

ADAPTATIONS BY DESIGN - EXTREME ENVIRONMENTS STEM INVESTIGATION

**Print-and-go STEM
lab where students
learn heredity using
beetles: alleles,
Punnett squares,
genotype/phenotype,
probability, and a
dihybrid cross.**

Adaptations by Design - Extreme Environment Creature STEM Challenge

Learning Targets

- Identify environmental pressures in extreme or changing habitats.
- Design structural, behavioral, and physiological adaptations that address those pressures.
- Use Claim-Evidence-Reasoning (CER) to justify how each adaptation supports survival.
- Determine and graph a Survival Index for the class creatures.

What you will turn in: 1) a labeled creature sketch (6-8 callouts), 2) a one-paragraph CER (6-8 sentences), 3) your Survival Index table, and 4) one class bar graph with a 1-sentence caption.

Part 1 - Creature Design and Explain

Materials

- Student worksheet with prompts and CER scaffold
- Drawing materials (paper, colored pencils, markers) or digital tools
- Graph paper

Suggested Timing

- Hook & environment reveal: 5-7 min
- Brainstorm pressures & build a trait bank: 8-10 min
- Design + sketch & labels: 20-25 min
- CER draft: 15-20 min
- Gallery walk & peer feedback: 10 min

Extreme Environments (choose one)

- Hyper-Arid Dune Sea: 60 °C days, freezing nights, abrasive sandstorms
- Acidic Mire: pH $\approx$ 3 swamps with fungal mats and acidic runoff
- Storm-Lashed Coast: frequent surges, spray, high winds, shifting shorelines
- Polar Methane Flats: sub-zero temps, thin O₂, methane fogs
- Ashen Highlands (Volcanic): ash fall, low nutrients, high UV exposure

Trait Bank - Use the Word Bank below and/or outside research if needed.

Heat/Water: reflective scales, nasal turbinate filters, estivation, nocturnality, burrowing
Cold/Glare: counter-current heat exchange, dark dorsal/white ventral coat, antifreeze proteins, fat layer,
low surface area/volume
Acid/Low Ca: protective mucus, chitinous plates, ion-selective pumps, calcium-sparing teeth
Salt/Coast: salt glands, semi-permeable skin plates, webbed claws/anchors, nictitating membrane
Storm/Mobility: tendon toe-locks, suction pads, prehensile tail, low-profile body, flexible spine
Low O₂/Gases: high-affinity hemoglobin, cutaneous gas-exchange patches, gas-tolerant microbiome

Word Bank

- **Counter-current heat exchange:** blood vessels next to each other keep heat in the body.
- **Nictitating membrane:** a clear "third eyelid" that protects the eye.
- **Osmoregulation:** keeping water and salt levels balanced.
- **High-affinity hemoglobin:** blood that grabs oxygen more easily.
- **Uric acid excretion:** thick paste-like urine that saves water.
- **Ion-regulating (salt) glands:** organs that remove extra salt from the body.
- **Counter-shading:** dark on top, light underneath; helps with camouflage.

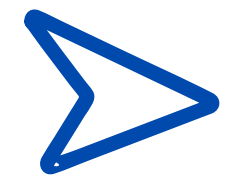


Teach With
Fergy

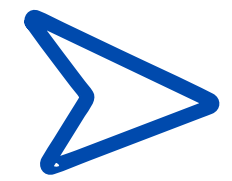
SCROLL
to take a look inside!



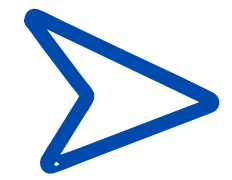
HOW THIS LAB WILL HELP YOU



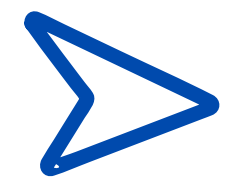
Print-and-go setup



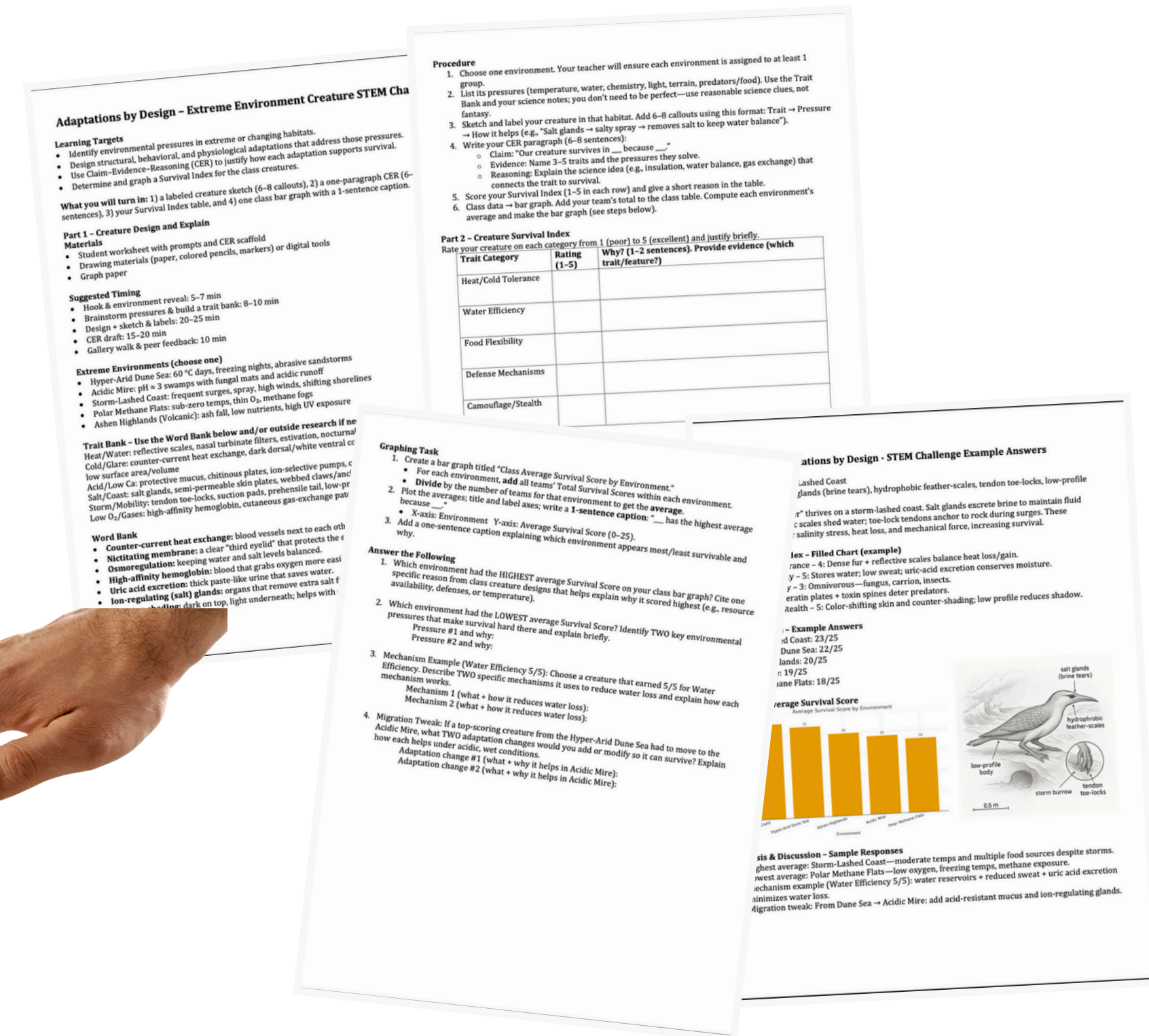
Clear Testing Procedure



Data & math supports



Low-cost & common
materials





Teacher Guide: setup, safety, pacing, and background science.



Student Packet: clear, step-by-step setup and timing instructions with blank data tables.

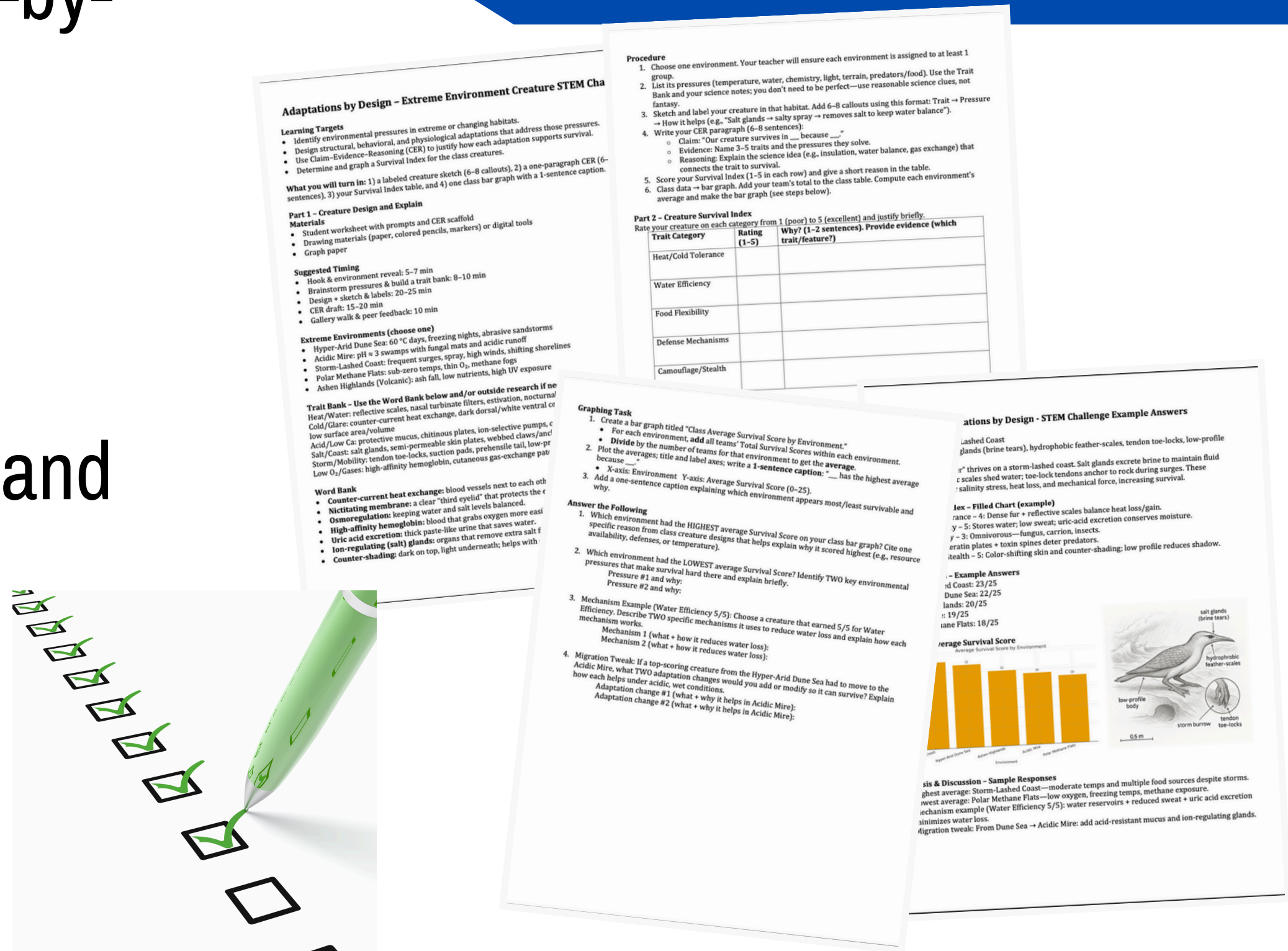


Graphing pages templates and marking rubric.



Complete answer key with example data tables.

What you get inside



Skills Your Students Will Learn/Improve



- ✓ Carrying out Controlled Experiments
- ✓ Precise Measurement
- ✓ Design and Redesign
- ✓ Graphing Data
- ✓ Claim–Evidence–Reasoning
- ✓ Analyzing Results

Your Lab

Procedure

1. Choose one environment. Your teacher will ensure each environment is assigned to at least 1 group.
2. List its pressures (temperature, water, chemistry, light, terrain, predators/food). Use the Trait Bank and your science notes; you don't need to be perfect—use reasonable science clues, not fantasy.
3. Sketch and label your creature in that habitat. Add 6–8 callouts using this format: **Trait** → Pressure → How it helps (e.g., “Salt glands → salty spray → removes salt to keep water balance”).
4. Write your CER paragraph (6–8 sentences):
 - Claim: “Our creature survives in __ because __.”
 - Evidence: Name 3–5 traits and the pressures they solve.
 - Reasoning: Explain the science idea (e.g., insulation, water balance, gas exchange) that connects the trait to survival.
5. Score your Survival Index (1–5 in each row) and give a short reason in the table.
6. Class data → bar graph. Add your team's total to the class table. Compute each environment's average and make the bar graph (see steps below).

Part 2 – Creature Survival Index

Rate your creature on each category from 1 (poor) to 5 (excellent) and justify briefly.

Trait Category	Rating (1–5)	Why? (1–2 sentences). Provide evidence (which trait/feature?)
Heat/Cold Tolerance		
Water Efficiency		
Food Flexibility		
Defense Mechanisms		
Camouflage/Stealth		

Class Data Table

Add up your **five** category ratings (1–5) for **your creature** to get a **Total Survival Score out of 25**.

Environment	Creature Name	Team	Total Survival Score (0–25)

All steps are clearly outlined and easy to follow

Students collect data in organized charts

Graphing

Students analyze their data and draw conclusions

Graphing Task

1. Create a bar graph titled “Class Average Survival Score by Environment.”
 - For each environment, **add** all teams' Total Survival Scores within each environment.
 - **Divide** by the number of teams for that environment to get the **average**.
2. Plot the averages; title and label axes; write a **1-sentence caption**: “__ has the highest average because __.”
 - X-axis: Environment Y-axis: Average Survival Score (0–25).
3. Add a one-sentence caption explaining which environment appears most/least survivable and why.

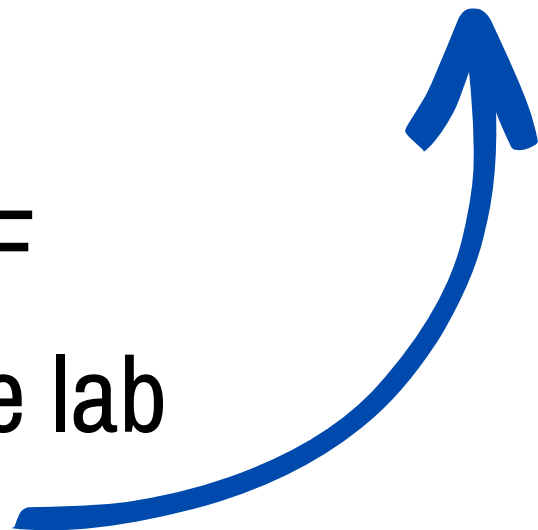
Answer the Following

1. Which environment had the **HIGHEST** average Survival Score on your class bar graph? Cite one specific reason from class creature designs that helps explain why it scored highest (e.g., resource availability, defenses, or temperature).
2. Which environment had the **LOWEST** average Survival Score? Identify **TWO** key environmental pressures that make survival hard there and explain briefly.
 - Pressure #1 and why:
 - Pressure #2 and why:
3. Mechanism Example (Water Efficiency 5/5): Choose a creature that earned 5/5 for Water Efficiency. Describe **TWO** specific mechanisms it uses to reduce water loss and explain how each mechanism works.
 - Mechanism 1 (what + how it reduces water loss):
 - Mechanism 2 (what + how it reduces water loss):
4. Migration Tweak: If a top-scoring creature from the Hyper-Arid Dune Sea had to move to the Acidic Mire, what **TWO** adaptation changes would you add or modify so it can survive? Explain how each helps under acidic, wet conditions.
 - Adaptation change #1 (what + why it helps in Acidic Mire):
 - Adaptation change #2 (what + why it helps in Acidic Mire):

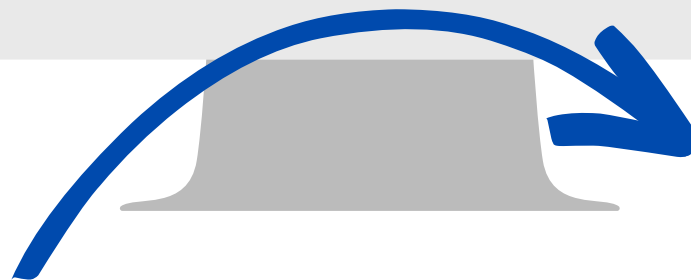
At School or at Home



Word and PDF
versions of the lab



Fully digital and editable - can be
done in class or through distance
education/homeschool



Ways to Use this Resource

- ★ Introduce the Scientific Method
- ★ Reinforce key ideas
- ★ Teach data analysis and graphing
- ★ Formative or Summative Assessment

Beetle Genetics Investigation: Punnett Squares & Traits

Purpose
Teach heredity with beetles: alleles, Punnett squares, genotype/phenotype, probability, and a CER.

Learning Objectives

- Differentiate genotype vs phenotype; dominant vs recessive.
- Use Punnett squares to predict genotype and phenotype ratios (monohybrid).
- Calculate expected probabilities and compare to outcomes.
- Extend to a dihybrid cross (AaBb × AaBb).
- Write a short CER using results.

Materials

- Printed Parent Genotype Cards (A/a, B/b, C/c, D/d, E/e) — two decks
- Student packet (Punnett grids and ratio tables)
- Colored pencils/markers
- Scissors, tape/glue

Background Science for the Teacher
Each trait has two alleles (dominant/recessive). Offspring receive one allele from each parent; squares organize combinations and ratios. Probability describes chance per offspring; small samples may vary from expectations.

Variables

- Independent Variable: Parent genotypes (allele pairs chosen).
- Dependent Variable: Offspring genotype/phenotype ratios.
- Controlled Variables: Dominance rules, list of traits, consistent procedure.

Expected Results Pattern
Aa × Aa → genotype 1:2:1, phenotype 3:1; AaBb × AaBb → phenotype 9:3:3:1 (independent assortment)

Implementation Notes

- Run 4-5 traits; begin with a single monohybrid.
- Students draw Parent 1 and Parent 2 from each gene deck (A-E).
- Require labeled grids, ratios, and CER; share-out to compare patterns.

Extension Ideas

- Add one incomplete-dominance trait with three phenotypes.
- Coin-flip allele model to visualize sampling error.
- Introduce pedigrees after Punnett mastery.

Teacher Notes on Common Pitfalls and Fixes

- Confusing genotype/phenotype → keep a reference box visible.
- Unlabeled alleles on grid edges → model an example live.
- Treating ratios as guarantees → emphasize probability.

Beetle Genetics STEM Investigation

Driving Question
How do parent genotypes determine offspring traits in beetles?

Hypothesis
Predict the phenotype outcomes for one trait and explain why.

Independent Variable	Describe for This Investigation (Parent genotypes (allele pairs drawn for each trait))
Dependent Variable	Offspring genotype and phenotype ratios
Controlled Elements	Dominance rules; trait list; procedure for analyzing crosses

Analysis Questions KEY

- Genotype vs phenotype: genotype = allele combo; phenotype = observable trait.
- Dominant vs recessive: dominant shows with one copy; recessive needs two.
- Example Aa × aa: genotype 1:1; phenotype 1 dominant : 1 recessive.
- 75% not guaranteed: each offspring is an independent event; small samples vary.
- Beyond simple dominance: incomplete dominance, codominance, polygenic traits.
- CER — Model Answer (Trait A: Shell Color)

Claim: When Parent 1 is Aa and Parent 2 is aa, about half of the offspring will have dark shells and half will have light shells.

Evidence: The Punnett square for Aa × aa shows 2 of 4 boxes = Aa and 2 of 4 boxes = aa. That's 50% dark (A_) and 50% light (aa).

Reasoning: Each parent passes one allele at random to the offspring. A is dominant, so Aa looks dark. a is recessive, so only aa looks light. Because the cross makes Aa and aa equally often, the genotypes lead to a 50/50 split in phenotypes.

Answer Key and Sample Results

Trait	Example Cross	Expected Ratios
A - Shell Color	Aa × aa	Genotype 1:1; Phenotype 1 dark : 1 light
B - Antennae	Bb × Bb	Genotype 1:2:1; Phenotype 3 long : 1 short
C - Elytra Pattern	Cc × cc	Genotype 1:1; Phenotype 1 spotted : 1 solid
D - Leg Spines	Dd × dd	Genotype 1:1; Phenotype 1 spines : 1 no spines
E - Eye Color	Ee × Ee	Genotype 1:2:1; Phenotype 3 red : 1 brown

Genotype Cards (Print & Cut)
Shuffle each gene's mini-deck; draw one for Parent 1 and one for Parent 2 per trait. The 16 stacks of genotype cards for one gene (i.e., all the A-cards)

(Dominant / Recessive)	
Dominant (Uppercase)	Recessive (Lowercase)
A = Dark brown	a = Light tan
B = Long	b = Short
C = Spotted	c = Solid
D = Spines present	d = No spines
E = Red	e = Brown

Genotype Cards (Print & Cut)
Shuffle each gene's mini-deck; draw one for Parent 1 and one for Parent 2 per trait. The 16 stacks of genotype cards for one gene (i.e., all the A-cards)

B-cards	C-cards	D-cards	E-cards
BB	CC	DD	EE
Bb	Cc	Dd	Ee
bb	cc	dd	ee
BB	CC	DD	EE
Bb	Cc	Dd	Ee
bb	cc	dd	ee

Punnett Square

Parent 1 allele: _____ P2 allele: _____

Phenotype ratio: _____

Challenge — A & B Together
Use the 4×4 Punnett square for AaBb × AaBb.

P1 gamete	P2 gamete	P2 gamete	P2 gamete
P1 gamete			
P1 gamete			
P1 gamete			
P1 gamete			

Summary Table (Monohybrid Results)

Trait	Parent Cross	Genotype Ratio	Phenotype Ratio
A			
B			
C			
D			
E			



Download my Angle of Attack STEM Lab FREE
CLICK HERE

✓ Teacher guide with setup, safety, background science, pacing

✓ Step-by-step procedure for testing

✓ Analysis questions with model answers and Rubric



Paper Airplane Angle of Attack STEM Lab

Scientific Method • Variables • Data & Graphing

✓ Classroom-Ready

✓ Data tables + bar graph templates included



Paper Airplane: Angle of Attack STEM Investigation: Scientific Method Activity

Teachers Reference:

Angle of Attack Explained - <https://youtu.be/D1J1oUP-aKA?si=vsnb9a72PajoWnZs>



Purpose

Use a high-engagement paper-airplane challenge to teach experimental design, variables and controls, proportional reasoning, data analysis, and communication of results.

Learning Objectives

- Plan and carry out a controlled investigation with clear independent, dependent, and controlled variables.
- Collect sufficient data (replicates) and compare results across angle conditions.
- Graph distance data to analyze trends and construct evidence-based claims.
- Explain the physical principles (lift, drag, stall) that affect flight distance.

only airplanes; no paper clips or sharp nose cones.
a clear launch lane; stand behind the throw line; throw parallel to the floor.
ing area clear; retrieve planes only after all throws in a round are complete.

- 8.5×11 in) — identical for all planes
- and template (optional, one standard design for all teams)
- factor (or angle guides) to set release angle relative to horizontal
- Tape for a throw line and distance marks; measuring tape or meter tape
- Data sheets (included), clipboards, pencils

Background Science for the Teacher

Lift vs Angle of Attack (AoA): Lift generally increases with AoA up to a point. Beyond a critical AoA, airflow separates (stall), causing lift to drop and drag to rise, shortening distance.

Drag and Energy: Higher AoA increases frontal area and induced drag; too much drag slows the plane quickly. Moderate AoA balances adequate lift with manageable drag for a longer glide.

Consistency: A single plane design, constant throw force/height, and a clear angle-setting method are key to fair comparisons.

Expected Results Pattern

- Distances typically peak at a moderate AoA (around 10°–15° for a simple dart design).
- Very low AoA (0°–5°) may dive or fail to generate a strong glide; very high AoA (20°+) often stalls or climbs then falls rapidly.
- As throw technique becomes consistent, variation decreases and the distance curve vs angle becomes clearer.

Implementation Notes

- Use one standard airplane design per class for consistency (provide a template or model).
- Assign roles: Thrower, Angle Setter/Checker, Measurer, Recorder. Rotate roles between angles.
- Mark the throw line and measure angle at release using a protractor or an angle card taped to the forearm or launcher guide.

Answer Key and Sample Results

Note: Actual class data will vary. The sample below models typical trends and acceptable analysis quality.

Sample Summary Data

Angle (°)	Average Distance (m)
0	7.8
5	10.6
10	12.9
15	12.1
20	8.9

Interpretation

- Greatest average distance at 10° (=12.9 m) with a close second at 15° (=12.1 m).
- Very low angle (0°) underperformed (dives/low lift). Very high angle (20°) lost distance (near-stall and higher drag).
- The trend supports a moderate-angle optimum due to balance of lift and drag.

Model Responses to Analysis Questions

- Best angle: 10° with an average of ~12.9 m (our class graph shows a peak around 10–15°).
- Consistency: Results were reasonably consistent after the practice round; using the same thrower and angle card reduced variation.
- Controls that mattered most: Plane design and paper type, release height and throw force, indoor/no-draft room, and measuring to first contact.
- Follow-up: Test nose mass with paper clips at the best angle. Hypothesis: Adding a small nose mass (1–2 clips) will increase distance by improving stability without greatly increasing drag.

STEM INVESTIGATION BUNDLE

Build a high-engagement, low-prep STEM program.

- This Bundle includes my best STEM investigations—each one built around true engineering design, fair testing, repeated trials, data tables, graphing, and CER writing.
- STEM develops crucial skills like critical thinking and creativity and prepares students for a changing world and future opportunities.

STEM Investigation Growing Bundle

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✓ Classroom-Ready

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