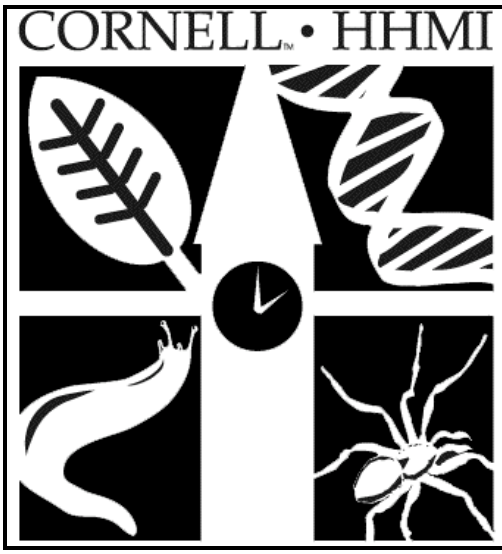

Cornell Institute for Biology Teachers

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Lab issued: October, 1994
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Title: Insect GENEration

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Appropriate Level: Middle School Life Science, Living Environment Regents

Abstract: Students build a model insect based upon genetic information provided to them in the lab directions. Gene forms (alleles) contributed by each parent are determined by tossing a coin with one side representing the dominant form of the gene and the other side representing the recessive form. Student teams record the genotype and phenotype for each trait and then construct the insect using inexpensive, readily available materials.

Time Required: Two class periods, about 40 minutes each

Special Needs: Materials for constructing small creatures

NYS Learning Standards: Standard 4: The Living Environment

Key Idea 2: Organisms inherit genetic information in a variety of ways that result in continuity of structure and function between parents and offspring.

2.1a Hereditary information is contained in genes. Genes are composed of DNA that makes up the chromosomes of cells.

2.1b Each gene carries a single unit of information. A single inherited trait of an individual can be determined by one pair or by many pairs of genes.

2.1e In sexual reproduction typically half of the genes come from each parent. Sexually produced offspring are not identical to either parent.

2.2a In all organisms genetic traits are passed on from generation to generation.

2.2b Some genes are dominant and some are recessive.

2.2c The probability of traits being expressed can be determined using models of genetic inheritance. Some models of prediction are pedigree charts and Punnet squares.

Teacher Information

By building insects based on nine genetic traits, students will achieve a better understanding of the role of probability in genetics. They should start to ask more thoughtful questions about the inheritance of traits.

Genetic information inherited by any organism plays an important part in determining its structure and function. Usually, genes come in pairs. Each gamete (egg or sperm) contains only one of each pair of parental genes. Thus each child receives half of his/her genetic information from each parent. Which one of the pair gets passed to a gamete is determined by chance alone.

This activity can be used to introduce or reinforce the understanding of basic genetic principles. The nine traits used in this activity are all determined by imaginary genes with one gene form being contributed by each parent. Each of the nine traits can come in either of two forms. Letter symbols are often used in genetics as symbols of gene forms. The letters **D** and **d** may be used to symbolize the gene forms or alleles. A capital letter (for example **D)** is used to symbolize the dominant allele. A lower case letter (**d)** is used to symbolize the recessive allele. An offspring inheriting the dominant form from each parent (**DD**) will express the dominant trait. An offspring with both the dominant and recessive forms (**Dd**) will also express the dominant trait. The dominant form masks the recessive form. An offspring inheriting the recessive allele from each parent (**dd**) will express the recessive trait. When the two alleles are the same (DD or dd), the organism is *homozygous* or *pure* for the trait. When the two alleles are different (Dd), the organism is *heterozygous* or a *hybrid*.

Genotype	Descriptive term	Phenotype (the trait that appears)
DD	homozygous dominant	dominant trait
dd	homozygous recessive	recessive trait
Dd	heterozygous	dominant trait

Punnett squares can be used to show the possible combination of alleles that the offspring may inherit for a given trait.

Parent #1 has the genotype **Dd** and may contribute a **D** or a **d** to the offspring

Parent #2 has the same genotype and may contribute the same alleles

	D	d
D	**DD**	**Dd**
d	**Dd**	**dd**

This Punnett square displays the possible genotypes of the offspring resulting from the cross of two parents who are both heterozygous for the trait. Notice there is a 75% chance the dominant trait will appear and a 25% chance the recessive trait will appear in any one offspring. An important point to stress is that each parent contributes an equal amount of genetic information.

In the next example, **Parent #1** has the genotype **DD** and may contribute only a **D** to the offspring. **Parent #2** has the genotype **dd** and may contribute only a **d** to the offspring.

	D	D
d	**Dd**	**Dd**
d	**Dd**	**Dd**

Notice that in this cross between two individuals (one homozygous dominant and the other homozygous recessive) the only combination of alleles possible is **Dd**. All offspring will be heterozygous for the trait or hybrid. The genotypes **DD** or **dd** are not possible.

It is worthwhile to note that there are a variety of factors that influence the expression of traits. Students may ask why an organism inheriting the heterozygous condition (**Dd**) for antennae does not have something between straight and curly antennae. In some instances an intermediate phenotype is expressed and this type of inheritance pattern is called *incomplete dominance*. This is analogous to mixing red and white paint to produce pink. Students may ask why some traits appear more frequently in one sex than the other. An example of a *sex-linked* trait in humans is color blindness that appears more often in the male population. Students should be encouraged to research other mechanisms not addressed in this activity.

It may be valuable to demonstrate why traits that are dominant always appear. Color is usually dominant over lack of color. Use **C** to symbolize the dominant allele for color and **c** to symbolize the recessive allele for the lack of color. Hold two colored pieces of plastic together and ask students what they observe. Then hold two clear pieces of plastic up together and again ask students what they observe. Next hold a colored piece of plastic and clear piece of plastic together. Have students

observe that lack of color is shown only by combining two pieces of clear plastic. In summary **CC** or **Cc = color** and only **cc = colorless**.

To focus student attention and to generate interest, display charts of mouthparts and other insect structures. Post them around the room. If you have any mounted specimens, also have them in visible places.

Coins will be used to represent the genetic information of parent insects. Initially all parents will be heterozygous for all nine traits. Using a marking pen label one side of a coin with **DOM** and **REC** on the flip side. Of course two parent coins will be needed to determine the genotype for each trait. Another way to accomplish this is to use plastic Bingo chips. You can also use White Out to mark one side of the chip or coin. This will represent the dominant allele. Leave the other side blank. This will be the recessive allele. Students can then toss two chips just as they would toss coins to determine the alleles inherited by the offspring.

After each 'parent coin' or each chip has been tossed, students will record the outcome by checking either the dominant (capital letter) or the recessive (lower case letter) on the record sheet. In the chart in the student section, the appropriate box for genotype and phenotype boxes have been checked for the humps and antennae traits. From the example data checked in the sample record sheet, the students will build a model insect with three humps (a recessive characteristic) and straight antennae (a dominant characteristic).

It is suggested that the record sheet should be completed for all nine traits **before** the insect is built.

Procedure

A. Building the Insects

Materials

Students will be working in small groups of 2. They will need the following items:

- Pushpins – 1 pair of round and 1 pair of longer ones.
- Flat top thumbtacks
- 2 foam cylinders, one large, one short
- 6 colored toothpicks, regular size
- 6 colored toothpicks, cut in half
- 4 plain toothpicks, regular size
- 4 small squares of foam
- 1 styrofoam egg
- 1 styrofoam ball
- Colored wire, 2 pieces in spiral, and 2 straight pieces
- 4 pieces of cut out foam sheet, for the wings: 2 pointy, 2 round ones
- 1 screw-in hook
- 2 pieces of cut drinking straw – one long and one short
- 3 insulated staples
- Coins or plastic chips

Supply each group with a box containing all the materials needed. Each group will need all the materials for both the dominant and recessive characteristics. Materials can be easily found at dollar stores and craft stores.

Head	Styrofoam ball attached to the thorax by short toothpicks.
Antennae	Wire that will hold its shape. Curly antennae can be made by wrapping wire around a pencil.
Eyes	Use flat top thumbtacks or use regular push pins.
Mouth parts	Small piece of a drinking straw should be used to represent the mouth. Two pieces are needed: one long and one short.
Thorax	Foam cylinder. Two pieces are needed: one long and one short. You can cut these pieces from a 'swim noodle'.
Legs	Colored toothpicks.
Foot pads	Small squares of foam.
Wing size	Wings may be cut from a foam sheet.
Abdomen	Styrofoam egg attached to abdomen with part of a toothpick. A screw-in hook should be used to represent the stinger, if present.
Humps	Use insulated staples

The insect should be constructed in such a way as to follow the general insect body plan as closely as possible. Remind students that the legs and wings are attached to the thorax, the middle body section.

Make a transparency of the Record Sheet Insect Generation Table on page 4 of the Student Section and model how the students are expected to fill this in. Also, display the last two pages of the student section, the chart with the picture and 'function' of the materials they will be using, for quick reference.

Warn students that they might have to adjust the legs in order to avoid the insect from tipping; otherwise they can place playdough inside the empty space inside the thorax to achieve balance. To avoid student frustration you might want to model this at the start of the lab.

Estimated Amount of Time for Lab and Typical Results Expected

The activity will take 2-3 class periods. This will allow time for some introduction of terminology and basic genetic principles and to set expectations for the activity. Additional time will be needed to complete extensions.

For any one trait, since both parents are heterozygous, a 75% chance is expected for the appearance of the dominant characteristic. However, it is unlikely the offspring will inherit all nine dominant characteristics. Probably no two insect offspring will have exactly the same phenotypes for all traits.

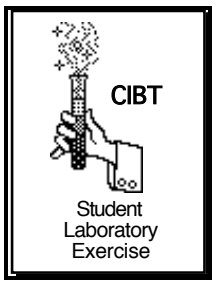
Assessment for the Lab Along with Rubrics

The record sheet and the model insect can be compared for accuracy. Also the insect should be constructed to reflect the general insect body plan. Observed effort and cooperation in the group can also be used in determining the success of each student.

More Ideas and Extensions

- Students could cross the insect "born" to their group with an insect "born" to another group and draw the phenotype of the resulting offspring.
- Students could determine genotype and phenotype probabilities of any given trait or traits by using Punnett squares. This could be based upon the possible crosses of their insect with another group's insect.
- Students could select a couple of traits that would be advantageous in a particular environment and then choose one insect from the class that they could cross theirs with to achieve the particular phenotype they are looking for. They could explain their selection and predict the offspring and the teacher can introduce the concept of selective breeding.
- Traits of real insect specimens or models could be evaluated for adaptability to a particular environment. Students could select an ecosystem such as a forest, pond, or desert; research the abiotic and biotic conditions that would directly impact their insect specimen or model; and then decide whether the insect would be able to survive in that particular environment.
- Students could design and build an insect with characteristics favorable to a described environment.
- Phenotypes and/or genotypes of the insect models could be compared.
- Students could investigate insect adaptations such as camouflage, mouthpart structure, wing structure, antennae, etc.
- Traits could be followed using live fruit flies.
- Differences among insects in the classroom can be used to illustrate Darwin's concept of 'variation within a population', which is sometimes hard for students to grasp.

Insect GENEration



How are traits passed from parents to offspring? In this activity, you will construct a model insect with nine different genetic traits that will be determined by chance.

Background

In this activity you will build an imaginary insect. The phenotype of this insect will be determined by its genotype. You will consider nine different traits, each of which is determined by a different gene. Each parent is heterozygous or hybrid for each of nine different genes. The *Record Sheet Insect GENEration* on page 4 shows the "traits" and indicates which allele or form is dominant for each gene.

Since each parent is heterozygous for each gene, either allele may be passed on to any given reproductive cell (sperm or egg). You will use a coin or a chip to represent the random process, which determines whether a dominant or recessive allele gets passed on to the offspring. Of course, since each parent passes on one allele for each gene, you need to use the coin twice for each gene being considered or use two coins at the same time. One side of the coin represents the dominant allele (**DOM**) under consideration, while the other side represents the recessive allele (**REC**).

If coins are going to be used, write here which side determines which allele:

Heads:_____

Tails:_____

Notice on the record sheet that letter symbols are used to represent gene forms. Each parent can contribute either a dominant allele such as D or a recessive allele d. There is a 50% chance either the dominant (D) or the recessive (d) allele will be carried by each sex cell produced. The possible combinations of gene forms or the genotype and the phenotypes are shown in the table below.

Genotype (possible gene forms)	Genetic Term	Descriptive term	Phenotype (trait that appears)
DD	homozygous dominant	pure dominant	dominant trait
dd	homozygous recessive	pure recessive	recessive trait
Dd	heterozygous dominant	hybrid	dominant trait

An offspring inheriting the genotype DD or Dd will show the dominant trait since the dominant characteristic is the one expressed. An offspring inheriting the genotype dd will show the recessive phenotype.

Materials

Each team of two students will need the following materials to build the model insect. Make sure you have all these materials before you start assembling your insect:

- Pushpins – 1 pair of round and 1 pair of longer ones
- 2 flat top thumbtacks
- 2 foam cylinders, one large, one short
- 6 colored toothpicks, regular size
- 6 colored toothpicks, cut in half
- 4 plain toothpicks, regular size
- 6 small squares of foam
- 1 styrofoam egg
- 1 styrofoam ball
- Colored wire, 2 pieces in spiral, and 2 straight pieces
- 4 pieces of cut out foam sheet, for the wings: 2 pointy, 2 round ones
- 1 screw-in hook
- 2 pieces of cut drinking straw – one long and one short
- 3 insulated staples
- Coins or plastic chips

Procedure

A team of two students will construct a model insect. You and your partner should each get one or two coins or plastic chips with a gene form indicated on each side. After tossing the coin it will land either **DOM** or **REC** side up. Of course two parent coins will be needed to determine the genotype for each trait. Check the dominant or recessive allele in the parent columns for each trait on the *Record Sheet Insect GENEration* on page 4. Then check one box in the offspring genotype column and phenotype column. Examine the examples shown in part of the student record sheet that follows.

Dominant traits are in CAPITALS; recessive traits are in lower case

Traits DOM or rec	Parent 1 Gene Check one box for each trait.	Parent 2 Gene Check one box for each trait.	Offspring Genotype Check one box for each trait.	Offspring Phenotype Check one box for each trait.
Humps TWO HUMPS or Three humps	☐ H ☑ h	☐ H ☑ h	☐ HH ☐ Hh ☑ hh	☐ TWO HUMPS ☑ three humps
Antennae STRAIGHT or curly	☑ N ☐ n	☐ N ☑ n	☐ NN ☑ Nn ☐ nn	☑ STRAIGHT or ☐ curly

For the hump trait the genotype **hh** was checked since each of the parent coins landed with the recessive side up. Therefore the expressed characteristic or phenotype in this offspring will be the recessive three humps. The Nn genotype was checked for the antennae trait since one parent coin landed with the dominant side up and the other parent coin landed with the recessive side up. The resulting phenotype is antennae that are straight. NN or Nn genotypes will code for the dominant characteristic. **After finding the phenotype for all nine traits, build your insect.**

Building the Insect

The insect should be constructed in such a way as to follow the general insect body plan as closely as possible. Be careful to attach wings and legs to the middle body section of the insect – the thorax.

General Insect Body plan		
Head	**Thorax**	**Abdomen**
Compound eyes	Three pairs of legs	Stinger
Antennae	Wings	
Mouthparts	Humps	

- **Thorax:** Use a cylinder of foam, long or short.
- **Head:** Attach a styrofoam ball to the thorax (cylinder of foam) using a plain toothpick.

- **Antennae:** Use wire that will hold its shape. These can be spiral or straight and should be attached to the head.
- **Eyes:** Use pushpins, either round or long.
- **Mouthparts:** Use a piece of a plastic straw. It can be long or short.
- **Legs:** Colored toothpicks. They could be long or short.
- **Foot pads:** Small squares of foam may be used and should be attached to the legs.
- **Wing shape:** Wings are either round or pointy, cut from a foam sheet and attached to the thorax.
- **Abdomen:** Fasten a styrofoam egg with part of a toothpick to the thorax. If a stinger is present, a screw-in hook should be used to represent it.
- **Humps** Insulated staples. The insect can have either three or two, attached to the thorax.

Record Sheet-Insect GENEration

Parent 1: HhNnEeMmTtLlFfWwAa **Parent 2: HhNnEeMmTtLlFfWwAa**

Traits- Dominant characteristic in CAPITALS / Recessive characteristic in lower case	**Parent 1._____** (write your initials) **Check one box for each trait contributed by this parent.**	**Parent 2 ._____** (write your partner's initials) **Check one box for each trait contributed by this parent.**	**Offspring Genotype** **Check one box for each trait for the corresponding genotype.**	**Offspring Phenotype** **Check one box for each trait for the corresponding phenotype.**
Humps TWO or Three Humps on the thorax	❑ H ❑ h	❑ H ❑ h	❑ HH ❑ Hh ❑ hh	❑ 2 HUMPS ❑ 3 humps
Antennae STRAIGHT or curly	❑ N ❑ n	❑ N ❑ n	❑ NN ❑ Nn ❑ nn	❑ STRAIGHT or ❑ curly
Eyes ROUND or long	❑ E ❑ e	❑ E ❑ e	❑ EE ❑ Ee ❑ ee	❑ ROUND or ❑ long
Mouthparts LONG or short	❑ M ❑ m	❑ M ❑ m	❑ MM ❑ Mm ❑ mm	❑ LONG or ❑ short
Thorax LARGE or small	❑ T ❑ t	❑ T ❑ t	❑ TT ❑ Tt ❑ tt	❑ LARGE or ❑ small
Legs LONG or short	❑ L ❑ l	❑ L ❑ l	❑ LL ❑ Ll ❑ ll	❑ LONG or ❑ short
Foot pads PRESENT or not present	❑ F ❑ f	❑ F ❑ f	❑ FF ❑ Ff ❑ ff	❑ PRESENT or ❑ not present
Wing shape ROUND or pointy	❑ W ❑ w	❑ W ❑ w	❑ WW ❑ Ww ❑ ww	❑ ROUND or ❑ pointy
Abdomen Styrofoam egg WITH or without stinger	❑ A ❑ a	❑ A ❑ a	❑ AA ❑ Aa ❑ aa	❑ ABDOMEN WITH STINGER or ❑ abdomen without stinger

Questions

1. Write down the complete genotype of your offspring insect:

   _____

2. How many traits expressed in the insect you built were dominant characteristics?_____

3. How many of these dominant characteristics were pure or homozygous?_____

4. How many traits expressed in the insect were recessive characteristics?_____

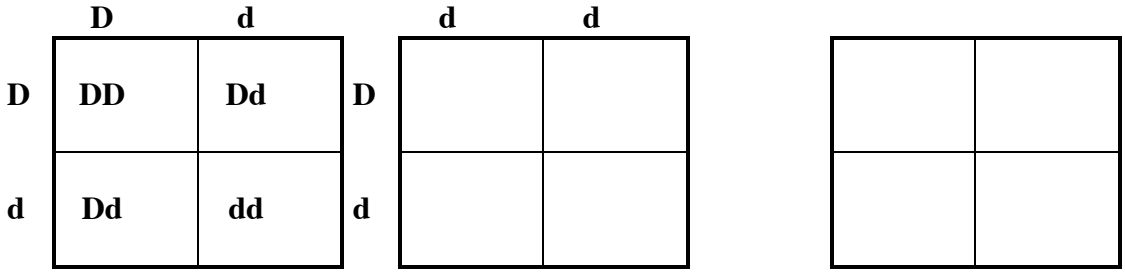
5. Would you expect more dominant or more recessive characteristics to appear in the offspring? Explain your answer.

6. Explain how it is possible that an offspring does not have round wings when both parents do have round wings.

More Ideas and Extensions

1. Cross your insect with an insect from another group. Record the results of your cross on another sheet. The Punnett square below shows the possible combination of alleles that the offspring may inherit.

Parent #1 has the genotype **Dd** and may contribute a **D** or a **d** to the offspring
Parent #2 has the same genotype and may contribute the same alleles



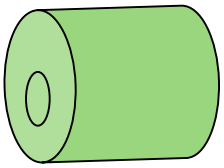
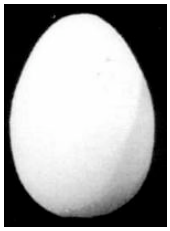
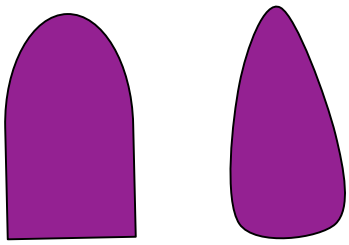
This Punnett square shows the possible genotypes of the offspring resulting from the cross of the two parents shown above who are both hybrid for the trait. Draw your own squares and use them to figure out the genotype of the offspring from your insect and another group's insect.

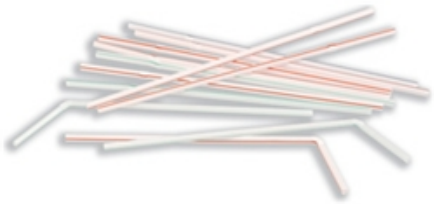
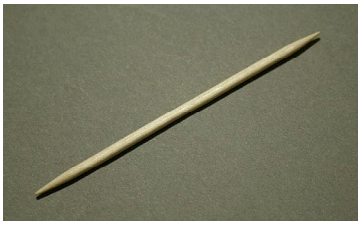
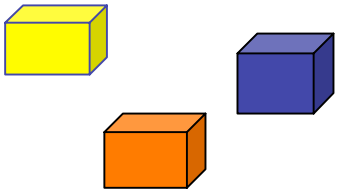
2. Survey the class and design a table that summarizes the phenotypes expressed in all the models built. Include totals that reflect the frequency of characteristics.

3. Cross live fruit flies to follow a trait.

4. Research a genetic disease such as cystic fibrosis.

5. Use the variations among the insects to discuss Darwin's concept of variation within a population.

Styrofoam ball	Head	
Green foam cylinder	Thorax	
Colored wire	Antennae (spiral or straight)	
Styrofoam egg	Abdomen	
Flathead thumbtacks	Use these to attach the wings to the thorax	
Foam cut-outs	Use for the wings (round or pointy)	

Piece of a plastic straw	Use for the mouth (short or long)	
Plain toothpicks	Use these to attach the head and the abdomen to the thorax	
Colored toothpicks	Use for the legs of the insect (long or short)	
Small squares of foam	Use as foot pads (present or absent) attached to the legs	
Insulated staples	Two or three humps attached to the back of the thorax	
Screw-in hook	Use for the stinger in the abdomen (present or absent)	

Pushpins (long or round)	Eyes (round or not)