EXPLORATIONS

Activity 4

Hello Dolly

In this activity, you will:

- Draw a model of a Punnett Square on the TI-73
- Discover all the possible combinations of genotypes
- Explore experimental and theoretical probability
- Generate data using experimental probability and the laws of heredity

Introduction

You may have noticed that offspring often resemble their parents. Tall parents with black hair often have tall children with black hair. However, they do not look exactly alike. Over 100 years ago, Gregor Mendel, an Austrian monk, became interested in this problem of how parents pass on characteristics to their offspring. He began experimenting on pea plants, which led to some important discoveries about heredity. A few years later, Reginald C. Punnett, an English geneticist, developed a model called the Punnett Square to show the possible ways alleles can combine at fertilization.

Alleles are the different forms a gene may have for a trait. In the Punnett Square, dominant alleles are shown with capital letters and recessive alleles are shown with the same letter in lower case. Using a 2 by 2 square, letters representing the parent's alleles are placed on the outer sides of the large square. Letters inside the smaller squares show the possible allele combinations for their offspring. If one allele is dominant, the recessive allele will be masked in the offspring. If two alleles are the same, then the form is pure. Pure traits have both dominant alleles, or both recessive alleles.

A form of the trait that is a combination of dominant and recessive alleles is called a *hybrid* trait. The model on the next page shows the results of a cross between pure tall and pure short plants where **T** represents the dominant

alleles for tallness and **t** represents the recessive alleles for shortness. The offspring are pure hybrid tall. The genotypes are shown in the cells of the Punnett Square below, while the effect of the indicated combinations is called the Phenotypes. For example, if the genotype is **Tt,** the phenotype will be tall.

Parent 1

|		T	T
Parent 2	t	Tt	Tt
	t	Tt	Tt

The Problem

In humans, free earlobes are a dominant trait over attached earlobes. Draw a Punnett square for each possible parent combination. Find the theoretical and experimental probability for the offspring.

Activity

1. Working in groups, draw Punnett squares using the draw function on the TI-73 for all the possible parent combinations. Let **F** represent free earlobes allele, which is the dominant trait, and **A** represent attached earlobes, which is the recessive allele.

2. Draw a 2 by 2 square.

   a. With the **Plots** and **Y=** functions turned off, and with the Mode in the default setting (as explained in the TI-73 Manual), set the window to 1st quadrant by pressing ZOOM and select **4:Zquadrant1**.

   b. Press WINDOW and change **Ymax** to 6.2 so you will have a square window.

   c. Press 2nd [FORMAT] and highlight **AxesOff** by moving the cursor over the word and pressing ENTER.

   d. Press GRAPH to go to the graph screen.

   e. To use the pen option from the **DRAW** menu to draw a 2 by 2 square, press DRAW and select **8:Pen**.

   f. In the graph screen, use the arrow keys to move to the coordinates (1, 1).

   g. Press ENTER to start drawing.

   h. Move horizontally using the arrow keys to coordinates (5, 1), being careful not to overshoot the point since you are leaving a trail.

   i. Move vertically up to coordinates (5, 5).

   j. Finish the square by moving to coordinates (1, 5) then back to the starting point of (1, 1).

   k. Turn the pen off by pressing ENTER.

l. Now, go to the midpoint (3, 1) of the lower horizontal segment.

m. Turn the pen back on by pressing [ENTER], and then go to midpoint of the upper horizontal segment.

n. Go through same process to connect the midpoints of the vertical segments.
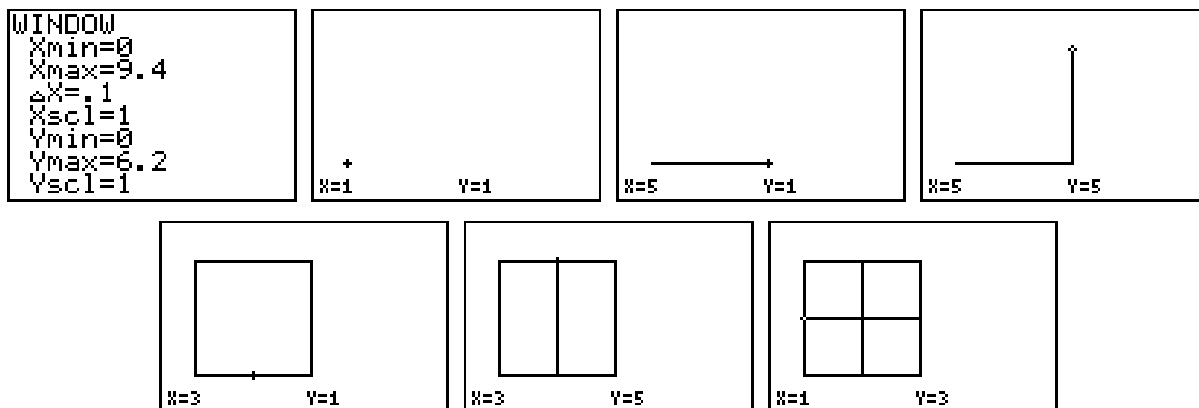
3. Each group of students should have members numbered 1 through 4. The "Ones" should draw a Punnett Square that is pure dominant (**FF**, **FF**). The "Twos" should draw a Punnett Square that is pure recessive (**AA**, **AA**). The "Threes" should draw a Punnett Square that is pure hybrid (**FF**, **AA**). The "Fours" should draw one of their choice different than the other three. Use the text option from the **Draw** menu to label the models.

4. Position the cursor above the square to label the top side around coordinates (2, 5.7).

a. Text letters are about 5 pixels tall. A pixel will be one press of the arrow key. Make sure you are at least 6 pixels above the side of the square so that there is enough space for the text.

b. Press [DRAW] and select the **7:Text(** option.

c. After you have moved to the correct position, press [2nd] [TEXT], and highlight **F.**

d. Press [ENTER], move the cursor down to **Done**, and then press [ENTER] to paste **F** above the square.

e. Move right to the midpoint of the adjacent box and place another **F** using the same technique as before.

f. On the left vertical side, type **A** and a second **A** underneath it. This is the model of the pure hybrid.

g. Complete the inside of the square.

✎ Answer questions 1 and 2 on student data sheet.
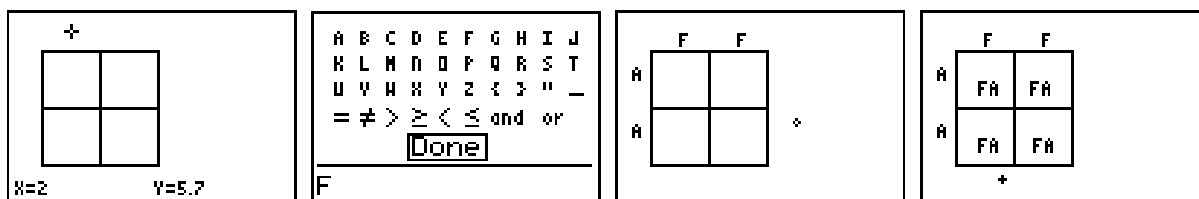
5. Save your drawing before you move on. This may be done with the
   TI-GRAPH LINK™ or by saving it as a **Pic**.

   a. To save as a **Pic**, from the Home screen ([2nd] [QUIT]), press [DRAW] [◄] and
      select the **1:StorePic** option by pressing [ENTER].

   b. Press the number that you want to use to name this **Pic**. Note that you
      may only use the numbers 1, 2, or 3 and that the old **Pic** with the
      name (number) selected will be erased by the new one.

6. Working in pairs, use the coin toss function of the TI-73 to simulate the
   birth of 40 offspring to a pair of hybrid parents (**FA, FA**).

   a. From the Home screen, press [MATH] [▶] [▶].

   b. Select the **6:coin(** option.

   c. Type the number **2** (to simulate tossing two coins).

   d. Repeatedly press [ENTER] (tossing the two coins).

      Which outcome is more likely when you toss a coin: a head or a tail? It
      is equally likely that a hybrid parent will pass a dominant or recessive
      allele to its offspring.

      A head will be represented by a **1** on the coin toss simulation and will
      represent the dominant allele, whereas a tail (which we will call **0**)
      will represent the recessive allele.

   e. Press [CLEAR] to clean the Home screen. Press [ENTER] and this will
      represent the genotypes when sperm and egg join. A **1** means a
      dominant allele (free earlobes) is passed by one parent and a **0** means
      a recessive allele (attached earlobes) is passed by the other parent.

✎ Record your data on Table 1 (question 3 on the student data sheet)
   initially using tally marks (XX Tally columns), and then record the
   frequencies (XX columns).

   The example above represents **FF**, **AA**, and **FA**. Remember that {1,0}
   and {0,1} are the same combinations.

✎ Answer questions 4 - 10 on the student data sheet.

7. Generate a circle graph to compare the probabilities of each gene combination.

  a. Create two lists in the List Editor, **PAIR** (for genotype) and **FREQ** (for the frequency). See the TI-73 manual for information on naming lists.

  b. In the **PAIR** list, enter the 3 possible pairs. The first element in the pair list must be in quotes since this is a categorical list.

  c. Enter the corresponding frequencies in the **FREQ** list from Table 1.
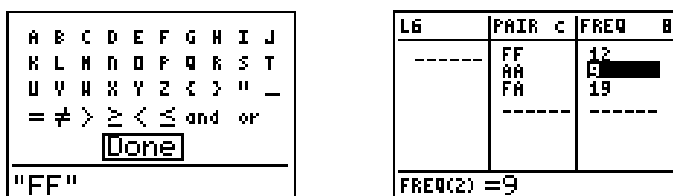
  d. Turn all plots **Off** by pressing [2nd] [PLOT] [4] [ENTER].

  e. Display the **STAT PLOTS** menu by pressing [2nd] [PLOT].

  f. Define **Plot1** as a circle graph as shown below.

  g. Display the plot by pressing [GRAPH]. Print one copy of your results if TI-GRAPH LINK™ is available, or save this graph as a **Pic**.
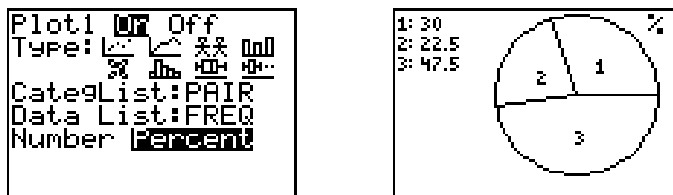
8. Turn in your data.

  a. To do this, let List 1 (**L1**) represent group 1's data, List 2 represent group 2's data, and so on. If there are more than six groups, the other groups will have to be named lists.

  b. One person in each group should call out the frequencies for each outcome.

  c. Record this information on Table 2 (question 11 on the student data sheet) and then add to get a total.

  d. Create a list called **TFREQ** (total frequency).

  e. Enter the class data into this list and create a 2nd circle graph on **Plot2**. Make sure you turn off **Plot1** before displaying **Plot2**.

  f. Trace around this graph to verify the data.



✎ Answer questions 12-13 on the student data sheet.

9. Create a third statistical plot (pictograph) for either the group or the class data. Use the following **STAT PLOTS** selections. The scale tells the calculator the quantity represented by each icon. However, the calculator displays no more than seven icons for each category. So you will need to set the scale according to the greatest frequency.

```
Plot3 On Off
Type: ⌐ ∠ ▦ ▥
      ⊕ ▟ ▦ ▦
CategList:PAIR
Data List:FREQ
Scale:3
Vert Hor
Icon:⛄ ♣ $ ▣ ⊚ ◇ ✳
```

10. Press GRAPH TRACE and discuss.

```
                ✳
                ✳
                ✳
                ✳
  ✳         ✳   ✳
  ✳    ✳    ✳   ✳
  ✳    ✳    ✳   ✳
  ✳    ✳    ✳   ✳
PAIR:FA        FREQ:19
```
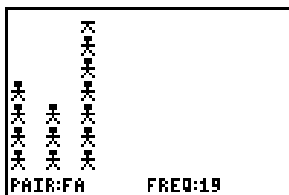
Going Further

1. A family consisted of the mother, father and two children. The mother had attached earlobes and the father had free earlobes. One child had attached and the other had free. Explain how this is possible.

2. Using the TFREQ list, and using the fact that the free earlobe allele is dominant, calculate the percent of the offspring that would have the free earlobes phenotype.

3. Given the following data from a class in Dallas, create a graph representing the genotype distributions.

Genotype	Frequency
MM	117
MN	221
NN	101

4. Create two different Punnett Squares that would create a person with the **NN** genotype from the above Dallas data.

┌─────────────────────────────┐
│ **Student Data Collection** │
│   **and Analysis Sheet**   │
└─────────────────────────────┘

Name(s) _____

Date _____

Activity 4

Hello Dolly

1. For each cross between two parents, what is the probability of the offspring receiving any one of the four combinations?

_____

2. Draw and label all possible Punnett Squares showing combinations of parents and offspring.

3. Complete Table 1.

Table 1

Genotypes	FF Tally	FF	AA Tally	AA	FA Tally	FA	Total Trials
Total							40
Class Total							

4. Of the 40 offspring in your sample, how many were pure dominant (**FF**)?

_____

5. How many out of the 40 did you expect to be pure dominant? _____

6. Which of the three gene combinations occurred the most?

_____

7. What is the theoretical probability (what is supposed to happen) of an offspring having pure dominant genes? _____

What is the theoretical probability of an offspring having hybrid genes?

_____

What is the theoretical probability of an offspring having pure recessive genes? _____

8. Which gene combination did you expect to occur the most and why?

_____

_____

9. Find the experimental probability (from your experiment) of an offspring having pure dominant genes._____

Find the experimental probability (from your experiment) of an offspring having hybrid genes._____

Find the experimental probability (from your experiment) of an offspring having pure recessive genes._____

10. Describe how these results compare to the theoretical probability._____

11. Complete Table 2 below.

Table 2

Genotype	Group 1 L1	Group 2 L2	Group 3 L3	Group 4 L4	Group 5 L5	Group 6 L6	Tally LTFREQ
FF							
AA							
FA							

12. Find the experimental probability (using the whole class data) of an offspring having pure dominant genes._____

Find the experimental probability (using the whole class data) of an offspring having hybrid genes._____

Find the experimental probability (using the whole class data) of an offspring having pure recessive genes._____

13. How do these results compare to the theoretical probability?

_____

Teacher Notes

Math Strands: Number Sense, and Data Analysis

Students will draw a model of a Punnett Square on the TI-73 and discover all of the possible combinations of Genotypes. Experimental and theoretical probability will be explored.

Science Strands: Life Science

Collecting data through experimental probability and using the laws of heredity.

Classroom Management and Safety

Place students in groups of four. A printout of all possible combinations of the model Punnett Square combinations can be done using TI-GRAPH LINK™ if the classroom is equipped.

Activity

1. The setting on page 2 for the **WINDOW** is required to give "nice" values to draw on. They have **X**-values as a multiple of 94 and **Y**-values as a multiple of 62.

2. If the students mess up on the drawing of the Punnett Square, they can start again by selecting the **ClrDraw** option from the Draw menu or the Catalog and pressing ENTER .

3. When placing the text, the screen is set so that a pixel is 0.1 in value since ⌂X and ⌂Y are equal to 0.1. But with the Text mode you don't see the coordinates, so the students should just count up from the line of the square. One press of the arrow key is one pixel (0.1 in value).

4. Students will need to leave the Text placement mode before they save or transfer their drawing of the square so that they don't mess it up with the commands appearing on the screen. If this happens they may "clean up" the screen using the **Pt-Off(** options from the **Draw/Points** menu.

5. Explain to the students that (**FF**, **AA**) is the same combination as (**AA**, **FF**). Likewise **FA** is the same as **AF**. However, the dominant trait/allele should be listed first. In a combination, the order does not matter. Survey the "Fours" in each group to get their parent combinations and have them display the other three possibilities which are: (**FA**, **FA**), (**FA**, **AA**), (**FF**, **FA**). There are a total of 6 possible parent combinations that could be calculated by taking a combination of 4 traits 2 at a time.
    $C(4, 2)=(4*3)/(2*1)$. This combination can also be calculated on the TI-73 by typing 4 , then MATH ▶ ▶ to the **PRB** menu. Then select **4:nCr** and type 2 ENTER .

6. To collect the class data, you may try this procedure. You (not the students) enter the group totals of each outcome on a viewscreen calculator and tell the students to record the data on their table.

7. To the right of the list named **Pair**, insert List 1 (**L1**). Ask a member of group 1 to give the frequencies in this order (same as on table) **FF**, **AA**, **FA**. Insert List 2 to the right of List 1 if it is not already there. Ask a member of group 2 to give their group frequencies as above. Continue doing this, using lists 3-6 until all groups have been collected. If there are more than 6 groups, the remaining groups could be named **GRP7**, **GRP8**, and so forth. After all of the groups data has been entered into the lists, name a list **TFREQ** for total frequencies. Enter the formula **L1**+ **L2**+ **L3**+ **L4**+… to get the total frequencies of each outcome for the entire class. The students will need this named list (**TFREQ**) to enter the data after you have the totals, which can be sent through the data link cable. (See the TI-73 manual for information on linking between calculators.)

8. You can discuss how a small sample compared to the larger sample.

9. Additional information can be found on the Internet at various locations including: **http://www.netspace.org/MendelWeb/** and from Access Excellence® at **http://www.gene.com/ae/**.

10. Topics such as sickle-cell anemia and the Human Genome Project (**http://www.ornl.gov/TechResources/Human_Genome/home.html**) would be good extensions or lead-ins for this investigation.
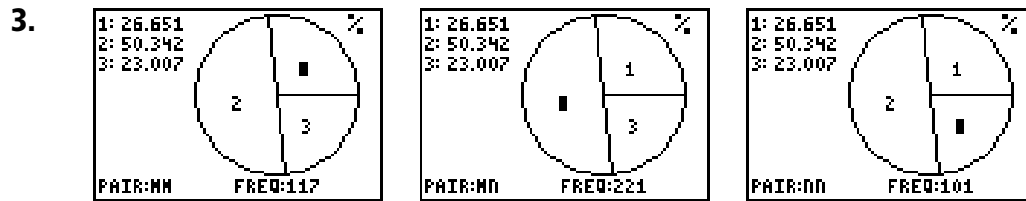
Student Data Collection and Analysis Sheet – Key

1. 1 out of 4.

2. Drawings.

3. Answers will vary, but check totals.

4. From Table 1.

5. 1/4 of 40, or 10.

6. **FA**.

7. 1/2, 1/4, 1/2.

8. **FA**, because the probability of this outcome is 1/2, whereas the other two outcomes each just have a probability of 1/4.

9. From Table 1.

10. Answers will vary, but the data should be similar.

11. Table 2.

12. See Table 2.

13. Again answers will vary, but now they should be closer to the theoretical.

Going Further – Key

1. The father has a genotype of **FA** and the mother has **AA**.

2. $\dfrac{FF + FA}{FF + FA + AA} * 100$

3.

1: 26.651 2: 50.342 3: 23.007 % PAIR:MM FREQ:117	1: 26.651 2: 50.342 3: 23.007 % PAIR:MN FREQ:221	1: 26.651 2: 50.342 3: 23.007 % PAIR:NN FREQ:101

4. **NN** by **NN** and **NN** by **MN** squares.