

The Cotton-Swab Orchard: How Do Bees Turn Blossoms into Almonds?

Investigation question: In a model almond orchard, how do the arrangement of two varieties and the number of bee visits change how many blossoms receive pollen from the other variety and can set a nut?

Physical model

Groups of 4

1 session

Setup 5 · Activity 45 · Cleanup 5 min

MS-LS2-5 · practice

MS-LS2-2 · supports

Name _____

Group _____

Date _____

Your role today

- ☐ **Bee:** Moves the swab one blossom per visit by the die rule, delivers pollen to the stigma, then loads pollen from the petals, and grooms the swab every fourth visit.
- ☐ **Navigator:** Draws the starting blossom, rolls the die, calls each move aloud, rerolls moves that would leave the orchard, and tallies visits.
- ☐ **Inspector:** After each trial checks every stigma label with a hand lens and calls O (other-variety color), S (own color only) or N (no chalk).
- ☐ **Recorder:** Fills the group data table, calculates nut set, posts results to the class table, and makes sure roles rotate so everyone is the Bee at least once.

Safety

- Chalk dust can irritate eyes and airways. Rub chalk gently, never blow on the mats, and keep dust on the tray; students with asthma can take a role that does not handle chalk.
- Cotton swabs stay out of ears, noses and mouths; use one swab per trial and throw it away afterward.
- Wash hands after the lab, because chalk on fingers ends up in eyes and on food.
- No live bees or real flowers are used. If you add real blossoms as a demonstration, check first for pollen allergies.

Procedure

1. Read the recording-sheet background and layout key, then answer q1: predict which layout will set the most nuts in 20 visits, using the bee's movement rule in your reasoning.
2. Prepare the mats. Rub chalk on the petals of each blossom in the color marked (B blue, P pink) until they are well dusted; leave the center white. Stick a fresh white label in the center of every blossom: it is that blossom's stigma.
3. Learn the visit rule. At each visit the Bee (a) presses the swab tip once on the stigma label to deliver whatever pollen it carries, then (b) rolls the swab tip once around that blossom's petals to load its pollen.

After every fourth visit, the Bee wipes the swab twice across the paper towel, standing for the way bees groom much of their pollen into their pollen baskets.

4. Learn the movement rule. Draw a slip to choose the starting blossom. Before each later visit the Navigator rolls: 1 or 2 = one blossom right along the row, 3 or 4 = one blossom left along the row, 5 = up one row, 6 = down one row. If the move would leave the orchard, roll again. Revisiting a blossom counts as a visit. (Observers often report that honey bees work along a tree row more than across rows; this rule builds in that tendency.)
5. Trial 1: run 20 visits on Layout 1 (Blocks) with a new swab. The Inspector then checks every stigma and records O (shows any of the other variety's color), S (shows only its own variety's color) or N (no chalk). Only an O blossom can set a nut.
6. Rotate roles. Replace all 20 stigma labels, re-dust any faint petals, and run Trial 2 on Layout 2 (Alternating rows) and Trial 3 on Layout 3 (Mixed in rows), 20 visits each with a new swab each time.
7. Trial 4, half the bees: run Layout 2 again with only 10 visits. For every trial calculate nut set (%) = number of O blossoms / 20 x 100.
8. Post your four nut-set results on the class table, copy the class data, compute the class mean for each trial, plot the means on the graph, and answer q2-q5 as a group.
9. Clean up: peel off and discard labels and swabs, fold the chalk dust into the newspaper and throw it away, wipe trays, and wash hands. Answer the analysis questions individually in class or for homework.

Record your observations

Lab 1 recording sheet: The Cotton-Swab Orchard

Most almond varieties cannot be fertilized by pollen from their own variety. A blossom can set a nut only if a pollinator brings pollen from a **different, compatible variety**. In this model, **blue (B)** blossoms are the main variety (call it Nonpareil, the most widely planted variety) and **pink (P)** blossoms are a pollinizer variety planted to supply compatible pollen. The chalk on the petals is pollen, the white label in the center is the stigma, and your cotton swab is one honey bee.

Layout key: B = blue, P = pink, rows listed from the top

Row	Layout 1: Blocks	Layout 2: Alternating rows	Layout 3: Mixed in rows
Row 1	B B B B B	B B B B B	B P B P B
Row 2	B B B B B	P P P P P	P B P B P
Row 3	P P P P P	B B B B B	B P B P B
Row 4	P P P P P	P P P P P	P B P B P

- Before you start: which layout do you predict will set the most nuts in 20 visits, and which the fewest? Use the movement rule (bees mostly move along rows) in your reasoning.

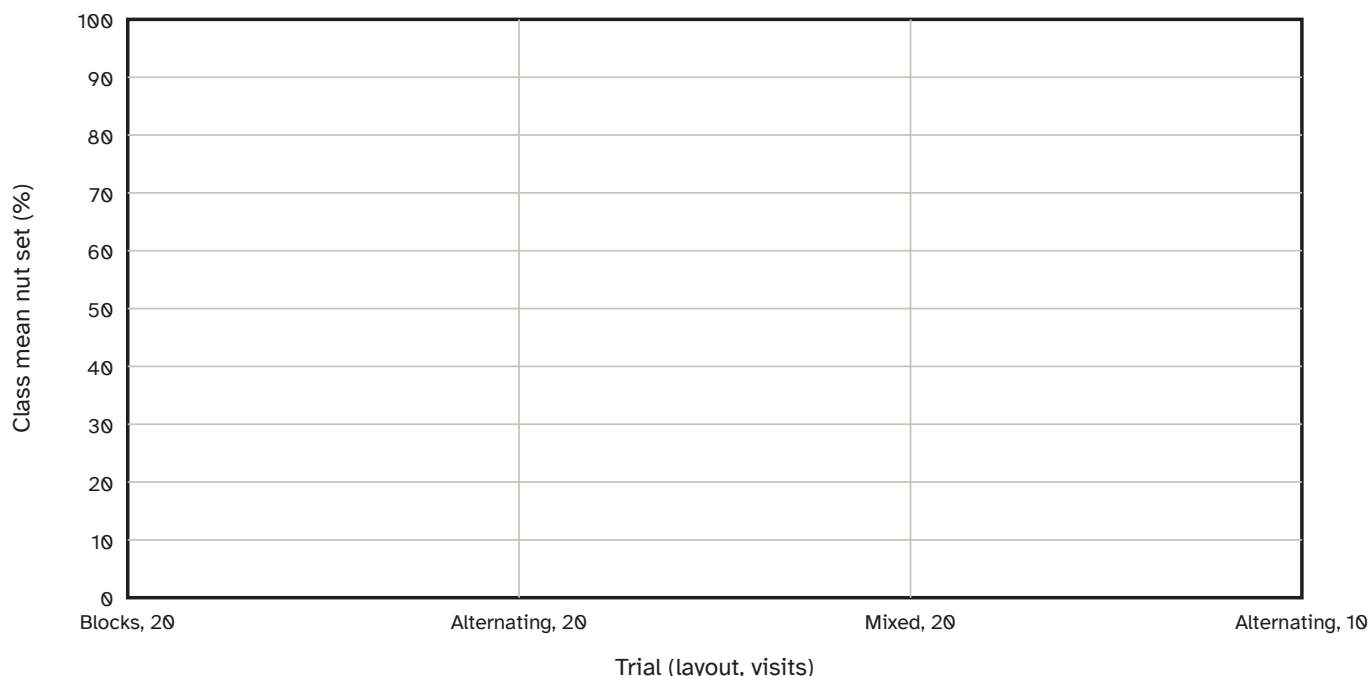
Group data (O = other-variety pollen, S = own pollen only, N = no pollen)

Trial	Layout	Visits	O blossoms	S blossoms	N blossoms	Nut set (%) = $O / 20 \times 100$
1	Blocks	20				
2	Alternating rows	20				
3	Mixed in rows	20				
4	Alternating rows	10				

Class data: nut set (%) for each trial

Group	Trial 1: Blocks, 20 visits	Trial 2: Alternating, 20 visits	Trial 3: Mixed, 20 visits	Trial 4: Alternating, 10 visits
Group 1				
Group 2				
Group 3				
Group 4				
Group 5				
Group 6				
Group 7				
Group 8				
Class mean				

Class mean nut set for each trial



2. Which trial had the highest class mean nut set, and which had the lowest? Give both numbers.

3. How many S blossoms did your group find in Trial 1? Explain why a blossom that was visited, and has pollen on its stigma, still cannot set a nut.

4. Compare the class means for Trial 2 and Trial 4. By what percent did nut set change when the bees made half as many visits? Show your calculation.

5. How much did different groups' results vary for the same trial? Why does pooling the class data give a more trustworthy comparison than one group's single trial?

Information card: ways to keep an orchard pollinated — **Rent more hives:** works within a single season, but price and supply change from year to year, and colonies can be weakened by mites, viruses, poor nutrition and long trips. Honey bees fly little in cold, rainy or windy weather. **Hedgerows and cover crops:** flowering shrubs and ground plants, plus places to nest, let native bees such as the blue orchard bee live near the orchard. A study of 23 California orchards found wild bees on almond blossoms only where natural habitat or a strip of semi-natural vegetation was next to the trees, and a strip helped mostly at the orchard edge. A hedgerow takes a few years to grow and uses some land. **Self-fertile varieties:** can set nuts with their own pollen, so growers usually stock about half as many hives, though bees still raise yields; new trees take several years to start bearing. **Pollinizer rows close together:** planting a compatible variety in every other row shortens the trips bees must make; the varieties must bloom at the same time.

Analysis questions

6. Use the movement rule to explain the order of the three layouts in your class data. Why does the layout change how often the bee arrives at a blossom carrying the other variety's pollen?

7. Real growers mostly plant alternating solid rows, not varieties mixed within each row, even though mixing may set the most nuts in this model. Mixed rows are harder to harvest because varieties ripen at different times, and field trials have not shown consistently higher yields. What does this tell you about choosing a design using only one criterion?

8. A grower has 150 acres of traditional almonds and stocks 2 honey bee colonies per acre at \$200 per colony (close to recent averages; real prices vary). (a) How many colonies does the grower rent? (b) What is the yearly rent? (c) If a hive shortage raises the price by 25 percent, what is the new yearly rent?

- 9.** Use the information card and your data to evaluate the four ways to keep pollination reliable. Which two would you combine for a 150-acre orchard, and why? Name one criterion and one constraint your choice must meet.

- 10.** Name two ways a real orchard differs from the cotton-swab model. Explain how one of those differences could change your conclusion about which layout works best.

- 11.** Before the Central Valley was covered with orchards, what pollinated its wildflowers? Explain why a valley planted almost entirely in one crop supports few wild pollinators, and whether pollination is still a free ecosystem service there.
