

# Genetics – Monohybrid

## Teacher's Guide

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### 1.0 Summary

The *Monohybrid* activity is the fifth core activity to be completed after *Mutations*. This activity contains four sections and the suggested time to complete the activity is 50-60 minutes. Time will vary with student ability.

### 2.0 Learning Goals

**Driving Question:** Do traits really skip generations?

*Monohybrid* focuses on the use of Pedigrees and links them to representations of gametes, meiosis, and fertilization. Students investigate models of inheritance while learning how to create and analyze Punnett squares and Pedigrees.

*Part One: Introduction to Pedigree* teaches students how to use Pedigree tools to create and analyze pedigrees.

*Part Two: Meiosis, Pedigrees and Punnett Squares, Oh My!* makes connections between independent assortment in meiosis, random selection in fertilization, predictions made with Punnett squares, and breeding experiments that use Pedigree tools.

*Part Three: Studying Patterns of Inheritance Using Pedigrees and Punnett Squares* guides student reasoning as they determine probabilities of inheritance.

*Part Four: An Inheritance Puzzle* requires students to put everything learned in the previous three parts together in order to solve a puzzle.

#### Learning Goals

- Students will learn how to create and use Punnett squares.
- Students will learn how to create and read a Pedigree chart.
- Students will compare and contrast Punnett Squares and Pedigree Charts.
- Students will predict possible phenotypes of dragon traits using Punnett Squares and Pedigrees.
- Students will understand that independent assortment in meiosis and random selection in fertilization are together responsible for genetic variation.
- Students will know that these are tools that geneticists use to identify the dominant and recessive patterns of traits in organisms.
- Students will know that breeding organisms for specific traits can produce desired phenotypes.
- Students will understand that the variety of phenotypes within a large number of offspring is the result of the breeding of two parents and of random selection at fertilization (sexual reproduction).
- Students will be able to use probabilities and Punnett squares to estimate the distribution of phenotypes among offspring of parents with known genotypes.

## Additional Teacher Background

In this activity, students will learn to create and interpret Punnett Squares and Pedigree Charts. It is important that they understand that in a Punnett Square for autosomal traits, it is impossible to determine the gender of the offspring; therefore, probability numbers are established for the possible outcome of all offspring, not gender specific. If they are using a Punnett Square to investigate a sex-linked trait, they should understand that the probability is that one-half of all offspring are male and one-half are female; therefore when they state the probability for an X-linked trait, they state the numbers based on gender.

A pedigree chart shows how a particular trait is transmitted through generations of a family. A pedigree chart uses symbols that represent the sex of each member; circles represent females and squares represent males. A key identifies the code for the trait being studied. A pedigree chart is used to understand how an inherited trait is expressed within a family. For example, some traits are sex-linked traits because their genes are part of either the X chromosome (most common) or the Y chromosome (uncommon). A pedigree chart allows the researcher to view the sex of the affected individuals within a family. It also shows patterns of dominant and recessive traits.

### 3.0 Standards Alignment

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

Objective	Standards
<b>Students will learn that gametes are randomly selected for fertilization.</b>	Students will understand basic concepts of probability.
<b>Students will examine the effect of random selection on the distribution of traits.</b>	Students will be able to use simulations to construct empirical probability distributions.
<b>Students will explore the use of Punnett squares for understanding the combinations of allele distribution.</b>	Students will understand and apply basic concepts of probability.
<b>Students will learn to make predictions using Punnett squares.</b>	Students will understand and apply basic concepts of probability.

## 4.0 Activity Sections

### 4.1 Table of Contents

This activity has 4 sections that should be done in order. The last is an assessment exercise.

Table of Contents	
<a href="#">1. Introduction to Pedigrees</a>	Learn the tools and tips for figuring out parental genotypes.
<a href="#">2. Meiosis, Pedigrees and Punnett Squares, Oh My!</a>	How do these representations help you model inheritance?
<a href="#">3. Studying Patterns of Inheritance Using Pedigrees and Punnett Squares</a>	Putting it all together!
<a href="#">4. An Inheritance Puzzle</a>	A chance to show what you've learned!

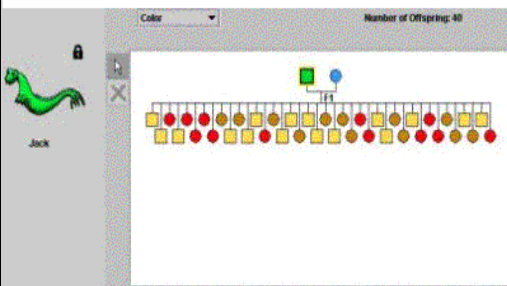
Table of Contents

### 4.2 Introduction to Pedigree

Students explore the Pedigree model, learn to use its tools and construct a key for dragon pedigrees.

**Welcome!**

**Introduction to Pedigrees**



Genetics is all about how offspring inherit traits from their parents. As you saw in Meiosis, the creation of gametes is a random process. Fertilization, also a random process, further ensures that each offspring inherits different chromosomes. This means that offspring may or may not look like their parents or their siblings.

In this activity, you will learn how to track traits through several generations of offspring as you learn to use pedigrees.

An advanced organizer for this section of the activity

Horns Number of Offspring: 0

Jill

You figured it out. A pedigree shows just one characteristic at a time. Right now you're looking at Horns - empty (white) circles and squares represent dragons without horns; filled-in (black) circles and squares represent dragons with horns.

*Click the Next arrow to start breeding dragons for the pedigree!*

Jill's pedigree indicates that she has horns. The student uses the Cross tool to breed Jill and Jack, producing 40 new dragons; the Horns characteristic is shown.

Horns Number of Offspring: 40

Jill

You just made 40 baby dragons! Did you notice that the offspring you made have a label? They're called the "F1 generation," meaning the direct descendants of the parents.

*Click the Next arrow to continue.*

Legs Number of Offspring: 40

dragon 2513

You are now looking at the pedigree for **Legs**. Notice that in addition to black and white circles and squares, there's a third option that's half black/half white. Click a few of the dragons in the pedigree to see what the corresponding dragon's legs look like.

Be sure to click all 3 types of representations, then fill in the key for Legs. When you are satisfied with your answers, click *Submit Answer*.

**5. Legs Key**

<input type="checkbox"/>	<input type="checkbox"/>	<input type="radio"/> No Legs	<input type="radio"/> Two Legs	<input type="radio"/> Four Legs
<input type="checkbox"/>	<input type="checkbox"/>	<input type="radio"/> No Legs	<input type="radio"/> Two Legs	<input type="radio"/> Four Legs
<input type="checkbox"/>	<input type="checkbox"/>	<input type="radio"/> No Legs	<input type="radio"/> Two Legs	<input type="radio"/> Four Legs

Students work through all dragon characteristics to produce a key for pedigrees; the Tail characteristic is shown.

Monohybrid.2 Student: pclifford1 ...Node: question1

Here is what all the different traits look like in the pedigree view.  
Squares represent males and circles represent females.

	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Horns</b>	No Horns	Horns	Horns		
<b>Wings</b>	No Wings	Wings	Wings		
<b>Legs</b>	No Legs	Four Legs	Two Legs		
<b>Tail</b>	Plain Tail	Fancy Tail			
<b>Fire</b>	No Fire	Fire			

6. How would you represent a female dragon with a fancy tail in a pedigree?

Key for all dragon characteristics

Horns

Number of Offspring: 40

No Horns     2 Horns

Jill

11. What do you think the F2 generation will look like?

All will have no horns.

All will have horns.

Some will have horns and some will not.

After investigating Jack and Jill's chromosomes, students are asked to predict how the next generation (F2) will look before they check their predictions out by making the F2 generation.

Horns

Number of Offspring: 80

No Horns     2 Horns

Jill

You just made 40 F2 offspring. 29 have horns and 11 don't. Use the Chromosome tool to figure out why, then answer the question below.

15. How can traits skip generations? Explain using the pedigree and what you know about the alleles of the parents and the first generation.

The hornless trait skipped the F1 generation because all of the F1 offspring are heterozygous and having horns is dominant. In the F2 generation some of the offspring got a recessive allele from both mom and dad.

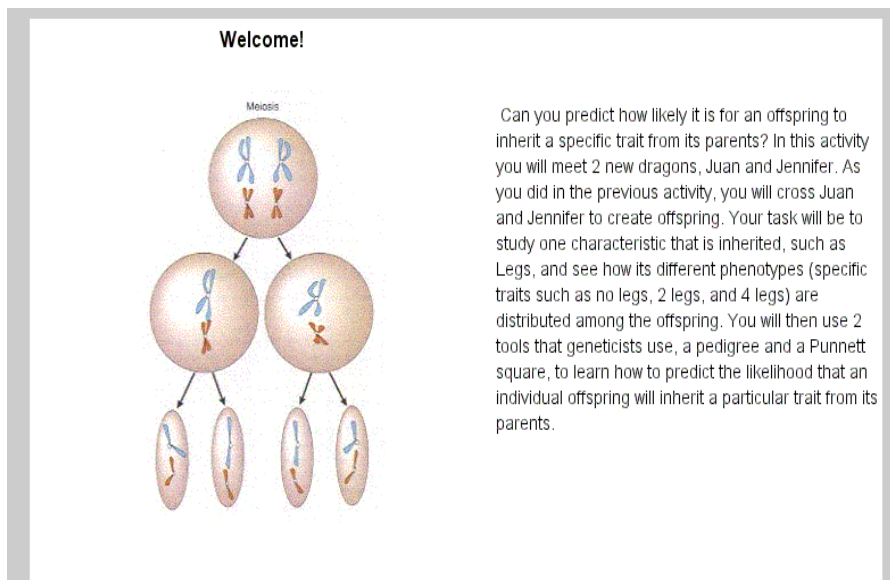
Submit Answer

Students are then asked to explain why traits appear to skip generations. Several additional questions are posed for students to answer.

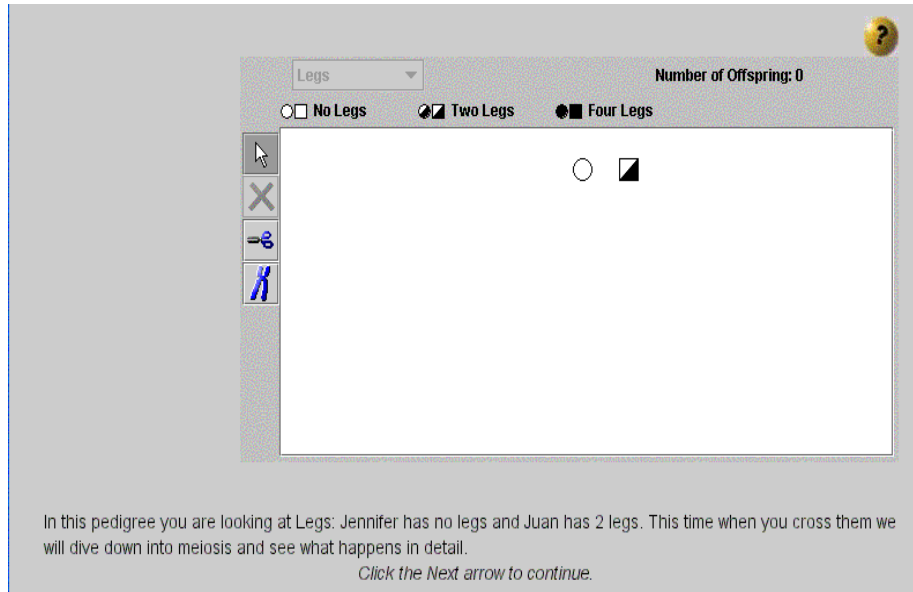
### 4.3 Meiosis, Pedigrees and Punnett Squares, Oh My!

This activity introduces students to Juan and Jennifer. Students predict how certain traits are passed from parent to offspring by crossing the gametes of Juan and Jennifer. Through use of the Model, they will visualize the inheritance patterns produced by these crosses.

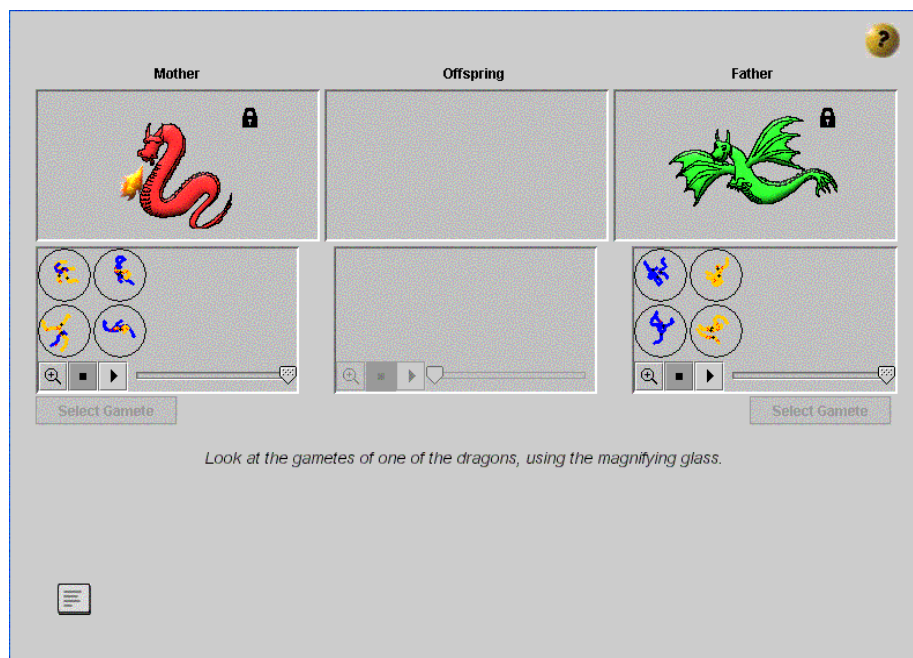
- Step 1 Make a cross of the dragons using the X tool.
- Step 2: Run meiosis.
- Step 3: Look at the gametes of one of the dragons using the magnifying glass and answer the questions regarding the traits for legs.
- Step 4: Run fertilization and answer the questions.
- Step 5: Try It: select the gametes and run the fertilization, see what happens.
- Step 6: Answer the questions.
- Step 7: Be introduced to Punnett Squares; practice what you learned.
- Step 8: Click to fill in the Punnett Squares for the trait of legs in the following screens and answer the questions.
- Step 9: Compare predictions of Punnett Squares with offspring in Pedigree Charts.
- Step 10: Click on Juan and Jennifer to see their chromosomes, find the alleles for tails, and note the genotype for both dragons.
- Step 11: Fill out a Punnett Square using the Genotypes (Tt x tt)
- Step 11: Answer a series of questions that relate to heterozygous and homozygous traits. Use the information obtained from the Models.
- Step 12: Compare and Contrast Punnett Square and Pedigree Charts
- Step 13: Made it Through; Review and Summary



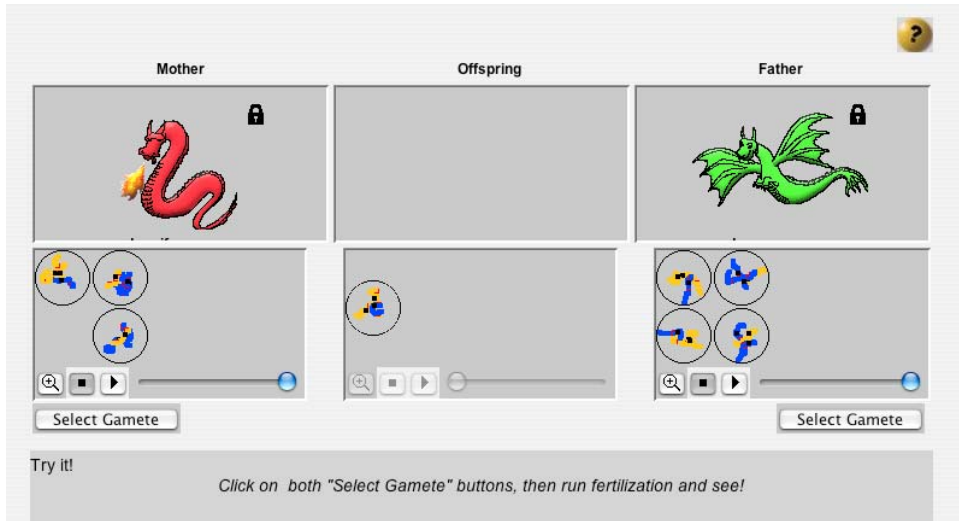
Meiosis Introduction



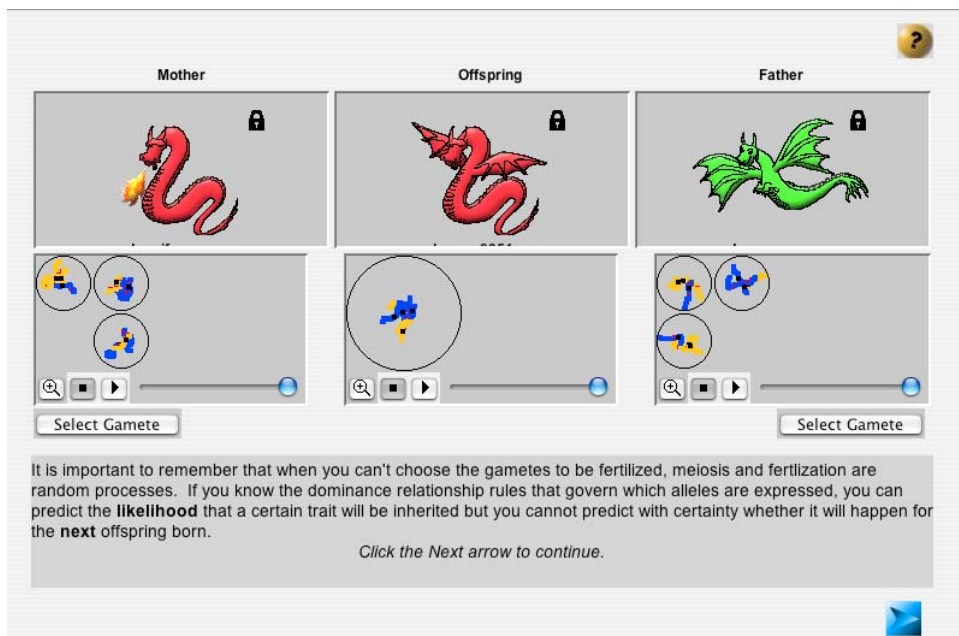
Use the Cross tool (X) to breed the parents.



Use the magnifying glass to examine the gametes of Juan and Jennifer, and then answer the questions.



Gametes are selected randomly with the Select Gamete button.



Random processes and probabilities are linked.

Legs Number of Offspring: 1

No Legs  Two Legs  Four Legs

Here are the same mother and father dragons you had before, Juan and Jennifer, and the baby that was born after running meiosis and fertilization.

24. If you were to use the Cross tool again to produce 40 babies, which of the following possibilities do you think will happen?

- All the offspring will have no legs, like their mother.
- Some of the offspring will have no legs and some will have 2 legs.
- All of the offspring will have 2 legs, like their father.
- The offspring will come in all varieties: no legs, 2 legs, and 4 legs.

Submit Answer

Before being introduced to the Punnett square students are asked to predict and explain what they think will happen when there are lots of offspring. Students are shown how to complete a Punnett square and make predictions about the proportions of offspring with particular traits.

And finally, we copy each of Jennifer's Legs alleles from the boxes on the left to the boxes on their right that represent the offspring's alleles. So each inner box gets 2 alleles, one from the father and one from the mother.

*Click "Next" to continue.*

Juan

Jennifer

Punnett Square

Legs Number of Offspring: 41

No Legs    Two Legs    Four Legs

There you go - 40 new babies! The Punnett square predicted half of the offspring (about 20 - 21 of them) would have no legs and about the same number would have 2 legs.

27. Compare the prediction of the Punnett square with the outcome of the cross in pedigree. Describe the differences and similarities.

The predictions were different. The Punnett Square was almost a 50/50 ration but the pedigree has only 15 out of 41 offspring with no legs.

**Submit Answer**

Pedigree Chart showing the Legs characteristic

Note: Because BioLogica randomly generates each new cross, there is considerable variability in the numbers of offspring with the different traits. In later sections we deal with proportions that differ from what is predicted by the Punnett square.

These are the same parent dragons you have been working with, Juan and Jennifer. If you click one of them, you can see its chromosomes.

Write the alleles for Tail for each of the dragons in the spaces provided, across the top and down the left side of the Punnett square. Then click "Next."

Students practice completing Punnett squares and receive feedback.

?

	T	t
t	Tt	tt
t	Tt	tt

Good! As you see, 2 of the boxes in the Punnett square correspond to offspring with fancy tails - the other 2 correspond to offspring with plain tails. So, of the 4 possible combinations of alleles from each parent, half will give rise to a plain-tailed baby and half will give rise to a fancy-tailed baby. That's what the Punnett square is telling you. In other words, only two phenotypes (plain tail or fancy tail) are possible when you cross these parents AND they are equally likely to appear.

29. Can a Punnett square tell you whether the next baby produced by Jennifer and Juan will have a fancy tail or a plain tail? Why or why not?

No, it can only provide probability .

Submit Answer

Students answer several multiple choice and completion questions, as well as higher order questions that require a thoughtful response.

Congratulations!

You learned to use pedigrees and Punnett squares, 2 very powerful tools that have helped geneticists figure out a lot about the inheritance of characteristics long before they had proof that chromosomes and genes exist.

You began to explore the difference between predicting possible phenotypes (specific traits) and predicting the probabilities that they will occur in large numbers of offspring. You learned that the randomness of meiosis and fertilization is responsible for the differences you observed in pedigrees and Punnett squares.

In [Studying Patterns of Inheritance](#) you'll learn more about how geneticists use pedigrees and Punnett squares to reason about dominant and recessive traits and their inheritance.

Done

Summary Screen

#### 4.4 Studying Patterns of Inheritance Using Pedigrees And Punnett Squares

In this activity, students will put into practice what they learned in the previous activities, with particular emphasis on predictions and probability.

- Step 1: Click to view the dragons' chromosomes.
- Step 2: Cross dragons using Cross (X) tool.
- Step 3: Notice the dominant traits in the pedigree chart and answer the questions.
- Step 4: Continue with new parents and varying traits.
- Step 5: Answer probability questions.
- Step 6: Explanation and questions screens complete this activity.

Welcome! Introduction

In this activity you'll explore the offspring phenotypes that are possible from a given cross and the probability that the different phenotypes will occur in the offspring.

Exploring Offspring Phenotypes

George

Lucinda

L	Ll	Ll
l	Ll	ll

The alleles of the parents are correct, but the offspring alleles are not. Check to be sure you have entered the correct allele from each parent in the inner boxes.

Punnett square showing George and Lucinda's genotypes for legs: both are heterozygous. Notice that the upper-left cell of the Punnett Square is incorrect (should be LL). Students have a chance to self-correct, but BioLogica will correct them if they are unable to rectify their mistake.

Legs: No Legs Two Legs Four Legs

Number of Offspring: 60

You said that about one-half (30) of the offspring will have 2 legs.. This cross produced 15 offspring with no legs, 31 offspring with 2 legs, and 14 offspring with 4 legs.

39. Does your answer agree?

Yes  No

Submit Answer

After making predictions based on the Punnett squares they completed, students cross George and Lucinda to see how close their prediction was to the actual outcome.

Legs: No Legs Two Legs Four Legs

Number of Offspring: 40

Romeo

Congratulations! You changed the alleles of one parent to "I" so that all of the offspring inherited a big "L" from one parent and a little "I" from the other resulting in only 2-legged offspring.

In the task that concludes this section students must change the alleles of one of the parents in order to produce offspring that are all heterozygous for Legs, shown above.

Note: Once you have crossed the parents you cannot change their alleles. If students don't succeed initially, they must use the scissor tool to snip out all the offspring before changing the parent's allele. Parents must be homozygous, one LL and the other ll, to produce offspring with only 2 legs.

## 4.5 An Inheritance Puzzle

This section returns to the original focus question: "How can a trait skip a generation?" It challenges students to set up the parents' alleles with a trait of their choosing and demonstrate under what conditions it is possible.

Welcome!

### Introduction to Inheritance Puzzle

In your investigations so far, you've seen cases where traits of both parents occur among their offspring and among their grandchildren. You've also studied traits that skip generations in certain circumstances. Now we have a challenge for you.

Introduction

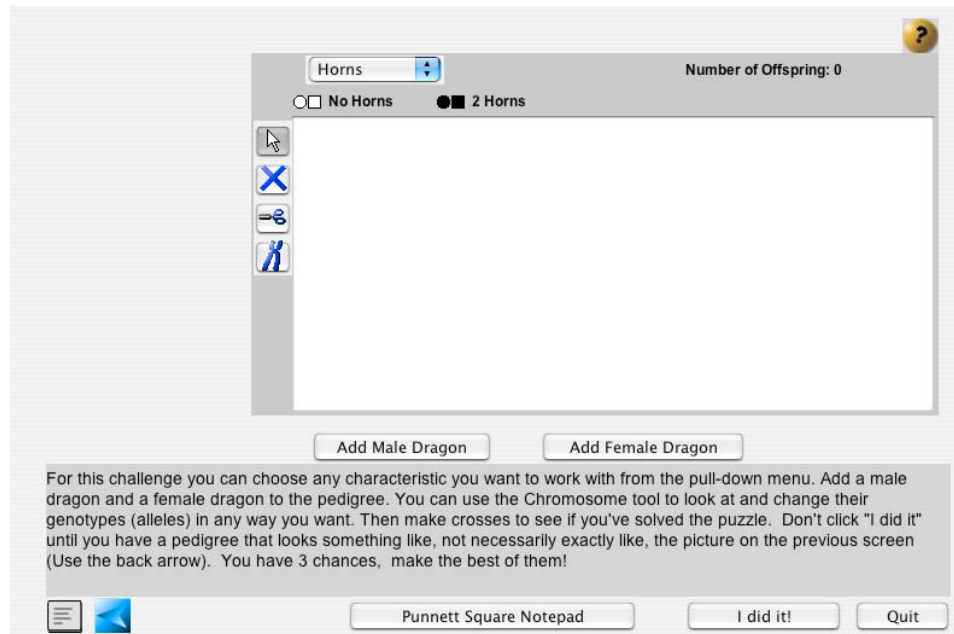
Create a cross between two dragons that demonstrates how traits can skip a generation. The cross must satisfy the following conditions:

1. One parent has a particular trait (like wings) while the other parent does not (no wings).
2. When you cross the parents, all of the offspring (the F1 generation) look like one of the parents.
3. When you cross two offspring to create the F2 generation, some of the F2 generation should look like the grandmother and some should look like the grandfather for the characteristic you've chosen.

The successful pedigree will look something like the one shown above.  
Are you ready?

*Click Next*

Rules of the game



First step in the puzzle.

Add a male and female dragon.

Use the Chromosome tool to view and change alleles.

Use the Cross (X) tool to breed them.

Use the Scissor tool to delete all the offspring and start again.

Use the Punnett square pad to check out allele combinations anytime.

Students' entries in the Punnett square are not checked or corrected.

Students have three tries to solve the problem.

Note: Once you have crossed the parents you cannot change their alleles. If students don't succeed initially, they must use the scissor tool to snip out all the offspring before changing the parent's allele.

Parent dragons must each be homozygous for a trait. This will create an F2 generation that is heterozygous for a particular trait.

Once students have completed the puzzle, they are asked to describe how they did so and which completed Punnett squares for each generation can be used to explain their results.

## 5.0 Student Reports

Your students' work with *Monohybrid* 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 *X-Linkage*, which focuses on the inheritance of traits on the X chromosome using breeding experiments and pedigree analysis learned in *Monohybrid*.