Instructional Sequence
Module 2—Genetics

RoboRiot is a digital game that addresses common misconceptions about Genetics. The game can help students visualize a number of difficult concepts related to randomness, dominant and recessive alleles, and inherited traits.

This instructional sequence provides: resources to help you link the game to your teaching unit; a PowerPoint presentation; several linking activities; discussion questions; and "quick writes." It also indicates optimal times for you to make links between the game and the content of your lessons.

Gameplay: Introductory Exploration

Give students ample time to explore the game before you begin your instructional unit. Pre-assign the game as homework for two days before you begin your genetics instruction. Students should play the game for at least 30 minutes, and think about the following questions as they play.

- What determines a particular type of bot? For example, what makes a water bot a water bot?
- How did you decide what bots to assemble for your team?

On the first day back in class after your students have played the game as homework, begin the class with a Quick Write. Give students 10–15 minutes to answer the questions above. Collect their written responses, and have a brief (5-minute) conversation about their answers.

[Notes for the Teacher:
This game focuses on two concepts, randomness and dominance, which have proven to be problematic for most middle-grades students. The following are some typical misconceptions about randomness.

- **An event or a number is "due**." In a random selection of numbers, the roll of a die, or a coin toss, since all numbers will eventually appear, those that have not come up yet are "due," and thus more likely to come up soon. Truly random processes such as these do not have memory, making it impossible for past outcomes to affect future outcomes.
- **Randomness means anything can happen, and all possibilities are equally likely.** People often think randomness means the outcome is completely open-ended, but you can't roll a 7 on a 6-sided

die, nor draw a red marble from a bag of blue ones. Even random processes function according to rules.

The following are typical misconceptions about dominance.

- **Dominant alleles (parts of genes) are generally the most frequently occurring alleles in a population.**
- **Dominant genes are the most desirable ones.**

The word "dominant" in layman's terms leads to these misconceptions. In genetics, dominance refers to the expression of an allele <u>within an individual organism</u>. The expression of an allele—whether dominant or recessive—that is selected for by the environment is the most desirable. Prevalence in the population is determined by fitness and natural selection.]

Classroom Instruction: Genetics

Implement your unit as usual, including the usual hands-on activities, video clips, and reading and writing assignments. Instruction should include concepts about randomness, chromosomes, genes, traits, Mendelian genetics, dominant and recessive alleles, and Punnet squares.

The PowerPoint (PPT) included here will serve as a complement to your genetics instruction. Review the entire PPT beforehand and decide how you want to use it. You may wish to use the entire PPT as an introduction to instruction, or as a review after instruction. You may prefer to pause the PPT after certain slides to ask questions, or you may wish to use just some of the slides to cover a particular concept.

After your students have viewed the genetics PowerPoint, you can introduce the *RoboRiot* Workbook, below.

***RoboRiot* Workbook**

This paper-and-pencil activity will help students reflect on their understanding about dominance and randomness. The activity "When They Meet, Who Wins?" parallels students' experience in the digital game where they assemble a team of bots to battle the infected bots. Students re-examine the concept of dominance as they revisit which bot wins, loses, or draws against another bot. Working in a grid that organizes their matches, students create the bot population. *This activity is carefully scaffolded to help students observe that dominance refers to the expression of an allele within an individual organism and not that dominant alleles are generally the most frequently occurring alleles in a population.*

The concept of randomness is also at play here. *Students often think that randomness means anything can happen, and all possibilities are equally likely.* This activity reinforces the idea that even random processes function according to rules. There are rules about which robot can defeat another robot.

Activity: When They Meet, Who Wins?

The activity has four parts. In Part A, students sort out which of the different kinds of robots wins or draws against each of the other kinds of robots. Students are given a grid to manage their matches.

[WHERE ARE THESE GRIDS? Where's the Answer Key?]

There are two grids, one that is blank that students fill out for themselves and one that already has a sample sequence filled in. The sample sequence is *not* a model for how students should organize the blank grid, it is just an example. Select the grid that will best challenge your students.

An answer key for the sample sequence is provided. There is no answer key provided for the blank grid. Since students' sequences will vary, there are several possible correct match configurations. *If you choose to use the empty grid, be sure to emphasize that students must write the robot names in the same order down the first column and across the first row.* It is a good idea for you to try this activity yourself before giving it to your students.

Directions: Students should compare the robots named in the first column one by one with the robots named in the first row and write the name of the robot that wins each match-up in the box where the two names intersect. If the two robots are equally matched, students should put an equal sign (=) in the box. Once the grid is complete, students work on Part B to tally the total number of wins for each type of robot and record that number in the table at the right of the grid.

After students have completed the grid and have tallied the total number of wins for each kind of robot, ask the following questions.

1. Is there any one robot that always wins the match?
2. Which robot wins the most matches? Why do you think that happens?
3. Is there more of that kind of robot than the other kinds of robots?
4. What do you think determines that one robot can defeat another robot?

These questions should help students recognize that the robot that wins the most matches does not win because there are a greater number of these kinds of robots or that this robot is "stronger" than the other kinds of robots. There is an equal number of each kind of robots, and this robot—with the greatest number of wins—loses when put against some of the other robots (e.g. waterbot versus icebot).

Next, in Part C, students create four sequences of robots, arranging them according to a robot that is stronger or equal to another robot. Here too there are several possible answers, since robots that are weak against some robots are strong against others. This part of the activity reinforces the idea that *the expression of an allele—whether dominant or recessive—that is selected for by the environment is the most desirable.*

Ask five students to share one of their sequences by putting them on the board. Give the class some time to review the sequences and to write down any questions they have about them.

Ask the following questions.

1. Did any of you have the same sequence as one of the sequences on the board?
2. How did you decide to create your sequence?
3. Why did you begin with that particular robot?
4. Did anyone begin with the same robot but have a different sequence?
5. How can you explain that there can be several different sequences?

Conclude by asking students:

1. What does the word "dominant" mean?
2. Do we use it the same way or differently when we talk about genetics?
3. Write the sentence, "Chance has no memory" on the board. Ask students to explain what the sentence means.

Most genetics units address the concept of randomness early on. Before introducing this concept, and to determine what students understand about this idea, use the following Crash Cars flash application as a formative assessment.

http://cct2.edc.org/rubyrealm/trafficgame/act1/bin/bin/Mod2Flash.html
THIS URL DOES NOT WORK
Explain to students that this animation shows the paths that two cars can travel along a road. Depending on the route each takes, the cars will pass each other or will crash into each other. Show students the flash screen and point out the various parts. Show them that there is a place to schedule the number of trips, and that on the left side there is a counter that automatically keeps track of the number trips taken, as well as the number of safe trips and the number of crashes.

Next, demonstrate how the flash works. Put the number 1 in the "schedule number of trips" box. Now, reset the flash and put the number 3 in the "schedule number of trips" box. Show students how the number of trips, the number of safe trips, and the number of crashes are automatically tallied.

Point out the bottom of the screen, where it says "count": They see X's and O's. The X's represent crashes and the O's represent safe trips.

Ask students if they have any questions about how the flash works.

Tell students that their task is to predict how many safe trips versus crashes the cars will have during a certain number of trips. Begin by asking:

- How many safe trips versus crashes do you think will occur if there are 10 trips? Why do you think so?
- Does everyone agree? Why or why not?

Run the flash to show students the outcome.

Now ask:

- What do you think will happen if you schedule 30 trips? Why do you think so?
- Does everyone agree? Why or why not?

Run the flash to show students the outcome.

Conduct a discussion about what students think is happening. Ask:

- Was your prediction accurate? If not, why not?

At this point students may not be sure about what is happening. Refrain from giving students any instruction about the flash outcomes.

Continue by grouping students into pairs and having each pair pick a number of scheduled trips. Write each pair's number on the board and ask everyone to make a prediction of the number of safe trips versus crashes for each.

Ask students:

- How did you come up with your prediction?
- Why do you think your prediction is a good one?

Explain that you won't be able to try each pair's choice for the number of scheduled trips, but that you will try several of them. Select 5 to 6 numbers of scheduled trips and run the flash. Have student pairs write down the outcome of each of the trials.

Ask:

- Did anything surprise you? Why?

Now have them think about the rest of the choices for which you did not run the flash. Ask students to consider if they would change their predictions. Have pairs discuss their ideas, and then hold a whole-group discussion about their thinking.

Ask:

- Who would change his/her prediction? Why did you decide to change it?
- Who would keep his/her prediction? Why did you decide to keep it?

Finish by showing students the randomness PowerPoint.

Once students are familiar with concept of randomness, the following linking activity can help them make connections between your instruction and the game.

Linking Activity 1: Random Drawing Game

In the Random Drawing Game, students confront the idea that randomness means anything can happen, that all possibilities are equally likely, and that in random processes each outcome is independent of the previous outcomes.

You will need

- Empty tissue boxes—enough so every group of 3 or 4 students can have one box
- Plain card stock cut into 1-inch by 1-inch squares—enough so every group can have 21 small squares

Procedure

Divide the class into groups of 3 or 4 students each. Each group gets an empty tissue box and a set of 21 squares ("tickets") cut from the card stock.
Have the students write a number on each square as follows: one 1, two 2's, three 3's, four 4's, five 5's, and six 6's. Each group places all 21 of their numbered squares in their box.
Next, ask students the following question and have them write down their predictions.

- What will be the outcome, if we draw one ticket from the box?
- Since there are more 6's than any other number, does this mean it is more likely that 6 will be picked, if we draw just one ticket from the box?

Have each group of students draw one ticket from their box.
Ask:

- What was the outcome?
- How many groups got a 6 with this first draw?

Remind students to return the ticket they've just drawn to the box. Every time they draw a ticket, they should be drawing from the full box of 21 tickets.

Have students draw one ticket 10 times, then 20 times, and then 30 times (returning the drawn ticket to the box each time, before drawing again). Have them record their draws in a data table that you give them, or have them create their own data table to ensure that each draw is properly recorded.
Ask:

- What is the outcome when you draw one ticket 10 times from the box?
- What is the outcome when you draw 20 times?
- What is the outcome when you draw 30 times?
- Which number did you pick the most?
- Which number was picked the least?
- Did the outcome change with an increase in the number of draws? If yes, how?
- Even though each group started with the same numbers, did they end with the same outcome? How was their outcome similar? How was it different?

Sense-Making Discussion: Randomness
Conduct a discussion about the similarities and differences between what students did in this activity and their experience with the *RoboRiot* game. In the game, students can see the random selection of one allele from each robot and how the resulting robot is always a combination of the two alleles of each of the two "parent" robots. Randomness is in play, because sometimes it takes many attempts to get the combination the player wants.
Have students write the answers to the following questions, either in class or for homework.

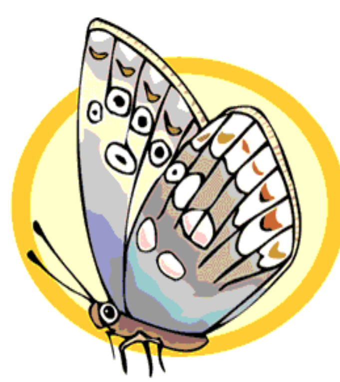
- How closely does the recycler in the game resemble a Punnet square? What is similar and what is different?
- Do you notice any similarities or differences between what happens in the recycler and how traits are inherited?

Classroom Instruction: Dominant and Recessive Alleles
Implement this part of your unit as usual, including the usual hands-on activities, video clips, and reading and writing assignments. Instruction should include ideas and concepts related to chromosomes, genes, traits, Mendelian genetics, dominant and recessive alleles, and Punnet squares.

Once students are familiar with the idea of dominance, use the following linking activity. This Peppered Moth Simulation is typically used to illustrate how predators locate prey in different environments; students analyze how color affects an organism's ability to survive in certain environments. The simulation here has been slightly modified to focus on two concepts: (1) the most frequently occurring alleles in this population were recessive, light-colored–with–dark-spot coloration; and (2) the dominant gene—in this case, black coloration—is not the most desirable one.

> **[Notes for the Teacher:**
> Before the Industrial Revolution in England, the peppered moth was found mostly in a light grey form with little black-speckled spots. The light-bodied moths were able to blend in with the common light-colored lichens and tree bark in their environment, while the less-common black moth was more visible and thus more likely to be eaten by birds. Thus, the light-colored moths were much more effective at hiding from predators, and the frequency of the dark allele was about 0.01%.
>
> As England became more industrial, the enviroment changed: Trees and lichens became sooty and dark-colored. Although light-colored moths initially continued to be in the majority, they became more visible to predators and most of them didn't survive. Meanwhile, the the dark-colored moths flourished, since they were now harder for birds to see. As a result, over the course of many generations of moths, the allele frequency gradually shifted towards the dominant allele, as more and more dark-bodied moths survived to reproduce. By the mid-19th century, the number of dark-colored moths had risen noticeably, and by 1895, the percentage of dark-colored moths in the Manchester peppered moth population was reported at 98%, a dramatic change (by almost 1000%) from the original frequency.]

Linking Activity 2: Peppered Moth Simulation



Objectives

- Describe the importance of coloration in avoiding predation

- Recognize that the most frequently occurring alleles in this population were recessive, light-colored–with–dark-spot coloration
- Explain why the dominant genes—in this case, black coloration—ws not the most desirable one

Materials

1. Sheet of white paper
2. Newspaper
3. Hole punch
4. Forceps or tweezers
5. Colored pencils
6. Clock or watch with a second hand

Purpose:
In this lab, you will simulate how predators locate prey in different environments. You will analyze how color affects an organism's ability to survive in certain environments, and why recessive traits can be more plentiful and more desirable than dominant ones.

Industrial melanism is a term used to describe the adaptation of a population in response to pollution. One example of rapid industrial melanism occurred in populations of peppered moths in the area of Manchester, England, from 1845 to 1890. Before the Industrial Revolution, the trunks of the trees in the forest around Manchester were light grayish-green due to the presence of lichens. Most of the peppered moths in the area were light-colored with dark spots. As the industrial revolution progressed, the tree trunks became covered with soot and turned dark. Over a period of 45 years, the dark variety of the peppered moth became more common.

Procedure

1. Use the hole punch to make 30 circles of white paper and 30 circles of newspaper.
2. Choose two students to demonstrate. Place a sheet of white paper on the table and have one student spread the 30 white circles and 30 newspaper circles over the surface while the other student (the "predator") looks the other way.
3. The predator student than has 15 seconds to pick up as many circles as possible, using the forceps.
4. Repeat the trial with white circles on a newspaper background, newspaper circles on a white background, and newspaper circles on a newspaper background. Record the data in chart below.

		Starting Population		Number Picked up	
Trial	Background	Newspaper	White	White	Newspaper
1	white	30	30		
2	white	30	30		
3	newspaper	30	30		
4	newspaper	30	30		

Analysis
Ask the following questions.

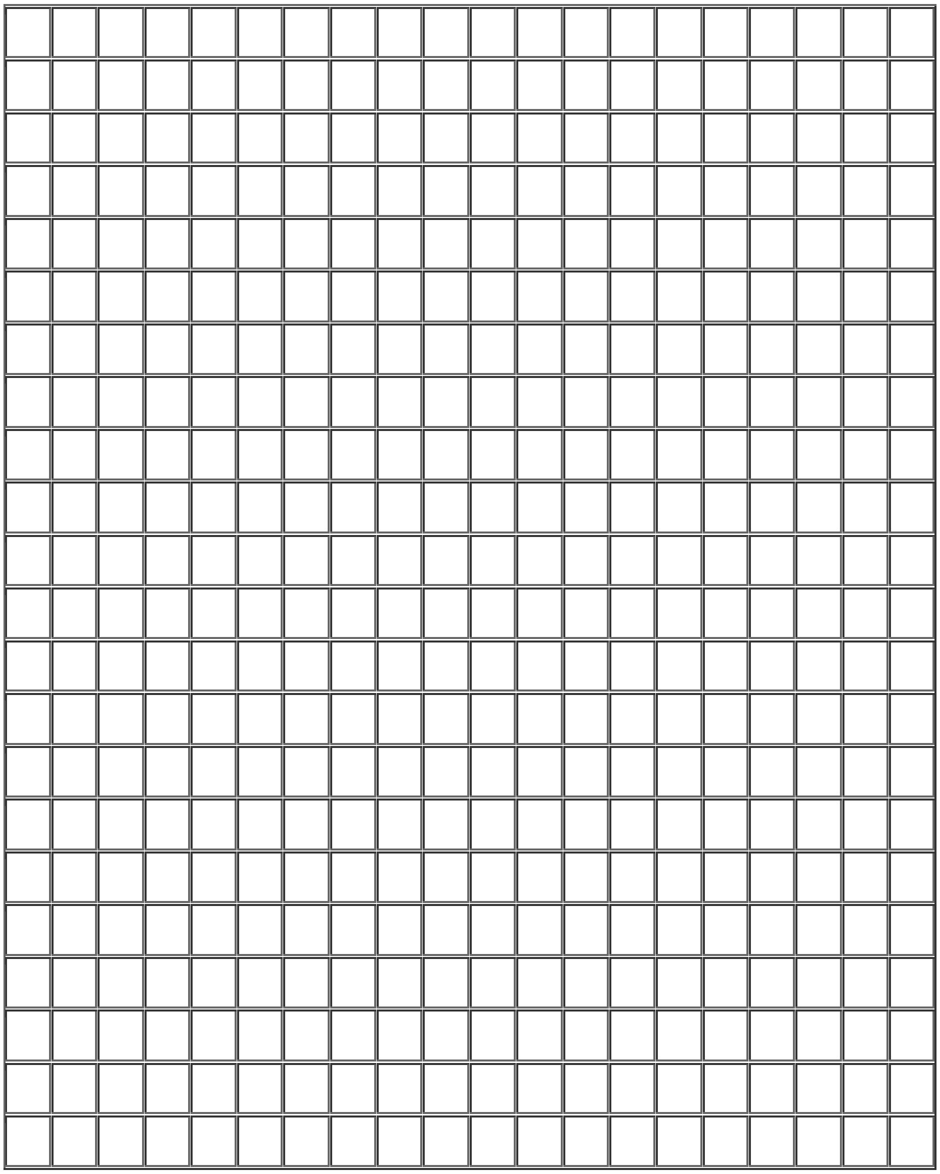
1. What did the activity show about how prey is selected by predators?

2. What advantage did the white-with-black-speckles moths have in the environment before the Industrial Revolution?

3. If the Industrial Revolution had not occurred, what would you expect the next generation of moths to look like after trial 1? What about the next generation after trial 3?

4. What does this activity tell you about dominant traits?

5. Examine the table below and construct a graph. Plot the years of the study on the X axis, and the number of moths captured on the Y axis. You should have two lines on your graph—one for light moths, and one for dark moths.



Year	# of Light Moths Captured	# of Dark Moths Captured
2	537	112
3	484	198
4	392	210
5	246	281
6	225	337
7	193	412
8	147	503
9	84	550
10	56	599

6. Explain in your own words what the graph shows.

7. Describe a situation where this type of selection might occur.

Sense-Making Discussion: Dominant and Recessive Alleles

Lead a discussion about the similarities and differences between what students did in the activity, what they did in the game, and what they learned during your instruction. It is important to draw out the randomness and dominance analogies in the game with what students learned during your genetics instruction. Have students write the answers to the following questions, either in class or for homework.

1. Are some bots better than other bots?
2. What similarities or differences did you notice between the bots and the peppered moths?