)
- Discuss new evidence and claims (1.5)

**Explanation that students can make to answer the Chapter 1 Question**

The spiders in this family must have different proteins for silk flexibility in their cells. Variation in traits can be caused by variation in protein molecules within individuals' cells. Protein molecules' structures affect their function and the way they connect to other molecules. Spider silk is made of proteins, and connections between these molecules affect silk flexibility.

# Traits and Reproduction: The Genetics of Spider Silk

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|---|---|---|
| **Problem students work to solve** | Why do Darwin's bark spider offspring have different silk flexibility traits even though they have the same parents? | |
| **Chapter 2 Question** | Why do Darwin's bark spiders make different proteins for silk flexibility? | |
| **Investigation Questions** | How can organisms make different protein molecules for a particular feature? (2.1-2.2) | Why do some organisms make one type of protein for a feature and other organisms make two? (2.3-2.4) |
| **Evidence sources and reflection opportunities** | • Read "Hemophilia, Proteins, and Genes" (2.1)<br>• Investigate the role of genes by using instructions to build physical models of proteins (2.2) | • Use the Sim to gather evidence about the Investigation Question (2.3)<br>• Revisit "Hemophilia, Proteins, and Genes" (2.3) |
| **Key concepts** | • Genes are instructions for proteins. (2.2)<br>• Each gene version provides a unique instruction to make a specific protein molecule in an organism's cells. (2.2) | • An organism has two copies of a gene for each feature. (2.3)<br>• The two copies of a gene for each feature can be the same version (homozygous) and provide instructions for only one type of protein. (2.3)<br>• The two copies of a gene for each feature can be different versions (heterozygous) and provide instructions for two types of proteins. (2.3) |
| **Application of key concepts to problem** | • Model variation in spider offspring using the paper Modeling Tool (2.4) | |
| **Explanation that students can make to answer the Chapter 2 Question** | Genes are instructions for proteins; each gene version provides an instruction to make a specific protein molecule. An organism has two copies of a gene for each feature; these can be the same version (homozygous) or different (heterozygous). The spiders in the family have different gene versions for silk flexibility; some are homozygous and some are heterozygous. | |

# Traits and Reproduction: The Genetics of Spider Silk

**Problem students work to solve**

Why do Darwin's bark spider offspring have different silk flexibility traits even though they have the same parents?

**Chapter 3 Question**

Why do the Darwin's bark spider offspring have different gene combinations even though they have the same parents?

**Investigation Questions**

How do organisms get their genes? (3.1-3.2)

How does sexual reproduction result in variation among offspring? (3.3)

**Evidence sources and reflection opportunities**

- Read "Why Are Identical Twins Rare?" (3.1)
- Revisit "Why Are Identical Twins Rare?" (3.2)
- Observe gene inheritance in the Sim (3.2)

- Make and test predictions about offsprings' traits in the Sim (3.3)
- Use the paper Modeling Tool to show how siblings can have different combinations of gene versions for venom (3.3)

**Key concepts**

- Organisms inherit their genes through sexual reproduction. (3.2)
- Each parent randomly passes on one of its two copies of each gene to its offspring. Each offspring, therefore, receives two copies of each gene, one from each parent. (3.2)

- Through sexual reproduction, each offspring can inherit a different combination of gene versions. Therefore, siblings can have different traits from each other and even from their parents. (3.3)

**Application of key concepts to problem**

- Write an argument explaining why the spiders have different traits for silk flexibility (3.6)
- Breed spiders in the Sim to produce offspring with the trait for medium silk flexibility (3.6)

**Explanation that students can make to answer the Chapter 3 Question**

In sexual reproduction, each parent randomly passes on one of its two copies of each gene to its offspring. Each offspring receives two copies of each gene, one from each parent. Each offspring can inherit a different combination of gene versions, so siblings can have different traits from each other and from their parents. This random recombination of genes accounts for the variation in silk flexibility among the spider offspring. Each gene version present in the offspring is also present in the parents, meaning no mutations took place.

# Traits and Reproduction: The Genetics of Spider Silk

**Problem students work to solve and the Chapter 4 Question**

Why is Jackie an elite distance runner when no one else in her family has that trait?

**Application of key concepts to new problem**

- Analyze and sort evidence based on claims (4.1)
- Observe mutations in the Sim (4.1)
- Participate in the Science Seminar (4.2)
- Use the Reasoning Tool to connect the evidence to the claims (4.3)
- Write an argument to support a claim (4.3)

**Explanation that students can make to answer the Chapter 4 Question**

**One possible explanation students can make:**
Jackie's trait can be explained by a mutation in her genes which led to a new protein, resulting in the long-distance running trait. I think Jackie has either A1Am or A2Am gene versions. Jackie could play a long time without getting tired when she was very young, which means that her combination of gene versions must produce a protein that results in a trait for endurance. Jackie's father has A1A2 gene versions. I think Jackie's mom has A1A1 gene versions because she is a good sprinter. People who are good sprinters tend to have a lot of ACTN3 protein in their cells, which means that she could have two copies of the A1 gene version. This means that Jackie inherited at least one copy of the A1 gene version. However, people with one or two copies of the A1 gene version are usually not good long-distance runners. Only 28 (25 and 3) out of 100 total distance runners have an A1 gene copy. This endurance trait cannot be explained by the gene versions she would likely have inherited from her parents, so she must have a mutated gene version that produces a long-distance running protein. I don't think she has AmAm gene versions, however, because mutations are pretty rare. A mutation explains why Jackie is an elite long-distance runner when no one else in her family has this trait.