STUDYWALKS · HOMESCHOOL PACK · FREE TO PRINT

Biology Lab Guide

Twelve home labs keyed to the units of Biology, from enzymes and osmosis to genetics, natural selection and a field survey, with household materials, data tables and analysis questions.

Twelve hands-on labs keyed to the units of the StudyWalks Biology course. Each lab can be done in a kitchen, a backyard or a park with household or inexpensive materials. No microscope is needed; if you have one, each cell lab can be extended with it.

Safety first

Read this page with your student before the first lab, and reread each lab's own safety notes before starting it.

- **An adult supervises every lab** and reads the whole lab, safety notes included, before it starts. An adult handles knives, the electric kettle, hot water and anything hot. No lab in this guide uses a stove, a burner, a candle or any other open flame.
- **Wear eye protection** (safety goggles marked ANSI Z87.1, sold inexpensively at hardware stores) in every lab with liquids, heat or anything that can splash or snap.
- **Wear gloves** (disposable nitrile, or rubber kitchen gloves) when a lab's safety box says so: iodine, hydrogen peroxide, cabbage juice, steel wool, cold salted ice, the sealed mold bags and outdoor work.
- **Never taste, eat or drink** anything used in a lab, even when it began as food. No food or drinks in the work area. Label every container, and wash borrowed kitchen tools well (or keep a set just for labs).
- **Never mix unknown chemicals** or household products, and use only the materials a lab lists. Never use bleach, ammonia, drain, oven or toilet-bowl cleaners in these labs: some combinations release toxic gases.
- **Ventilation:** work in a well-aired room, with a window open if you can.
- **Dress for it:** closed-toe shoes, long hair tied back, loose sleeves rolled up, old clothes or an apron.
- **Allergies:** before each lab, check for allergies to anything it uses, such as latex (balloons), iodine, foods, mold, plants, pollen or insect stings. Substitute or skip.
- **Cleanup and disposal:** the liquids in these labs can go down the sink with running water; food scraps go in the trash or compost; follow each lab's own disposal note. Wipe the surfaces and wash hands with soap after every lab.
- **If something goes wrong:** for a splash in the eye, rinse with running water for 15 minutes and get medical help; cool a burn under cool running water. In the U.S., Poison Help is 1-800-222-1222. Stop if anything unexpected happens.
- **Young children and pets** stay out of the work area. Balloons, marbles and small parts are choking hazards.
- **Outdoors.** Two labs (Labs 8 and 12) are outside. Wear gloves, learn to recognize poison ivy and stinging plants in your area, and check for ticks afterward.
- **Mold.** In Lab 9 the bags are sealed and taped before anything grows and are never opened, not even at the end. An adult wearing gloves double-bags them, still sealed, for the outdoor trash. Anyone with a mold allergy, asthma or a weakened immune system skips Lab 9.
- **Hot water and peroxide.** No lab uses a stove or a flame. Lab 4 heats potato with just-boiled water from an electric kettle, poured by an adult, and uses only 3% household hydrogen peroxide.

What this guide leaves out on purpose: open flames of every kind (no candles, matches, lighters or burners) and stove-top heating; mercury (no fluorescent tubes or CFL bulbs, and never a broken bulb of any kind); hydrogen peroxide stronger than the 3% sold for first aid; strong acids and bases; flammable solvents (which is why there is no DNA-extraction lab: it needs rubbing alcohol); dissection; opening anything that has grown mold; and anything that makes a toxic gas.

How to use this guide

1. Do each lab after the student has finished the course unit it names. The unit is listed with each lab.
2. Read the whole lab together first: purpose, safety, materials and procedure. Gather everything before starting.
3. The student records everything in a lab notebook as the lab happens (see the notebook guide), then writes a lab report using the template.
4. Grade the report with the parent rubric and log the hours.

Each lab ends with **Go further**, a second investigation that changes one variable. For a lab every week of the school year, add these and investigations of your student's own design.

Lab hours

There is no single national rule for how much lab work makes a "lab science", and rules differ by state. Many homeschool families plan a lab most weeks, about 1 to 2 hours of hands-on work plus time to write it up. The twelve labs here come to roughly 25 to 40 hours with write-ups; the Go further investigations add about as much again. Use the lab-hours log at the end. Lab time can also be logged as offline study hours for the course in StudyWalks, which counts them separately from lesson time. You decide what counts and what credit to grant.

The labs

Lab	Biology unit	Time
1. Drops on a Penny: Designing a Controlled Experiment	Unit 1: The Study of Life and the Chemistry of Life	1 hour
2. Testing Foods for Starch	Unit 1: The Study of Life and the Chemistry of Life	1 hour
3. Osmosis in Potato Strips	Unit 2: Cell Structure and the Plasma Membrane	45 minutes, a 2-hour soak, then 30 minutes
4. Catalase: An Enzyme at Work	Unit 3: Metabolism, Respiration, and Photosynthesis	1 hour
5. Yeast Fermentation and Temperature	Unit 3: Metabolism, Respiration, and Photosynthesis	1.5 hours
6. Floating Leaf Disks: Measuring Photosynthesis	Unit 3: Metabolism, Respiration, and Photosynthesis	1.5 hours
7. Coin-Toss Genetics	Unit 5: Meiosis and Mendelian Genetics	1 hour

Lab	Biology unit	Time
8. Natural Selection: Toothpick Predators	Unit 8: Evolutionary Processes	1 hour, outdoors
9. Bread Mold: Conditions for Fungal Growth	Unit 9: Microbial and Fungal Diversity	20 minutes to set up, then 5 minutes a day for 7 to 10 days
10. Celery and Transpiration	Unit 11: Plant Structure and Function	30 minutes to set up, then 30 minutes the next day
11. Reaction Time: The Ruler Drop	Unit 12: Animal Form, Nutrition, and Control Systems	45 minutes
12. Biodiversity Survey with a Quadrat	Unit 14: Ecology, Ecosystems, and Conservation	1.5 hours, outdoors

Keeping a lab notebook

- Use a bound notebook (a composition book works) and write in pen. Number the pages and keep a table of contents on the first page.
- Start each lab on a new page with the date, the lab title and anyone who helped.
- Record raw data the moment you take it, with units. Never copy it from scrap paper later.
- Do not erase or tear out pages. Cross out a mistake with a single line so it can still be read, and note why.
- Sketch what you see and label the sketch. Write down anything unexpected and any change you made to the procedure.
- End each entry with a one-line summary of the result. The parent initials and dates the entry.

Lab 1. Drops on a Penny: Designing a Controlled Experiment

BIOLOGY Unit 1: The Study of Life and the Chemistry of Life · About 1 hour

Purpose

Practice the parts of a controlled experiment (question, hypothesis, variables and repeated trials) while measuring the cohesion and surface tension of water, which come from hydrogen bonds between water molecules.

Materials

- 3 clean pennies (or any identical coins)
- A dropper, or a drinking straw used as a dropper
- Water and dish soap
- Two cups
- Paper towels

Safety

Adult present for the whole lab · **Wear:** nothing special · **Disposal:** Soapy water down the sink; dry and keep the coins.

- Wipe up spills right away; wet floors are slippery.
- Wash hands after handling coins.

Procedure

1. Write a question and a hypothesis, for example: *If soap is added to water, then fewer drops will fit on a penny, because soap weakens the attraction between water molecules at the surface.* Name the independent variable (soap or no soap), the dependent variable (number of drops) and at least three controlled variables (same penny, same dropper, same height above the penny).
2. Rinse and dry a penny and lay it flat on a paper towel, heads up.
3. Hold the dropper about 1 cm above the penny. Add plain water one drop at a time, counting, until water spills over the edge. Record the last count that stayed on the coin.
4. Dry the penny and repeat until you have five trials with plain water.
5. Stir 1 drop of dish soap into half a cup of water. Rinse the dropper well, then do five trials with soapy water.
6. Calculate the mean and the range (highest minus lowest) for each liquid.

Data

Trial	Plain water (drops)	Soapy water (drops)
1		
2		
3		
4		
5		
Mean		
Range		

Analysis questions

1. Did your data support your hypothesis? Use the means and the ranges in your answer.
2. Water molecules are polar and attract one another through hydrogen bonds. Use this to explain the dome of water that builds up on the penny.
3. How does soap change the attraction between water molecules at the surface, and where does your data show it?
4. Which controlled variable was hardest to keep the same? How could it have changed your counts?
5. Why are five trials better than one?

What to expect. Plain water builds a tall dome and usually holds many drops on a U.S. penny, often 20 to 40 or more depending on the dropper and drop size. Soapy water holds clearly fewer drops because soap lowers surface tension. Counts often vary by several drops from trial to trial.

Typical sources of error. Drop size changes with how hard the dropper is squeezed; soap left on the penny or dropper; a bumped table; a penny that is not level.

Go further. Test salt water, sugar water, or cold and warm water, changing only one variable at a time.

Lab 2. Testing Foods for Starch

BIOLOGY Unit 1: The Study of Life and the Chemistry of Life · About 1 hour

Purpose

Use an iodine indicator to find which foods contain starch, the polysaccharide plants use to store glucose, and practice using positive and negative controls.

Background

Iodine solution is orange-brown. When it meets starch it turns dark blue-black, because iodine fits inside the coiled starch chain. Sugars such as sucrose do not give this color.

Materials

- Povidone-iodine antiseptic (first-aid aisle)
- A dropper
- White plates or a white ice-cube tray
- Cornstarch, table sugar and water
- Food samples: raw potato slice, bread, cooked rice or pasta, cracker, apple slice, cheese, a ripe banana and (if you can find one) a green banana
- Labels or a marker

Safety

Adult present for the whole lab · **Wear:** safety goggles and gloves · **Disposal:** Every tested sample in the trash, never eaten; leftover indicator down the sink with running water.

- Povidone-iodine stains skin, clothing and counters and is harmful if swallowed. Wear eye protection, disposable gloves and old clothes and cover the work surface.
- Skip this lab if anyone is allergic or sensitive to iodine.
- Tested food is no longer food: throw every sample away and never taste it.

Procedure

1. Label a spot for each sample.
2. Make the controls: stir 1 teaspoon of cornstarch into 2 tablespoons of water (positive control). Plain water is the negative control. Also dissolve 1 teaspoon of sugar in 2 tablespoons of water.
3. Predict, for each sample, whether it contains starch.
4. Make the indicator: stir about 1 teaspoon of povidone-iodine into 1/4 cup of water.
5. Put a small piece or spoonful of each sample in its spot. Add 2 or 3 drops of indicator to each.
6. Wait one minute. Record each color and compare it with the two controls.

Data

Sample	Prediction	Color after 1 minute	Starch present?

Analysis questions

1. Why did you test cornstarch and plain water? What would it mean if the plain water had turned blue-black?
2. Which foods contained starch? Which plant part or seed did each come from, and why would a plant store starch there?
3. Table sugar is sucrose, a disaccharide. Did it react? What does that tell you about what this test detects?
4. If you tested a green and a ripe banana, compare them. What happens to stored starch as fruit ripens?
5. A result with no color change does not prove a food has zero starch. Explain why.

What to expect. Cornstarch, potato, bread, rice, pasta and crackers turn blue-black. Water, sugar water and cheese stay orange-brown. Ripe apple and ripe banana show little or patchy color; a green banana turns much darker, because ripening converts much of the stored starch to sugars.

Typical sources of error. Dark foods hide the color; indicator that is too strong looks dark on everything (compare with the water control); very small amounts of starch can be missed.

Go further. Test flour, oats, a soaked dried bean and a piece of leftover cooked potato from a family meal, cooled, using the same amount of each.

Lab 3. Osmosis in Potato Strips

BIOLOGY Unit 2: Cell Structure and the Plasma Membrane · About 45 minutes, a 2-hour soak, then 30 minutes

Purpose

Measure how plant tissue gains or loses water in salt solutions of different strength, and estimate the concentration at which there is no net movement of water.

Materials

- 1 large raw potato
- Knife and cutting board (adult)
- Kitchen scale, 0.1 g if possible (inexpensive 0.01 g pocket scales work well)
- Table salt and water
- 5 cups or jars, labeled
- Paper towels and a ruler
- Graph paper

Safety

Adult present for the whole lab · **Wear:** nothing special · **Disposal:** Salt solutions down the sink; potato in the trash or compost.

- An adult cuts the potato strips.
- Throw the potato away afterward.

Procedure

1. Make five solutions of 100 g each. Put a cup on the scale and zero it, add 0, 1, 2, 5 or 10 g of salt, then add water until the scale reads 100 g. These are 0, 1, 2, 5 and 10 percent salt by mass. Stir to dissolve.
2. An adult cuts 15 peeled strips from the same potato, all about 5 cm long and 1 cm by 1 cm.
3. Blot the strips, and weigh them in five groups of three. Record each group's starting mass.
4. Put one group in each cup, fully covered. Leave all five cups for the same time: 2 hours, or overnight in the refrigerator.
5. Remove the strips, blot them the same way as before, and reweigh each group. Note whether they feel firm or bendy.
6. Calculate percent change in mass = (final − starting) ÷ starting × 100.
7. Graph percent change (y-axis) against salt percent (x-axis), draw a best-fit line or curve, and find where it crosses zero.

Data

Salt (%)	Starting mass (g)	Final mass (g)	Change (g)	Change (%)	Firm or bendy?
0					
1					
2					
5					
10					

Analysis questions

1. In which solutions did the strips gain mass, and in which did they lose it? Explain using the direction water moves across a membrane.
2. Label each solution hypotonic, isotonic or hypertonic compared with the potato cells.
3. Where does your graph cross zero? What does that point tell you about the solutes inside the potato cells?
4. Why do we compare percent change rather than change in grams?
5. Plant cells in plain water swell but do not burst. What structure prevents bursting?

What to expect. Strips in plain water gain a few percent and feel firm; strips in strong salt lose mass and turn limp. The zero crossing is usually somewhere between about 0.5 and 2 percent salt, depending on the potato and the soaking time.

Typical sources of error. Blotting harder or softer at the end; strips of different sizes; the scale's resolution; water evaporating from the cups.

Go further. Repeat with sugar solutions, or with carrot or sweet potato, and compare the zero crossings.

Lab 4. Catalase: An Enzyme at Work

BIOLOGY Unit 3: Metabolism, Respiration, and Photosynthesis · About 1 hour

Purpose

Watch the enzyme catalase speed up the breakdown of hydrogen peroxide, and test how temperature affects it.

Background

Catalase is found in nearly all cells that use oxygen. It protects them by breaking down hydrogen peroxide: 2 $H_2O_2 \rightarrow 2\ H_2O + O_2$. The bubbles in this lab are oxygen.

Materials

- 3% hydrogen peroxide from the first-aid aisle (not stronger)
- A raw potato and a grater or knife (adult)
- An electric kettle and a heat-safe mug (adult only)
- 4 identical tall, narrow glasses or cups
- Measuring spoons, a ruler and a timer
- A refrigerator

Safety

Adult present for the whole lab · **Wear:** safety goggles and gloves · **Disposal:** Liquids down the sink with running water; potato in the trash. Cap the peroxide and keep it in its own bottle.

- Wear eye protection and disposable gloves. Hydrogen peroxide can irritate eyes and skin; if it splashes, rinse with plenty of water.
- Use only 3% household hydrogen peroxide from the first-aid aisle, poured from its own bottle. Stronger peroxide (hair-salon or "food grade") can burn skin and must not be used.
- Never mix peroxide with vinegar, bleach or any other product, and never store it in another container.
- An adult handles the grater, the knife, the kettle and the hot water. There is no stove in this lab.
- Work in a well-aired room. Pour used liquids down the sink with running water.

Procedure

1. Grate or finely chop the potato and divide it into equal portions of 1 teaspoon each.
2. Prepare four treatments: raw potato at room temperature; raw potato chilled for 30 minutes in the refrigerator in a sealed bag; heated potato (an adult puts a portion in the heat-safe mug, covers it with just-boiled water from the electric kettle, waits 5 minutes, pours the water off and lets the potato cool to room temperature); and no potato (control).
3. Pour 1 tablespoon (15 mL) of peroxide into each glass.
4. Add one portion to a glass and start the timer. After 1 minute, measure the height of the foam above the liquid with the ruler. Record what you see.
5. Repeat for each treatment, then run the whole set two more times.

Data

Treatment	Trial 1 foam (mm)	Trial 2 (mm)	Trial 3 (mm)	Mean (mm)
Raw, room temperature				
Raw, chilled				
Heated, cooled				
No potato (control)				

Analysis questions

1. According to the balanced equation, what gas is in the bubbles?
2. What was the no-potato glass for? What did it show?
3. Explain the heated potato's result using the enzyme's shape. What is this change called?
4. Compare chilled and room-temperature potato. Is the effect of cold permanent, like heating? Describe how you could test that.
5. Name two variables you kept the same and one you could not fully control.

What to expect. Peroxide alone barely bubbles. Raw potato makes a steady foam. Chilled potato may start a little slower, though it warms quickly in the peroxide, so the difference is often small. Heated potato makes little or no foam, because heat denatures catalase.

Typical sources of error. Unequal portions or particle sizes (surface area); foam is hard to measure; peroxide in an opened bottle slowly breaks down over months.

Go further. Compare grated potato with the same mass in cubes, or use a pinch of dry yeast in place of potato.

Lab 5. Yeast Fermentation and Temperature

BIOLOGY Unit 3: Metabolism, Respiration, and Photosynthesis · About 1.5 hours

Purpose

Measure the carbon dioxide made by yeast at three temperatures, and connect it to fermentation and cellular respiration.

Background

Yeast break down sugar for energy. With little oxygen they ferment: glucose → ethanol + carbon dioxide. The bottles start with some air, so the yeast also respire aerobically at first; both processes release carbon dioxide.

Materials

- 4 identical plastic bottles (about 500 mL)
- 4 balloons (use non-latex balloons if anyone has a latex allergy)
- 4 packets of active dry yeast
- Sugar, measuring spoons and cups, a funnel
- A kitchen thermometer
- 3 large bowls for water baths: cold water from the refrigerator, room-temperature water, and warm water at about 38 °C
- String and a ruler

Safety

Adult present for the whole lab · **Wear:** nothing special · **Disposal:** Mixtures down the sink; balloons in the trash.

- The warm bath should feel comfortably warm, not hot. An adult checks it with the thermometer.
- Balloons are a choking hazard for young children; keep pieces picked up.
- Nobody drinks the mixtures; pour them down the sink afterward.

Procedure

1. Put 1 packet of yeast and 1 tablespoon of sugar into three bottles. Put yeast but no sugar in the fourth (control).
2. Add 1/2 cup (120 mL) of water at the temperature of the bath each bottle will sit in: cold, room, warm, and warm for the control. Swirl gently.
3. Stretch a balloon over each bottle's mouth right away.
4. Stand each bottle in its water bath. Record each bath's temperature at the start and the end.
5. Every 10 minutes for 60 minutes, measure each balloon's circumference at its widest point with the string and ruler.
6. Graph circumference against time, one line per bottle.

Data

Time (min)	Cold (cm)	Room (cm)	Warm (cm)	Warm, no sugar (cm)
0				
10				
20				
30				
40				
50				
60				

Analysis questions

1. Which temperature produced gas fastest? Use the slopes of your lines.
2. Why did the bottle without sugar make little gas?
3. Write the word equation for fermentation in yeast. What is made besides carbon dioxide?
4. Predict what would happen in a 70 °C bath, and explain using enzymes.
5. Circumference is not volume. Does that change your conclusion about which bottle was fastest? Why or why not?

What to expect. The warm bottle inflates most within the hour, room temperature less, and the cold bottle very little. The no-sugar control stays nearly flat. Water above roughly 50 to 60 °C kills yeast.

Typical sources of error. Water baths cool or warm toward room temperature; balloons that leak at the neck; yeast of different freshness; balloons that stretch differently.

Go further. Keep the temperature the same and vary the amount of sugar, or compare sugar with honey, flour or a sugar-free sweetener.

Lab 6. Floating Leaf Disks: Measuring Photosynthesis

BIOLOGY Unit 3: Metabolism, Respiration, and Photosynthesis · About 1.5 hours

Purpose

Measure the rate of photosynthesis by timing how long sunken leaf disks take to float as oxygen collects inside them, in light and in darkness.

Background

A syringe vacuum pulls the air out of the spaces inside small leaf disks and replaces it with a baking-soda solution, so the disks sink. The baking soda supplies carbon dioxide (as bicarbonate). In light, photosynthesis releases oxygen into the leaf spaces and the disks rise. The disks also carry out cellular respiration, which uses some oxygen.

Materials

- Fresh spinach leaves
- Baking soda and dish soap
- A plastic syringe without a needle, 10 mL or larger (pharmacies and garden stores sell them)
- A drinking straw or a single-hole paper punch, to cut disks
- 2 clear cups
- A bright LED lamp (it stays cool) or a sunny window; not a halogen or incandescent bulb
- A dark cupboard or a box, a timer

Safety

Adult present for the whole lab · **Wear:** nothing special · **Disposal:** Solution down the sink; leaves in the compost or trash.

- Use a syringe with no needle.
- Use an LED lamp, which stays cool. Do not use a halogen or incandescent bulb: it gets hot enough to burn.

Procedure

1. Make the solution: 1/8 teaspoon of baking soda in 300 mL (about 1 1/4 cups) of water, plus one small drop of dish soap.
2. Cut 20 disks from the spinach, avoiding the large veins.
3. Take the plunger out of the syringe, drop in 10 disks, and put the plunger back. Draw up about 5 mL of solution and push out the air.
4. Cover the tip with a finger and pull the plunger back for about 10 seconds to make a vacuum, then release. Repeat 2 to 4 times until the disks sink.
5. Pour the disks into a cup with about 3 cm of solution. Repeat steps 3 to 5 with the other 10 disks.
6. Put one cup about 15 to 20 cm under the lamp and the other in the dark at the same room temperature.
7. Every 2 minutes for 30 minutes, count the floating disks in each cup (check the dark cup quickly). Find the time at which half the disks float.

Data

Minute	Floating in light	Floating in dark
0		
2		
4		
6		
8		
10		
12		
14		
16		
18		
20		
22		
24		
26		
28		
30		

Analysis questions

1. Why did the disks sink after the vacuum, and why did they rise later?
2. What was the baking soda for? Predict what would happen in plain water.
3. Compare the time for half the disks to float in light and in darkness.
4. The disks also carry out cellular respiration. How does that affect the cup in the dark?
5. Besides light, what else might have differed between the two cups?

What to expect. In bright light most disks usually float within about 10 to 25 minutes; in the dark few or none float in that time.

Typical sources of error. Disks that are not fully infiltrated; disks stuck to the cup; warming from the lamp; pieces of vein in some disks.

Go further. Vary the distance from the lamp, or cover cups with colored cellophane, and graph the time for half to float.

Lab 7. Coin-Toss Genetics

BIOLOGY Unit 5: Meiosis and Mendelian Genetics · About 1 hour

Purpose

Model Mendel's monohybrid and dihybrid crosses with coins, compare observed counts with the ratios a Punnett square predicts, and see why large samples matter.

Background

A parent with genotype *Aa* passes on *A* or *a* with equal chance, like a coin toss. In this model, heads stands for the dominant allele and tails for the recessive allele.

Materials

- 4 coins, marked with tape: two for gene A, two for gene B
- Paper and a calculator

Safety

Adult present for the whole lab · **Wear:** nothing special · **Disposal:** Nothing to throw away.

- No special hazards.

Procedure

1. Monohybrid cross *Aa* × *Aa*: toss the two A coins together, one for each parent. Each pair of tosses is one offspring. Record its genotype: AA (two heads), Aa (one of each) or aa (two tails).
2. Make 100 offspring. Family members can share the tossing.
3. Draw the Punnett square and write the expected genotype ratio (1:2:1) and phenotype ratio (3 dominant : 1 recessive).
4. Dihybrid cross *AaBb* × *AaBb*: toss all four coins (one A and one B coin for each parent). Record the phenotype: dominant for both traits, dominant A only, dominant B only, or recessive for both.
5. Make 80 offspring. The expected 9:3:3:1 ratio gives expected counts of 45, 15, 15 and 5.
6. Optional: for each class, calculate (observed − expected)^2 ÷ expected and add them up (the chi-square value). Compare it with the critical value at the 0.05 level: 3.84 for the monohybrid phenotypes (1 degree of freedom) and 7.81 for the dihybrid (3 degrees of freedom).

Data

Class	Observed	Expected	$(O - E)^2 \div E$
AA			
Aa			
aa			
Dominant phenotype (monohybrid)			
Recessive phenotype (monohybrid)			
Both dominant			
A dominant only			
B dominant only			
Both recessive			

Analysis questions

1. How close to 3:1 were your first 10 offspring, and how close were all 100? Explain the difference.
2. What does the coin toss assume about how alleles separate into gametes? Which of Mendel's laws is that?
3. The model tossed the A and B coins separately. Which law does that represent, and when does it fail for genes on real chromosomes?
4. Was your chi-square value below the critical value? What does that mean, and what does it not prove?

What to expect. With 100 offspring the counts land near 1:2:1 and 3:1 but are often off by several. The dihybrid counts land near 45:15:15:5. Most honest runs give a chi-square value below the critical value; about 1 run in 20 exceeds it by chance alone.

Typical sources of error. Miscounting or misrecording; small samples.

Go further. Model a cross between Aa and aa, or model sex-linked inheritance by using a blank card for the Y chromosome.

Lab 8. Natural Selection: Toothpick Predators

BIOLOGY Unit 8: Evolutionary Processes · About 1 hour, outdoors

Purpose

Simulate predators hunting prey of different colors on a background, and track how the population's color makeup changes over generations.

Materials

- Colored toothpicks: about 25 each of green, red, yellow and natural wood, plus extras of each for offspring
- A lawn or patch of ground about 2 m by 2 m, marked with string
- A helper to act as the predator
- A timer and bags or cups for sorting

Safety

Adult present for the whole lab · **Wear:** gloves · **Disposal:** Count every toothpick back in; none left in the grass.

- Toothpicks are sharp. Pick them up gently and do not run with them.
- Count every toothpick back in so none are left in the grass for pets, children or mowers.
- Watch for stinging insects and check for ticks afterward.

Procedure

1. Generation 1: scatter 25 toothpicks of each color (100 prey) evenly over the area.
2. The predator picks up toothpicks one at a time, as fast as possible, and stops when 50 have been caught.
3. Find the survivors: count the toothpicks still in the grass by color (100 minus those caught).
4. Reproduction: each survivor has one offspring of its own color. Add one toothpick of the same color per survivor, so the population is back to 100.
5. Scatter the new population and repeat for at least three generations.
6. Graph the number of each color at the start of each generation.

Data

Color	Gen 1 start	Gen 1 survivors	Gen 2 start	Gen 2 survivors	Gen 3 start	Gen 3 survivors	Gen 4 start
Green							
Red							
Yellow							
Natural							
Total							

Analysis questions

1. Which color increased over the generations? Why?
2. Did any single toothpick change color? Explain why selection acts on individuals while evolution is a change in a population.
3. In this model, what stands for variation, for inheritance and for differential survival? Name one part of real evolution the model leaves out.
4. Predict the results on a background of brown mulch or bare soil.
5. Is this directional, stabilizing or disruptive selection? Explain.

What to expect. On green grass, green toothpicks usually survive best and increase; red and yellow fall quickly; natural wood depends on the background. With small numbers, a well-hidden color sometimes drops by chance, which is a reminder that chance also changes populations.

Typical sources of error. The predator gets better with practice; uneven scattering; lost toothpicks; different lighting between rounds.

Go further. Repeat on a second background and compare, or let one color "mutate" by swapping in a new color in generation 2.

Lab 9. Bread Mold: Conditions for Fungal Growth

BIOLOGY Unit 9: Microbial and Fungal Diversity · About 20 minutes to set up, then 5 minutes a day for 7 to 10 days

Purpose

Test how moisture, temperature and light affect the growth of bread mold, a fungus, in sealed bags.

Materials

- 4 slices of the same bread
- 4 zip-top bags and clear tape
- A spoon and water
- A marker
- A sheet of 1 cm graph paper (or draw a 1 cm grid) to hold behind each bag

Safety

Adult present for the whole lab · **Wear:** gloves · **Disposal:** Sealed bags, never opened, double-bagged by an adult for the outdoor trash.

- Seal each bag and tape every edge before anything grows. Never open a bag, not even at the end. Look only through the plastic; do not smell or squeeze the bags.
- Anyone with a mold allergy, asthma or a weakened immune system does not do this lab or handle the bags; do the yeast lab's extension or a virtual lab instead.
- Keep the bags away from food, on a tray, and out of reach of young children and pets.
- Disposal: at the end, an adult wearing gloves puts the sealed bags, unopened, into a second bag, ties it and puts it in the outdoor trash. Never wash out or reuse the bags. Wash hands afterward.
- If a bag splits or comes open, an adult (not anyone with allergies or asthma) wearing gloves puts it into a new bag outdoors and ties it, wipes the spot with soapy water, and everyone washes hands.

Procedure

1. Label the bags: dry, room temperature; moist, room temperature; moist, refrigerator; moist, dark cupboard.
2. Sprinkle about 2 teaspoons of water evenly over three slices. Leave one dry. Do not add anything else: mold spores are already in the air.
3. Seal and tape each bag now, before anything grows, and put it in its place. The bags stay closed from here on. The two room-temperature bags in the light sit side by side.
4. Each day, without opening the bags, hold the grid behind each bag and estimate the percent of the slice covered by mold. Note colors and textures.
5. Continue for 7 to 10 days, then graph percent covered against day.

Data

Day	Dry, room (%)	Moist, room (%)	Moist, refrigerator (%)	Moist, dark (%)
0				
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Analysis questions

1. Which condition grew mold first and fastest? Explain why.
2. Where did the mold come from, since you never added any?
3. The fuzzy growth is a mycelium made of hyphae, and the colored dots hold spores. Explain how mold spreads to new food.
4. Why does a refrigerator slow mold without killing it?
5. Did light make a difference? What does that tell you about how a fungus gets its food?

What to expect. Moist slices at room temperature usually show mold first, often within about 3 to 7 days. Light and dark grow at similar rates, because fungi do not photosynthesize. The refrigerator slice is much slower, and the dry slice is slowest. Store bread with preservatives molds more slowly than bakery or homemade bread.

Typical sources of error. Uneven moisture; estimating area by eye; slices that start with different numbers of spores.

Go further. Compare bread with and without preservatives (read the labels), keeping everything else the same.

Lab 10. Celery and Transpiration

BIOLOGY Unit 11: Plant Structure and Function · About 30 minutes to set up, then 30 minutes the next day

Purpose

Trace water moving up through xylem with dye, and measure how much water a plant loses through its leaves.

Materials

- 3 fresh celery stalks with leaves
- Blue or red food coloring
- 4 tall glasses
- A knife (adult), a ruler and a kitchen scale
- Plastic wrap
- A magnifying glass (optional)

Safety

Adult present for the whole lab · **Wear:** nothing special · **Disposal:** Colored water down the sink; celery in the trash.

- An adult does the cutting.
- Food coloring stains; cover the work surface.

Procedure

1. Part A. Trim the bottom of one stalk and stand it in a glass with 1/2 cup of water and about 20 drops of food coloring.
2. After 30 minutes, 1 hour, 4 hours and the next day, note how far the color has risen. The next day, an adult cuts thin cross-sections at several heights; look at them with the magnifier and sketch where the color is.
3. Part B. Fill three glasses with the same mass of water. Trim two stalks to the same length. Leave the leaves on one and remove them from the other. Put one stalk in each of two glasses; the third glass has no celery.
4. Cover the top of each glass with plastic wrap, pressed snugly around the stalk, so water cannot evaporate from the surface.
5. Weigh each glass (with its stalk) at the start and again after 24 hours.

Data

Part A: dye

Time	Height of color (cm)	Observations
30 minutes		
1 hour		
4 hours		
Next day		

Part B: water lost

Setup	Starting mass (g)	Mass after 24 h (g)	Water lost (g)
Celery with leaves			
Celery without leaves			
No celery (control)			

Analysis questions

1. Where was the dye in the cross-sections? Which tissue carries water up the stalk?
2. What pulls water up the stalk? Explain how evaporation from leaves and the cohesion of water molecules work together.
3. Which setup lost the most water? What does that tell you about the role of leaves?
4. Why did you need the glass with no celery?
5. Predict the effect of a fan blowing on the leaves, and of very humid air.

What to expect. Color reaches the leaves within hours. Cross-sections show colored dots (the vascular bundles) arranged near the outer, ribbed side of the stalk. The leafy stalk loses clearly more water than the leafless one; the control loses almost none if the wrap is snug.

Typical sources of error. Plastic wrap that leaks; stalks of different sizes; scale resolution.

Go further. Set up a leafy stalk in front of a fan and one without, or put a clear bag over a houseplant's leaves overnight and look for collected water.

Lab 11. Reaction Time: The Ruler Drop

BIOLOGY Unit 12: Animal Form, Nutrition, and Control Systems · About 45 minutes

Purpose

Measure reaction time from how far a falling ruler drops before it is caught, compare conditions, and trace the path of the nerve signals involved.

Background

A dropped ruler falls a distance $d = \frac{1}{2} g t^2$, so the time is t = square root of ($2d \div 9.8$), with d in meters and t in seconds. A catch at 10 cm means about 0.14 s, at 20 cm about 0.20 s, and at 30 cm about 0.25 s.

Materials

- A 30 cm ruler (or a meter stick)
- A helper
- A calculator

Safety

Adult present for the whole lab · **Wear:** nothing special · **Disposal:** Nothing to throw away.

- Use a light ruler and keep faces clear.
- This is a classroom measurement, not a test of health. Reaction times vary for many ordinary reasons.

Procedure

1. The subject sits with a forearm resting on a table, hand over the edge, thumb and finger about 3 cm apart at the ruler's 0 mark.
2. The helper holds the ruler at the top and lets go without warning, waiting a different time (1 to 5 seconds) before each drop.
3. The subject catches the ruler. Record the distance at the top of the thumb.
4. Do 10 trials with the dominant hand, 10 with the other hand, and 10 with the dominant hand while the subject counts backward from 100 by threes.
5. Convert each mean distance to a time with the formula.

Data

Trial	Dominant hand (cm)	Other hand (cm)	Counting backward (cm)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
Mean (cm)			
Time (s)			

Analysis questions

1. Trace the signal from the eye to the finger muscles: receptors in the retina, sensory neurons, the brain, motor neurons through the spinal cord, and the muscles.
2. Catching a ruler is not a reflex. What is the difference, and why is a reflex faster?
3. How did counting backward change the time? Explain.
4. Doubling the reaction time does not double the distance. Use the formula to explain why.
5. What could make a single trial misleading?

What to expect. Typical reaction times are about 0.15 to 0.25 s, a catch at about 11 to 30 cm. Counting backward usually slows the catch. The dominant and other hand often differ only a little.

Typical sources of error. Guessing when the ruler will drop; the finger's starting position; reading the ruler; air and finger friction (small).

Go further. Compare a sound cue (the helper says "now" as she drops it, with the subject's eyes closed) with the visual cue.

Lab 12. Biodiversity Survey with a Quadrat

BIOLOGY Unit 14: Ecology, Ecosystems, and Conservation · About 1.5 hours, outdoors

Purpose

Sample plants in measured squares to estimate population density, and compare the biodiversity of two habitats.

Materials

- 4 sticks or tent pegs and 4 m of string (to mark a 1 m by 1 m square), or a hula hoop
- A plant field guide or an identification app
- Gloves, a magnifier and a phone camera
- A beanbag or other soft object to toss

Safety

Adult present for the whole lab · **Wear:** gloves · **Disposal:** Leave plants and animals where they are; take home only notes, photos and your string.

- Wear gloves and long pants. Learn to recognize poison ivy, nettles and other stinging plants in your area, and avoid them.
- Check for ticks afterward. Avoid stinging insects; anyone with a sting allergy should have a plan and medicine on hand as the doctor directs.
- Get permission on land that is not yours. Do not pull up plants or disturb animals.

Procedure

1. Choose two habitats, for example a mown lawn and an unmown edge, garden or field.
2. In each habitat, toss the beanbag over your shoulder to pick a random spot, and mark a square there. Do three squares per habitat.
3. In each square, count the individual plants of each kind. Give unknown plants a label (Species A, B...) and photograph or sketch them. For grass, estimate the percent of the square it covers instead.
4. Record any animals you see.
5. For each habitat, calculate: species richness (the number of kinds); mean density of each kind per square meter; and a simple diversity index, $1 - \Sigma p^2$, where p is each kind's share of all the individuals counted.

Data

Habitat 1

Species (name or label)	Square 1	Square 2	Square 3	Total	Share (p)

Habitat 2

Species (name or label)	Square 1	Square 2	Square 3	Total	Share (p)

Analysis questions

1. Which habitat had greater species richness and a higher diversity index? Why?
2. Why place the squares at random, and why use more than one?
3. Which plants were hardest to count? How did you decide what counted as one individual?
4. Suggest one human activity that shapes the less diverse habitat.
5. How would you design a study to track changes in one habitat over a year?

What to expect. The unmown habitat usually has more kinds of plants and a higher diversity index; a lawn is dominated by a few grasses. Results depend on the season and the place.

Typical sources of error. Misidentified plants; spots that are not truly random; deciding what counts as one plant in a clump.

Go further. Repeat the survey in another season, or survey a third habitat such as a stream bank or a wood edge.

Lab report template

Print one copy per lab, or copy the headings into the notebook.

Student _____ Lab number and title _____ Date _____

Course unit _____

Question or purpose

Hypothesis (If … then … because …)

Variables: independent, dependent, and those kept the same

Materials and procedure (summarize; note any changes you made)

Safety steps followed

Data (attach tables and graphs) and calculations, with units

Results in words

Conclusion: claim, evidence from the data, reasoning

Sources of error, how each affected the result, and improvements

Hands-on minutes

Write-up minutes

Rubric score (of 20)

Parent initials

Parent grading rubric

Score each criterion from 4 to 1 and add them (20 points in all). How the score becomes a grade, and how lab grades combine with course work, is the parent's decision.

Criterion	4	3	2	1
Safety and procedure	Followed every safety rule without reminders; set up, carried out and cleaned up carefully; noted any change to the procedure.	Followed safety rules and the procedure with few reminders.	Needed several reminders; some steps rushed or skipped.	Unsafe or careless work, or procedure not followed.
Data	Complete, organized tables with units; repeated trials; raw data recorded as it was taken; clear observations.	Mostly complete, with units; minor gaps.	Incomplete or disorganized; units missing.	Little usable data.
Analysis	Calculations correct and shown with units; graphs titled, labeled and scaled well; all questions answered fully.	Minor calculation or graph errors; questions mostly answered.	Several errors; graph or questions incomplete.	Calculations, graph or questions largely missing.
Conclusion	Answers the purpose with a clear claim, evidence from the data and scientific reasoning; compares with the expected result.	Claim and evidence given; reasoning thin.	Claim stated with little evidence.	No real conclusion.
Error and improvement	Names specific sources of error, says how each would change the result, and proposes a better method.	Names specific sources of error.	Only general errors ("human error").	Not addressed.

Score sheet

Lab	Safety	Data	Analysis	Conclusion	Error	Total (20)
1. Drops on a Penny: Designing a Controlled Experiment						
2. Testing Foods for Starch						
3. Osmosis in Potato Strips						
4. Catalase: An Enzyme at Work						
5. Yeast Fermentation and Temperature						
6. Floating Leaf Disks: Measuring Photosynthesis						
7. Coin-Toss Genetics						
8. Natural Selection: Toothpick Predators						
9. Bread Mold: Conditions for Fungal Growth						
10. Celery and Transpiration						
11. Reaction Time: The Ruler Drop						

Lab	Safety	Data	Analysis	Conclusion	Error	Total (20)
12. Biodiversity Survey with a Quadrat						

Lab-hours log

Log every lab and investigation, including Go further and the student's own. Print as many copies as you need.

Date	Lab or investigation	Unit	Hands-on min	Write-up min	Running hours	Parent

Total lab hours _____ Parent signature _____ Date _____

Beyond the kitchen

Virtual labs. Free simulations from universities and science organizations cover gas laws, circuits, genetics, titrations and more, including experiments that are not safe at home. They are good practice and a good way to repeat a lab with many more trials. Use them alongside hands-on labs; whether a simulation counts toward a lab requirement is your call under your state's rules.

A formal lab course. If you want lab work with equipment a home cannot have, such as microscopes, analytical balances and fume hoods, look for lab classes through a homeschool co-op, your state or local homeschool association, a community college's dual-enrollment office, or a science center. StudyWalks does not endorse or partner with any provider; ask each one what is covered and how work is documented.

StudyWalks is a curriculum and study-tool provider, not a school. In a homeschool the parent decides the courses, the credit and the grades, and keeps the records. Check your own state's homeschool rules. This pack is free to print and copy for your family or homeschool group; please do not sell it or repost the file.

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