

## Codon Bingo

### Introduction

Codon Bingo is a stimulating game that involves deciphering the genetic code. The game is designed to give students practice with transcription and translation of codons while at the same time generating full class participation. As students play the game, they develop increased proficiency while unraveling the genetic code found in the base pairs. After playing Codon Bingo, the students will find it easier to transcribe the DNA base pair messages into mRNA codons and to translate the mRNA codons into an amino acid sequence.

### Concepts

- Amino acids
- Nucleotide (base) pairing rules
- Transcription
- DNA
- RNA
- Translation

### Background

The DNA that makes up the human genome can be subdivided into genes. Each gene encodes for a protein (or part of a protein) that performs a specific function in a cell. The two-step process of transcription and translation is responsible for transforming the DNA instructions into a functional protein. During *transcription* the DNA code is copied into a strand of messenger RNA (mRNA). The nucleotide pairing rules for transcribing DNA to RNA are slightly different than the base pairing rules for replicating a strand of DNA. In DNA, the purine adenine (A) always pairs with the pyrimidine thymine (T), and the pyrimidine cytosine (C) always pairs with the purine guanine (G). In RNA, the pyrimidine cytosine (C) still pairs with the purine guanine (G), but the purine adenine (A) pairs with the pyrimidine uracil (U). The strand of mRNA travels out to the cytoplasm of the cell. In the cytoplasm a ribosome binds to the mRNA strand at a specific point called a start codon. The ribosome reads three mRNA nucleotides at a time—these base triplets are called *codons*.

A single mRNA nucleotide sequence—adenine-uracil-guanine (AUG)—acts as the starting point for the translation of any mRNA into a chain of amino acids. There are three different codons that are read as “stop” by the ribosome, causing the ribosome to detach from the mRNA strand. The remaining 61 of the 64 possible nucleotide combinations codons correspond to one of the twenty amino acids used to form an amino acid chain that will become a protein. Each mRNA codon is matched to an anticodon on a transfer RNA (tRNA) molecule. The tRNA molecule has two key areas that are important for translation. The first area is the anticodon. The *anticodon* is a triplet base nucleotide sequence that mirrors and is complementary to the 64 codon sequences found in mRNA. The second area on tRNA has a specific amino acid bonded to it. The codons are a universal code, meaning that each mRNA codon codes for the same amino acid in all living things from bacteria to humans. It is the specific sequence of amino acids that varies in different proteins. Changes in the amino acid sequence cause the amino acid string to bend and fold in unique ways, creating unique proteins for each organism.

### Materials

Amino Acid Decoding Chart  
Bingo card, blank  
Bingo chips, 25 per student

Index cards, 64  
Small cups to hold the bingo chips

### Procedure

1. Using index cards, create the bingo “draw cards” by writing the name of an amino acid, an mRNA codon for that amino acid (or stop), and the DNA code that corresponds to the mRNA codon. Create one card for each of the 64 RNA codons.

2. Create bingo cards using a word processing program. Bingo cards have five columns and five rows, creating twenty-five empty boxes. If desired, a free-space may be added to the center box of each bingo card.
3. Have the students randomly write the name of all 20 amino acids plus stop on the bingo card. Five amino acids must be used twice to fill the bingo card. *Note:* Students should not use methionine or tryptophan more than once as they only have one RNA code.
4. Give an Amino Acid Decoding Chart and a small cup containing 25 bingo chips to each student.
5. Shuffle the bingo draw cards and begin the first game.
6. Draw one bingo draw card. Call out the mRNA codon. Students must use the Amino Acid Decoding Chart to translate the mRNA codon into the amino acid. If the student's bingo card has the amino acid, a bingo chip should be placed on that box.
7. Lay the bingo draw card to one side. It will be used to check the winner's bingo card. Give the students enough time—especially in the beginning of the game—before drawing the next game piece.
8. Continue to call out mRNA codons until a student says “Bingo!” Check the winner's bingo card against the bingo draw cards. If the student has made a mistake continue to call out new mRNA codons; otherwise, have the students clear the bingo cards and start a new game.
9. Advanced variation—rather than call out mRNA codons, call out the DNA bases. Students must first transcribe the DNA to mRNA, and then translate the mRNA code to the amino acid.

## Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

### ***Unifying Concepts and Processes: Grades K–12***

Systems, order, and organization

### ***Content Standards: Grades 5–8***

Content Standard A: Science as Inquiry

Content Standard C: Life Science, reproduction and heredity

### ***Content Standards: Grades 9–12***

Content Standard A: Science as Inquiry

Content Standard C: Life Science, molecular basis of heredity

## Tips

- Most student textbooks contain an amino acid decoding chart or table. Three versions are typically found in textbooks—two versions are tables, whereas the third version is circular with the amino acids appearing as “spokes on a wheel.” Allow students to use the type of chart they are likely to use during a test.
- Bingo may be called when any five spaces across are filled, either horizontally, vertically or diagonally. Four corners, post-age stamp, or blackout are less traditional bingo choices. Play the game with as many or as few bingo variations as you desire.

## Acknowledgment

Special thanks to Cynthia Mannix for bringing this activity to our attention.

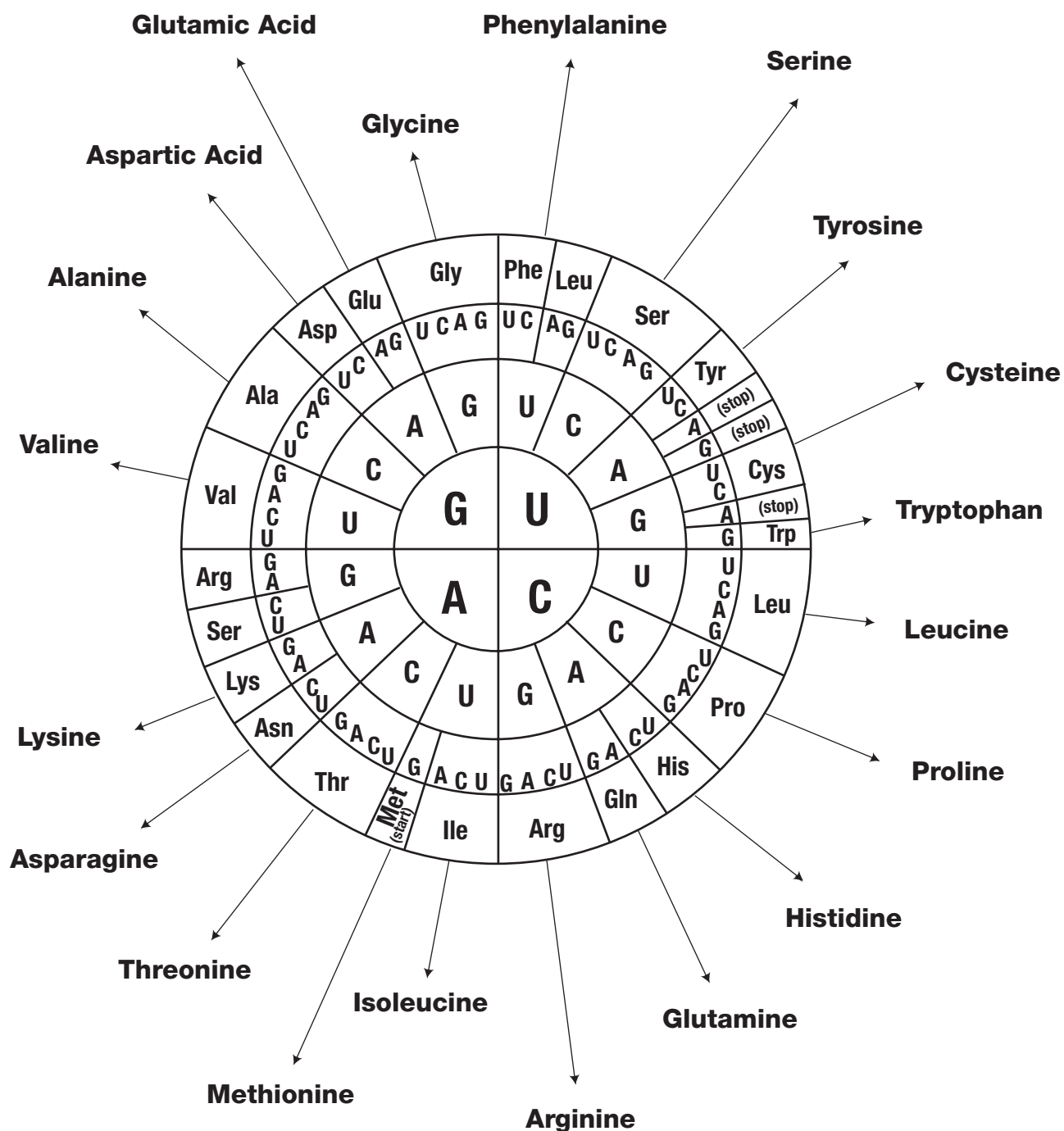
## A Codon Bingo Kit is available from Flinn Scientific, Inc.

| Catalog No. | Description     |
|-------------|-----------------|
| FB1112      | Codon Bingo Kit |

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.

# Amino Acid Decoding Chart

mRNA



# Beaks

## Flinn STEM Design Challenge™

### Introduction

Natural selection is the theory that explains how slight differences among members of a population can be advantageous to survival and reproduction of that population. Those differences are passed on to offspring, with the most beneficial traits increasing in frequency within the population. Over time, changes become noticeable among the population.

### Concepts

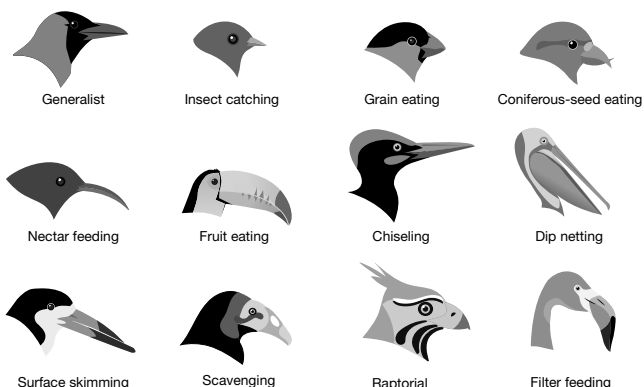
- Microevolution
- Natural selection
- Engineering Design

### Background

Evolution on the smallest scale is called *microevolution*. It is the change of allele frequency from generation to generation within a population. A *population* is a local group of individuals of the same *species* with the potential to mate and produce viable offspring. The individuals that reproduce successfully pass their unique genetic material to the next generation. Those that do not reproduce die prior to passing on their genetic material.

*Alleles* are alternative forms of a gene. All the genes within a population are known as the *gene pool*. The gene pool is where the genetic variation is stored and pulled from for future generations. The gene pool varies based on how environmental factors impact natural selection. For example, if the environment "selects" for traits, and the conditions increase the ability to survive and reproduce, then those traits become more common, indicating a change in the gene pool.

A terrific example of microevolution occurs regularly on the Galapagos Islands. This is the same set of islands where Charles Darwin studied. The data he collected helped form his ideas of evolution through natural selection. Currently, there are 13 different species of finches that call the Galapagos Islands home. They are distinguished primarily by their beaks, each suited for a different food source. The medium ground finch, *Geopiza fortis* is a medium-sized bird with a blunt beak suited for crushing small seeds. All the finches will dine on small, soft seeds, but some—those with slightly bigger beaks—can eat larger, tougher seeds as well. In this activity, you will be given a finch "beak" and participate in a simulation to show how variation within the gene pool can be caused by environmental changes from generation to generation. You will then design and construct a finch beak to see if it can survive generationally and through environmental changes.



### Materials

Calculator  
Food items  
Forceps

Fork  
Skewer, bamboo  
Weighing dish

### Safety Precautions

*This classroom activity is considered nonhazardous. Follow all standard laboratory and classroom safety guidelines. Students must walk to and from their nests and walk with their beaks down.*

## Procedure

### Part A. Predetermined Beaks

#### Feeding Rules:

- You may not use your hands except to hold the “beak.”
- You may not push other “birds,” knock the food out of the other “birds’ beaks,” or steal food from other “birds’ nests.”
- You may not move your nest to another location once you have selected your location.
- When time is called, you must stop where you are. If you have food in your “beak,” you may place it in your nest.
- Do NOT eat any of the food items.
- You can use your fingers to remove “food” from your “beak” to your nest.

#### Generations 1–3

- Obtain one of the “beaks” from the designated beak area.
- At each lab station, there is one weighing dish for each student. This is your nest. All food items must be placed inside your nest.
- Find a location in the room to place your nest.
- In Generation 1, only one “beak” of each type will participate. Anyone not participating is required to assist with data collection, clean up and replenish food.
- Once time has started, walk from your nest to the feeding site and obtain food. Once the food item(s) is secure in your beak, walk back to your nest and place it inside your nest. *Note:* The beak is used to obtain and carry food, no hands.
- Continuing adding food to your nest until time is called.
- Using the Beak Survival table below, determine the number of “beaks” that will participate in Generation 2.

#### Beak Survival

| Food Items Collected | Outcome                           |
|----------------------|-----------------------------------|
| Fewer than 10        | Does not survive                  |
| 10–20                | Survives but does not reproduce   |
| 21–30                | Survives and produces 1 offspring |
| 31–40                | Survives and produces 2 offspring |
| 41–50+               | Survives and produces 3 offspring |

- Return food to the feeding site—this simulates nutrient cycling. Birds that do not survive do not return their food, rather put the food in a designated container.
- Repeat steps 1–8 for Generations 2 and 3.

#### Generations 4–6

- For the next three generations, the food source has changed due to environmental conditions.
- All the “beaks” from Generation 3 will participate in Generation 4.
- Follow steps 1–9 for generations 4, 5 and 6.
- Follow the same rules as generations 1, 2 and 3.

### Part B. Beak Design Challenge

Utilizing what you learned from Part A, design a bird beak that you believe will allow for the greatest survival chances. Remember, with natural selection if you increase your chance of survival, you live long enough to reproduce and therefore allow your traits to be passed on to your offspring. Here are a few rules and hints to consider while designing:

- Different food items will be used during the design challenge.
- You want a beak that can withstand changes to environmental conditions.
- The beak you design must be “beak-like.” For example, there needs to be a hinged jaw and it must open and close like a beak.
- You can use any materials you want however, it must be a modified or original design. For example, you cannot bring in a kitchen spoon unless it was modified to behave like a beak.

5. The size of the beak needs to fit within the following parameters (unless otherwise given by your instructor):
  - a. length—under 10 cm
  - b. width—under 3 cm
  - c. height—under 5 cm
6. Because each beak will be unique, changes in the number of birds with a particular beak type cannot be modeled. Therefore, the “best beak” will be determined by process of elimination, see Beak Design Challenge Survival rules below.

### Beak Design Challenge

#### Survival Rules

| Generation  | Food Items collected to Survive |
|---|---------------------------------|
| 1   | More than 20                    |
| 2   | More than 40                    |
| 3   | More than 60                    |
| <i>All students return to the ecosystem before generation 4 due to migration.</i> |                                 |
| 4   | More than 20                    |
| 5   | More than 40                    |
| 6   | More than 60                    |

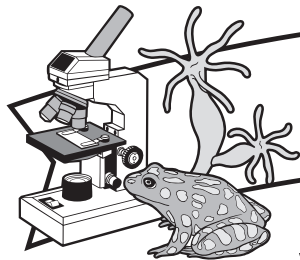
### Tips

- The beaks students use and create represent beaks for the same bird species, just with variations among them.
- Allow 30–60 seconds for feeding depending on the laboratory setting.
- Feeding sites can be a large area, like the teacher lab station, or there can be smaller areas within the laboratory. The supplies can easily be pushed off flat surfaces creating a mess and safety hazard. Placing food items onto large trays will minimize such issues.
- Start with soft foods at the feeding site(s) for the 1st, 2nd and 3rd generations and switch to hard foods in the 4th, 5th and 6th generations.
- Soft food items could include cotton balls, pom poms, foam peanuts. Hard food items could include tooth picks, pebbles, and beans.
- Utilize different food items during the Beaks Design Challenge.
- For the Beaks Design Challenge, have all the students start during generation 1 and return for generation 4. Explain that since there are fewer birds competing for food, other birds would have the opportunity to migrate in. This will allow for maximum participation throughout the activity.
- The switch to hard food is representative of a drought as an environmental change.
- Extensions and/or modification to this activity are many. For example, students could bring in different food items that challenge each other’s beak. As a class, group the beaks prior to Part B and then the procedure from Part A could be followed to show variation while practicing or reviewing classification. Another extension could be to require each beak to obtain at least one particular food item in order to survive and reproduce. (For example, each beak must have a fishing lure in the nest; this could represent protein required during the breeding season for robin red breasts.) This could be required in both Part A and Part B.

**The Beaks—Flinn STEM Design Challenge™ is available from Flinn Scientific, Inc.**

| Catalog No. | Description                        |
|-------------|------------------------------------|
| FB2130      | Beaks—Flinn STEM Design Challenge™ |
| AP5429      | Demonstration Tray, Large          |

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.



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## Take as Directed

### Antibiotic Resistance Simulation

#### Introduction

A scratchy throat, an earache or a cut that won't heal—all could be signs of a bacterial infection. Antibiotics are prescribed to reduce the length and severity of infections. Antibiotics taken on time and finished completely are very effective. Study the effects of antibiotics on bacterial populations.

#### Concepts

- Antibiotic treatment
- Bacteria
- Antibiotic resistance

#### Materials

Bingo chips, red, 20

Colored pencils

Bingo chips, blue, 15

Die

Bingo chips, yellow, 15

#### Safety Precautions

*The materials used in this activity are considered nonhazardous. Please follow all laboratory safety guidelines.*

#### Procedure

1. Obtain 20 red bingo chips, 15 blue bingo chips, 15 yellow bingo chips, and one die. Place 13 red, 6 blue, and 1 yellow bingo chip on the work surface in front of you and your partner. These chips represent harmful bacteria found in a patient's body before beginning antibiotic treatment. Set aside the remaining bingo chips.
2. It is time to take the first dose of antibiotics. Roll the die and follow the key below.

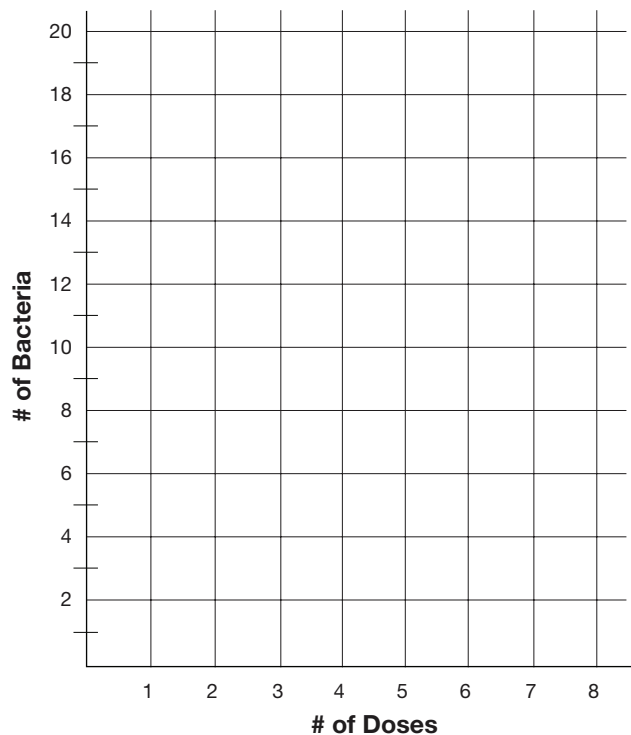
| Number Tossed | Event  | Results  |
|---------------|--|--|
| 2, 3, 4 or 5  | Antibiotic was taken at appropriate time—bacteria killed | Remove 5 disks in the following order: remove red bingo chips first, followed by blue and then yellow as needed. |
| 1 or 6        | Antibiotic was not taken at the appropriate time.        | Do not remove any bingo chips.   |

3. Record the number of each remaining type of bacteria in the table on the next page.
4. Bacteria are constantly reproducing in the host; in this case the host is the patient's body. If one or more bacteria of a particular type (color) are still present in the patient's body after the first dose (step 2), add one chip of that color to the population. *Example:* If the patient still has blue and red bacteria present, add one blue and one red chip to the population.
5. Repeat steps 2–4 at least eight times (or until all bacteria have been eliminated) to complete the table.

## Teacher's Notes *continued*

6. Using the data from the table, construct a graph displaying the number of each type of bacteria versus the number of doses. Use different color pencils to plot the following data: total number of bacteria, least resistant bacteria, medium resistant bacteria, and most resistant bacteria. Connect each set of data points by drawing a colored line.

| Dose No. | No. Rolled | Bacterial Population |                          |                          |       |
|----------|------------|----------------------|--------------------------|--------------------------|-------|
|          |            | Low Resistance (Red) | Medium Resistance (Blue) | High Resistance (Yellow) | TOTAL |
| INITIAL  | N/A        | 13                   | 6                        | 1                        | 20    |
| 1        |            |                      |                          |                          |       |
| 2        |            |                      |                          |                          |       |
| 3        |            |                      |                          |                          |       |
| 4        |            |                      |                          |                          |       |
| 5        |            |                      |                          |                          |       |
| 6        |            |                      |                          |                          |       |
| 7        |            |                      |                          |                          |       |
| 8        |            |                      |                          |                          |       |





## Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

### ***Unifying Concepts and Processes: Grades K–12***

Evidence, models, and explanation  
Constancy, change, and measurement  
Evolution and equilibrium

### ***Content Standards: Grades 5–8***

Content Standard C: Life Science, structure and function in living systems, diversity and adaptations of organisms  
Content Standard F: Science in Personal and Social Perspectives; personal health; risks and benefits

### ***Content Standards: Grades 9–12***

Content Standard C: Life Science, behavior of organisms  
Content Standard F: Science in Personal and Social Perspectives; personal and community health

## Tips

- Enough materials are provided in this kit for 30 students working in pairs or for 15 groups of students. This laboratory activity may reasonably be completed in one 50-minute class period. The *Pre-Lab Questions* may be completed before coming to class, and the data compilation and *Post-Lab Questions* may be completed the day after the lab.
- Stress to students the importance of recording the number of each bacterial type on Table 1 before adding one more bingo chip of each type present as instructed in step 4. If the population grows before the data is recorded students may be confused by the results.

## Discussion

Antibiotics are powerful drugs that are used to treat many serious and life-threatening diseases. Antibiotics are only effective against bacterial infections, some fungal infections, and some parasites. The principles of antibiotic treatment were actually discovered by accident in 1928 by Alexander Fleming (1881–1955). Fleming was culturing bacteria in glass dishes in his laboratory. However, mold (fungus) had contaminated some of his bacterial cultures. He planned on throwing them away but instead noticed that no bacteria grew in the vicinity of the mold. The bread mold named *Penicillium* produces an antibacterial chemical named penicillin.

Since the discovery of penicillin, scientists have developed numerous antibiotics to help stop the spread of infectious disease. Although antibiotics have been proven very useful, misuse of antibiotics has become a serious problem. Frequent unnecessary use has resulted in the evolution of bacteria which are resistant to many common antibiotics. These extremely antibiotic-resistant bacteria develop because the original antibiotic failed to kill all of the targeted bacteria. As a result, the remaining bacteria survive and become resistant to the original antibiotic. Doctors then prescribe a different antibiotic, but resistant forms of the bacteria quickly develop the ability to withstand the new antibiotic as well, bringing about a continual cycle requiring different, more powerful drugs to treat infection.

As more bacteria become resistant to the original antibiotic, the consequences become more severe. Consequences include longer lasting illnesses, increased risk of serious complications, and death. The inability of antibiotics to treat infection also leads to longer periods in which a person is contagious and able to spread resistant strains to other people.

## References

“Antibiotics: Misuse Puts You and Others at Risk.” Mayo Clinic. <http://www.mayoclinic.org/antibiotics/ART-20045720> (Accessed January 2014)

**Materials for Antibiotic Resistance Simulation are available from Flinn Scientific, Inc.**

| Catalog No. | Description                                      |
|-------------|--|
| FB1928      | Antibiotic Resistance Simulation—Super Value Kit |

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## Help from MOM

### A Colorful Antacid Demonstration

#### Introduction

Milk of magnesia (MOM) and other antacids are bases that relieve heartburn by neutralizing the acid found in the stomach's gastric juices. When hydrochloric acid and universal indicator are added to milk of magnesia, a dramatic rainbow of color changes is observed as the antacid neutralizes the simulated stomach acid. This is a great demonstration to teach concepts of acids and bases, solubility, digestion, and "antacid-testing" consumer biochemistry.

#### Concepts

- Acid-base neutralization
- Digestion
- Antacids

#### Materials (for each demonstration)

|  |                                    |
|--|------------------------------------|
| Milk of magnesia (MOM), 20 mL                    | Graduated cylinder, 25-mL or 50-mL |
| Hydrochloric acid, HCl, 3 M, approximately 20 mL | Ice, crushed (or ice cubes)        |
| Universal indicator solution, 4–5 mL             | Magnetic stirrer and stir bar      |
| Water, distilled or deionized, 800 mL            | Pipets, thin-stem, disposable, 2   |
| Beaker, 1-L (or other large beaker)              | Universal Indicator Color Chart    |

#### Safety Precautions

*Milk of magnesia that has been brought into the lab is considered a laboratory chemical and is intended for laboratory use only. Hydrochloric acid solution is toxic by ingestion, inhalation and is corrosive to skin and eyes. Universal indicator solution contains ethyl alcohol and is a flammable liquid. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Wash hands thoroughly with soap and water before leaving the laboratory. Follow all normal laboratory guidelines. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.*

#### Procedure

1. Measure 20 mL of milk of magnesia (MOM) using a graduated cylinder and pour it into a 1-L beaker.
2. Add a stir bar to the MOM solution and place the 1-L beaker on a magnetic stirrer. (If a magnetic stirrer is not available, use a stirring rod to mix the solution as other reactants are added in steps 3–5.)
3. Add water and crushed ice (or ice cubes) to give a total volume of approximately 800 mL. Turn on the stir plate so as to create a vortex in the mixture.
4. Add about 4–5 mL (about 2 pipets-full) of universal indicator solution. Watch as the white suspension of milk of magnesia turns to a deep purple color. The color indicates that the solution is basic.
5. Add 2–3 mL (1 pipet-full) of 3 M HCl. The mixture quickly turns red and then goes through the entire range of universal indicator color changes back to purple.
6. Repeat this process, adding HCl one pipet-full at a time, waiting after each addition until the mixture turns back to blue-purple.
7. The process can be repeated a number of times before all of the milk of magnesia has dissolved and reacted with the HCl. As more acid is added, the color changes will occur more rapidly and eventually the suspended solid in MOM will be completely dissolved. The final solution, when all the MOM has reacted, will be red and clear.

## Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for proper disposal procedures. Neutralize the final solution with sodium carbonate or excess milk of magnesia according to Flinn Suggested Disposal Method #24b. Excess milk of magnesia can be disposed of according to Flinn Suggested Disposal Method #26a solid waste disposal in landfill.

## NGSS Alignment

This laboratory activity relates to the following Next Generation Science Standards (2013):

### Disciplinary Core Ideas: High School

HS-LS1 From Molecules to Organisms: Structures and Process  
LS1.A: Structure and Function

### Science and Engineering Practices

Engaging in argument from evidence

### Crosscutting Concepts

Cause and effect

## Tips

- If a 1-L beaker is not available, use a 600-mL or 400-mL beaker. Adjust chemical amounts accordingly. *Note:* The amount milk of magnesia added does not have to be exact in order for the demonstration to work.
- The acid used in the demonstration is 3 M hydrochloric acid (HCl). Actual stomach acid ranges approximately from 0.1 to 1 M HCl. The higher concentration is used in this demonstration in order to limit the total acid volume and allow the reaction to go to completion with a reasonable volume of acid. If desired, use 1 M HCl to perform the experiment as written. The volume of acid needed will be three times greater.
- The reaction is performed with ice in order to slow down the color changes so that all colors in the universal indicator color range can be viewed. The reaction may be performed without the use of ice.

## Discussion

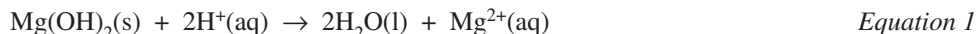
Hydrochloric acid secreted in the stomach gives the gastric juice a pH of between 1.5 and 3.5, depending upon the amount of food within the stomach. The pH of an empty stomach is usually less than 2. When gastric juices contact the esophagus, the acid may irritate and partially digest the esophageal lining. The resulting heartburn is often treated with antacids. Antacid literally means “against acid.” Antacids are weak bases that work by neutralizing the acidic environment of the stomach. This demonstration uses the antacid milk of magnesia (MOM). The active ingredient in milk of magnesia is magnesium hydroxide,  $\text{Mg}(\text{OH})_2$ . MOM works well for the demonstration because the magnesium hydroxide forms a suspension in water due to its very low solubility—0.0009 g/100 mL in cold water and 0.004 g/100 mL in hot water. This limited solubility makes it an ideal compound for use in commercial antacids because, rather than dissolving all at once, it slowly dissolves as it reacts with and neutralizes stomach acid. As the “excess stomach acid” neutralizes the dissolved magnesium hydroxide, more magnesium hydroxide enters the solution from the solid suspension state until the solution is neutralized or all of the reactants are used up.

Universal indicator is added to the MOM suspension to help visualize the neutralization reaction as it occurs. The initial color of universal indicator in the MOM suspension is violet, corresponding to a basic solution ( $\text{pH} \geq 10$ ). (See the Universal Indicator Color Chart on the next page.) When hydrochloric acid (the simulated “stomach acid”) is added, the mixture quickly turns red ( $\text{pH} 4$ ) as the acid disperses throughout the beaker and neutralizes a small amount of dissolved magnesium hydroxide. Some unreacted acid is still present, however, so the solution remains red. However, the unreacted acid causes more magnesium hydroxide from the suspension to gradually dissolve and react. As more of the magnesium hydroxide goes into solution, the excess acid is neutralized and eventually the solution turns blue or violet ( $\text{pH} 9\text{--}10$ ) again, indicating excess magnesium hydroxide is present. The added universal indicator allows this process to be observed. During the process, the color of the mixture cycles through the entire universal indicator color range—from red to orange to yellow to green to blue and finally back to violet. By adding more “stomach acid,” the process can be repeated several times before all of the magnesium hydroxide dissolves and is neutralized. The final solution, after all the MOM has dissolved and reacted with HCl, is red and clear.

### Universal Indicator Color Chart

| Color | Red | Orange | Yellow | Green | Green-blue | Blue | Violet |
|-------|-----|--------|--------|-------|------------|------|--------|
| pH    | 4   | 5      | 6      | 7     | 8          | 9    | 10     |

The neutralization reaction is the reaction between  $\text{Mg}(\text{OH})_2$  (a weak base) and  $\text{HCl}$  (a strong acid). The overall reaction is summarized in Equation 1.



In aqueous solution, the reacting species for the strong acid,  $\text{HCl}$ , is the hydrogen ion,  $\text{H}^+$ . The products are a  $\text{H}_2\text{O}$  molecule and a  $\text{Mg}^{2+}$  ion in solution. The chloride ion,  $\text{Cl}^-$ , from  $\text{HCl}$  is considered a “spectator” ion (it is not involved in the reaction), and thus is not included in the net ionic equation.

### Acknowledgments

Special thanks to Bette Bridges, retired, Bridgewater-Raynham High School, Bridgewater, MA; Annis Hapkiewicz, retired, Okemos High School, Okemos, MI; and Penney Sconzo, Westminster School, Atlanta, GA for separately bringing this demonstration to our attention.

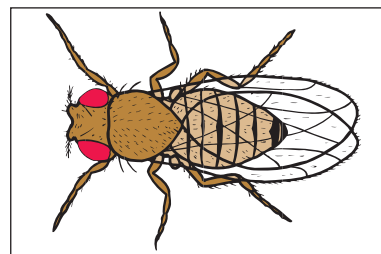
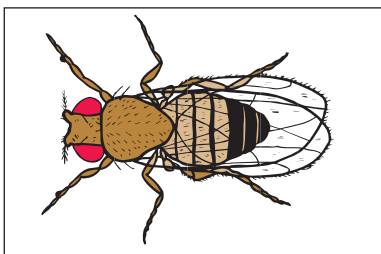
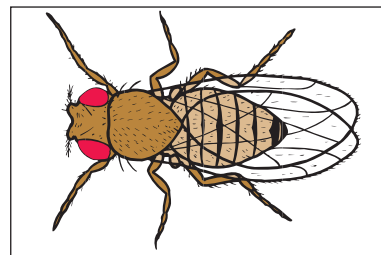
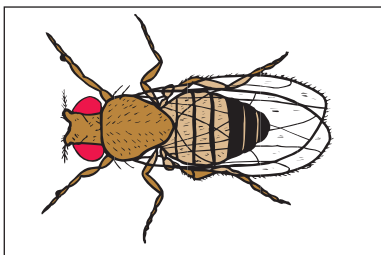
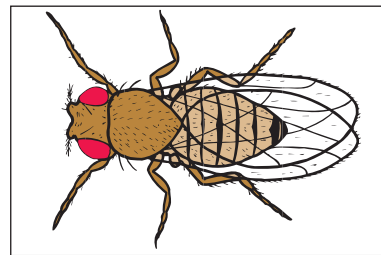
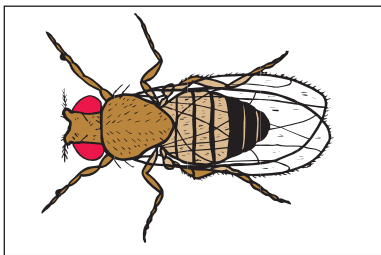
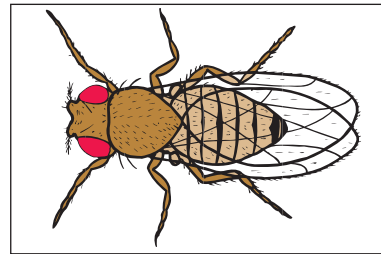
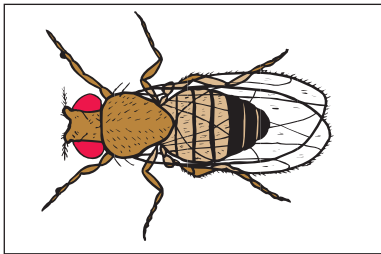
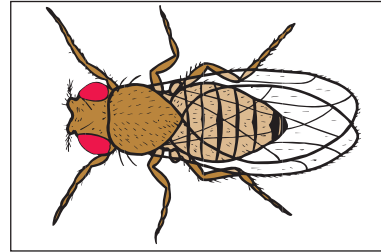
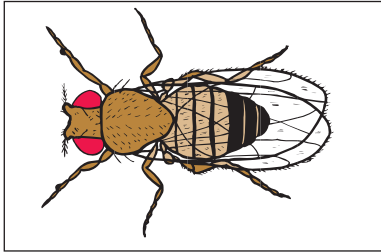
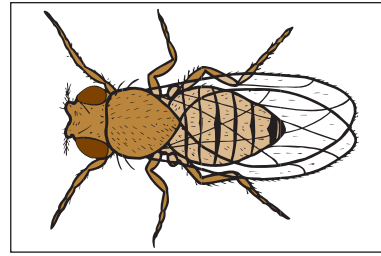
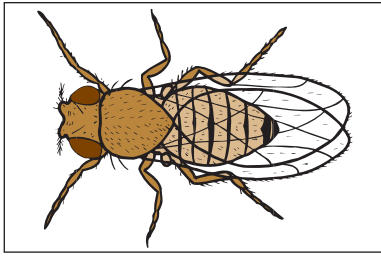
### References

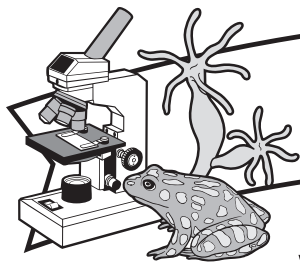
Summerlin, L. R.; Borgford, C. L.; Ealy, J. B. *Chemical Demonstrations: A Sourcebook for Teachers*, Vol. 2; American Chemical Society: Washington, DC. 1988; p 173.

**Materials for *Help from MOM—A Colorful Antacid Demonstration* is available from Flinn Scientific, Inc.**

| Catalog No. | Description   |
|-------------|---|
| FB1857      | Help from MOM— The Biochemistry of Antacids Demonstration Kit |
| AP7235      | Magnetic Stirrer  |
| M0122       | Magnesium Hydroxide, Saturated Solution, 500 mL               |
| U0001       | Universal Indicator Solution, 100 mL                          |
| H0034       | Hydrochloric Acid Solution, 3 M, 500 mL                       |
| H0013       | Hydrochloric Acid Solution, 1 M, 500 mL                       |
| AP5367      | Universal Indicator Overhead Color Chart                      |

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.





## *Drosophila* Genetics Simulation

### Introduction

Explore how the appearance of an organism relates to its genetic makeup using this interactive *Drosophila* Genetics card simulation. Simulate a monohybrid genetic cross between wild-type and sepia fruit flies.

### Concepts

- Genotype vs. phenotype
- Monohybrid cross

### Background

Genetics is the scientific study of heredity. Scientists substitute simple organisms for humans when studying inherited diseases and disorders. About 60% of the genes that are known to cause human disease have a recognizable match in the genetic code of the common fruit fly (*Drosophila melanogaster*), and 50% of *Drosophila*'s protein sequences are similar to those of mammals. Fruit flies are commonly used in genetic research because these gene and protein similarities are contained in an organism with only four pairs of chromosomes—the X/Y sex chromosomes and three autosomes, numbered 2, 3 and 4. The four pairs of chromosomes contain 132 million base pairs of DNA, comprising 13,676 genes. For comparison, the human genome has 3.2 billion base pairs, which make up 20,500 genes on 23 chromosomes. Other advantages to using *Drosophila* are that they breed and mature rapidly, are inexpensive and easy to raise, produce several hundred offspring per generation, and require very little space. The fruit fly is also an ideal candidate for genetic studies because simple mutations cause obvious phenotype (the outward appearance of an organism) differences, and its genome map has been fully sequenced (completed in 2000).

*Genes* are sections of a chromosome that code for individual proteins. A trait is defined as a physical characteristic that can be passed from parent to offspring. Alternate forms of a gene are called *alleles*. Most organisms have two copies of every gene, one inherited on the chromosome from the mother and one on the chromosome inherited from the father. Individuals carrying two identical versions or alleles of a given gene, which may be either AA or aa, are said to be *homozygous* for the gene. Similarly, when two different alleles are present in a gene pair, labeled Aa, the individual is said to have a *heterozygous* genotype. The homozygous dominant genotype (AA) and the heterozygous genotype (Aa) will both show dominant phenotypes (because A is dominant to a) whereas the homozygous recessive genotype (aa) will exhibit a recessive phenotype. These rules apply not only for a single characteristic or traits resulting from a monohybrid cross, but also for a dihybrid cross in which two genes associated with different traits with contrasting characteristics are considered. A special case exists for genes on the sex chromosomes. Since the Y chromosome contains very few genes, the only copy of a gene in a male resides on the X chromosome which may cause a recessive gene to be expressed even though there is only one copy of the gene present. Sex-linked inheritance occurs mostly in males because a female has two copies of the X chromosome and therefore her genotype will follow normal inheritance rules.

### *Drosophila* Characterization

Like all insects, *Drosophila* have three main body parts: the head, the thorax, and the abdomen (see Figure 1). The major structures on the head of a wild-type fruit fly are the large red compound eyes. There are also two antennae on top of the fly's head used for smelling. The mouth is a proboscis—the fly lowers it to suck up food like a vacuum cleaner. The thorax has six legs, two wings and, on the dorsal (top) side, a number of long dark bristles. Females have stripes on every segment of their abdomen. Males have shorter abdomens, and the last few segments of the abdomen are solid black. Males also have a set of brown anal plates on the ventral (bottom) side of the abdomen (see Figure 2 on page 2).

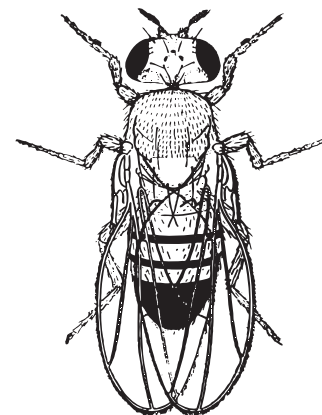
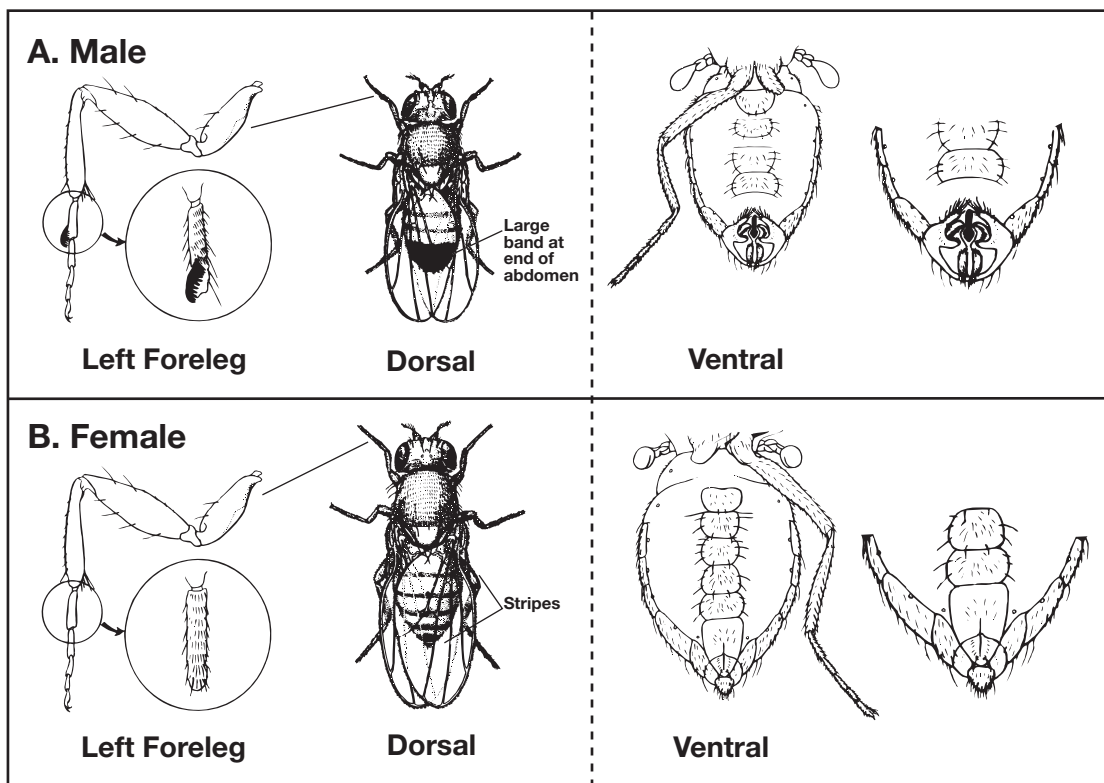


Figure 1. *Drosophila*



## Sexing Flies

In selecting flies for genetic mating, it is absolutely essential that the sex of each fly be properly identified. Identification of sex is most reliably done by examination of the genital organs with the aid of magnification, using a stereoscope. The external reproductive organs of both the male and the female are located on the ventral, posterior part of the abdomen (see Figure 2). The male genitalia are surrounded by heavy, dark bristles that are not found on the female. This characteristic is quite distinct even in a fly that has just emerged from the puparium. Female genitalia are seen as a small bump on the end of the abdomen. The posterior part of the abdomen is quite dark in males and considerably lighter in females. The tip of the abdomen is also rounded in males and more pointed in females. Male fruit flies tend to be smaller than females.



**Figure 2.** Dorsal and Ventral View of *Drosophila*

With practice and care, the front legs can also be used to distinguish the sexes. There are sex combs on the front legs of the male fly (used for grasping the female).

## *Drosophila* Mutations

The wild-type fruit fly has full wings, red eyes, and brownish-tan coloring, along with bristles and antennae. There are many trait mutations available for crossing. Most mutations involve a change in the eyes, wings, bristles or antennae. The changes may be the complete absence of the feature, such as no eyes, a change in shape, such as bar-shaped eyes, or a change in color, such as white eyes. Each mutant type is given a name suggesting the main distinguishing feature. The name is usually a descriptive adjective, such as “black,” or a noun, such as “bar.” For convenience in listing and labeling, a representative symbol is assigned to each mutant type. By convention, if the trait is recessive it is listed as lowercase letter(s), while dominant traits are listed as uppercase letter(s). Wild-type is designated by a plus sign (+). See Table 1 for a list of common trait mutations in *Drosophila*.

**Table 1.** Common *Drosophila* Mutations

| Trait     | Symbol | Dominant or Recessive | Description   | Chromosome # |
|-----------|--------|-----------------------|---|--------------|
| Bar       | B      | Dominant              | Eyes are restricted vertically to a narrow bar in males and in homozygous females.            | X            |
| White     | w      | Recessive             | Eyes are a distinctive white in color.  | X            |
| Yellow    | y      | Recessive             | Body color is yellow.   | X            |
| Apterous  | ap     | Recessive             | Wings are absent.   | 2            |
| Black     | b      | Recessive             | Black color on the ends of the legs, wing veins, and the body. Pigmentation darkens with age. | 2            |
| Dumpy     | dp     | Recessive             | Wings shortened 25%, to approximately the length of the body.                                 | 2            |
| Lobe      | L      | Dominant              | Eyes greatly reduced in size, with indentation at anterior edge.                              | 2            |
| Vestigial | vg     | Recessive             | Stumpy, underdeveloped wings.   | 2            |
| Ebony     | e      | Recessive             | Body color is shiny black.  | 3            |
| Sepia     | se     | Recessive             | Red-brown eyes at emergence darken to sepia and ultimately to black as the fly ages.          | 3            |

## Punnett Squares

Punnett squares will be used in this activity to determine the gene combinations that might result from *Drosophila* crossings. A sample Punnett square for a monohybrid cross between a dumpy female (dp/dp) and a wild-type male (+/+) is shown in Figure 3 below. Notice how the gametes are individually represented in the Punnett square. In this cross, all of the resulting phenotypes are wild-type flies.

| P       | dp/dp | +/+  |
|---------|-------|------|
| Gametes | +     | +    |
| dp      | dp/+  | dp/+ |
| dp      | dp/+  | dp/+ |

**Figure 3.**

In a dihybrid cross, two pairs of contrasting characteristics are compared simultaneously. For example, a heterozygous non-vestigial winged female with non-ebony body color (vg<sup>+</sup>/vg e<sup>+</sup>/e) is crossed with a heterozygous male with non-vestigial wings and non-ebony body color (vg<sup>+</sup>/vg e<sup>+</sup>/e). In the dihybrid cross represented above, four possible gamete combinations (vg+e+, vg+e, vge<sup>+</sup>, and vge) would be placed in a four-column by four-row Punnett square and crossed with one another to find the resulting offspring.

## Materials

Fruit Fly Genetics Card Deck

Monohybrid Cross Sheet

## Safety Precautions

*This classroom activity is considered nonhazardous. Follow all standard classroom safety guidelines.*

## Procedure

### Part I. Monohybrid Cross

1. A monohybrid cross will be simulated as a wild type (+) male fly will be crossed with a virgin female sepia fly (se). The genotype symbol for this parent (P) fly cross is written as se/se and +/+. The parent fly genotype symbols are already provided on the Monohybrid Cross Sheet.
2. The cards from the Fruit Fly Genetics Card Deck represent the phenotypes of the flies. Locate a female sepia Fruit Fly Card and a male wild type Fruit Fly Card from the Fruit Fly Genetics Card deck. Use the information from the *Background* section to help identify these cards.
3. Place these cards on the P squares of the Monohybrid Cross Sheet.



4. Record the corresponding gamete symbols in the Punnett square headers below the P generation. The gamete for each header of the Punnett square is simply one-half of each parent's genotype symbol. For example, the male wild type fly will have a + in each of the top two empty gamete boxes.
5. Complete this cross by writing in the genotype for each gamete combination in the four squares below the parent cards. The resulting genotype(s) represent the F1 generation.
6. Locate the corresponding Fruit Fly Cards for each F1 genotypes. The fruit fly cards may be male or female. Place the correct cards over each written genotypes for the F1 generation. Remember that the wild type gamete + is dominant. These cards represent the F1 phenotypes.
7. Cross an F1 female (would be virgin in an actual cross) with an F1 male. Record the genotype symbols for each of these flies next to the F1 Parents boxes.
8. Place a male Fruit Fly Card and female Fruit Fly Card from the F1 generation from step 7 on each of the F1 parent genotype symbols.
9. Record the corresponding gamete symbols in the Punnett square headers below F1 parent cards.
10. Complete this cross by writing in the genotype for each gamete combination in the four squares below the F1 parent cards. The resulting genotype(s) represent the F2 generation.
11. Locate and place the correct Fruit Fly Cards for each of the resulting F2 genotypes. The fruit fly cards may be male or female. Place the correct cards over the written genotypes for the F2 generation. These cards represent the F2 phenotypes.

## Disposal

The cards used in this activity may be saved and stored for future use.

## Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

### ***Unifying Concepts and Processes: Grades K–12***

Evidence, models, and explanation

Constancy, change, and measurement

### ***Content Standards: Grades 5–8***

Content Standard A: Science as Inquiry

Content Standard C: Life Science, structure and function in living systems, reproduction and heredity, populations and ecosystems, diversity and adaptations of organisms

### ***Content Standards: Grades 9–12***

Content Standard A: Science as Inquiry

Content Standard C: Life Science, the cell, molecular basis of heredity, biological evolution, interdependence of organisms; matter, energy, and organization in living systems

## The *Drosophila* Genetics Simulation is available from Flinn Scientific, Inc.

| Catalog No. | Description                           |
|-------------|---------------------------------------|
| FB1912      | <i>Drosophila</i> Genetics Simulation |

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.

MONOHYBRID CROSSES

P

se / se

+ / +

| Gametes | _____ | _____ |
|---------|-------|-------|
| _____   | _____ | _____ |
| _____   | _____ | _____ |

F<sub>1</sub> Parents

|       |       |
|-------|-------|
| _____ | _____ |
|-------|-------|

| Gametes | _____ | _____ |
|---------|-------|-------|
| _____   | _____ | _____ |
| _____   | _____ | _____ |