Teaching Science with Math & Engineering in Diverse Classrooms

bloom

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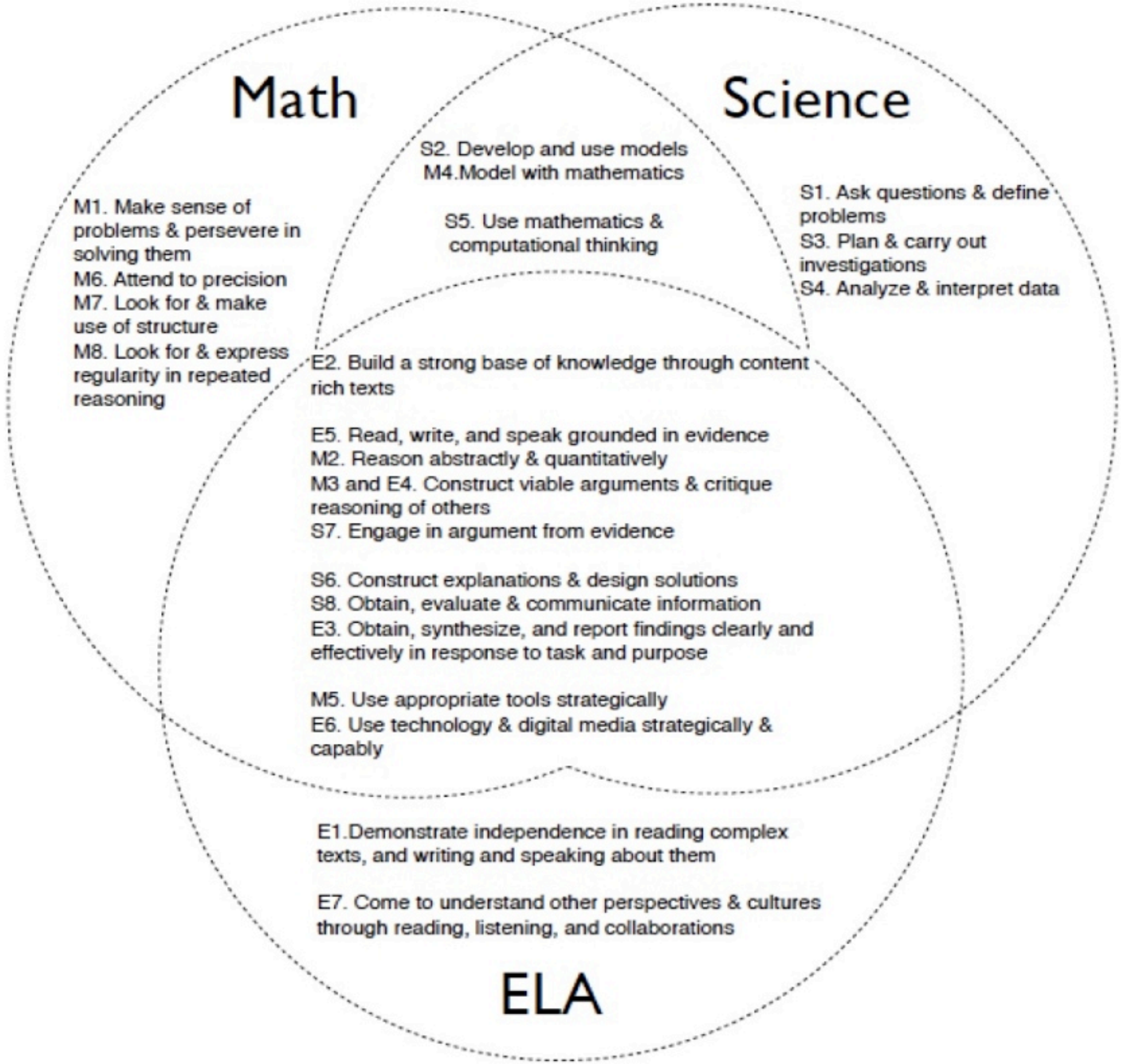
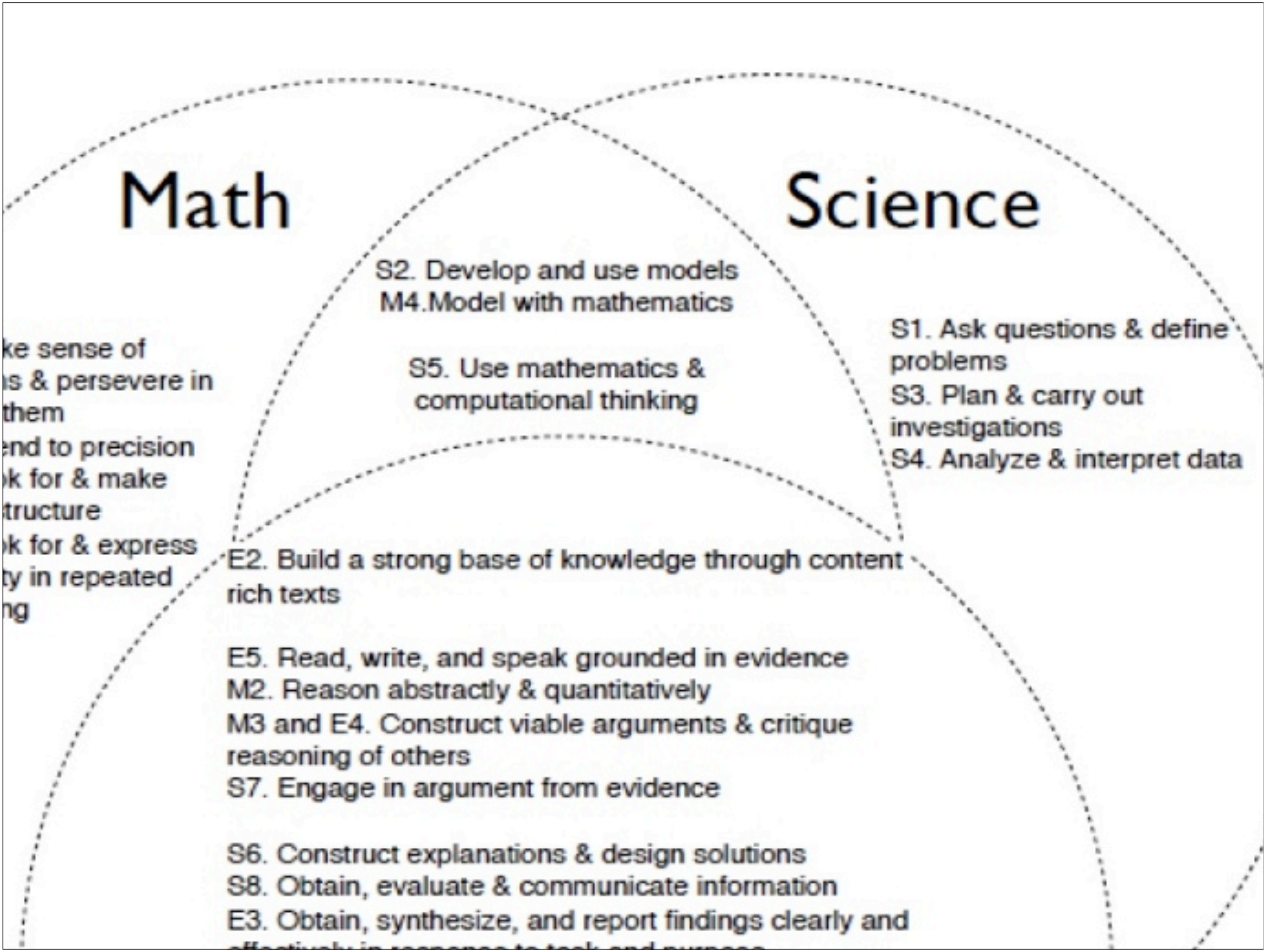
LRDC Learning Research & Development Center

NEXT GENERATION SCIENCE STANDARDS
For States, By States

Beginning a New Era of Science Instruction?

Until now	Moving forward
rapid topic march	focus on big ideas
skills vs. concepts	integrated skills & concepts
another teaching silo	embracing S**TEM**
(procedural) mathematics on the way out	conceptual mathematics and simulation demanded
engineering ignored	engineering integrated


Math
Science
S2. Develop and use models
M4.Model with mathematics
S5. Use mathematics & computational thinking
M1. Make sense of problems & persevere in solving them
M6. Attend to precision
M7. Look for & make use of structure
M8. Look for & express regularity in repeated reasoning
S1. Ask questions & define problems
S3. Plan & carry out investigations
S4. Analyze & interpret data
E2. Build a strong base of knowledge through content rich texts
E5. Read, write, and speak grounded in evidence
M2. Reason abstractly & quantitatively
M3 and E4. Construct viable arguments & critique reasoning of others
S7. Engage in argument from evidence
S6. Construct explanations & design solutions
S8. Obtain, evaluate & communicate information
E3. Obtain, synthesize, and report findings clearly and effectively in response to task and purpose
M5. Use appropriate tools strategically
E6. Use technology & digital media strategically & capably
E1.Demonstrate independence in reading complex texts, and writing and speaking about them
E7. Come to understand other perspectives & cultures through reading, listening, and collaborations
ELA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Biology:
The big battle ground

- Most dense packing on content
- Largest teaching force
- Largest student size (2:1 chemistry, 7:1 physics)
- Biggest disconnect between use of mathematics in high school vs. in discipline

Is the mathematics about procedures or understanding?

HS-LS3-d.
Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

HS-LS4-c.
Apply concepts of statistics and probability to support explanations for how organisms with an advantageous heritable trait tend to increase in proportion to organisms that lack this trait.

The Landmine Crisis

A 3-week-long

Engineering Design Challenge

(Replacement unit)

https://www.youtube.com/watch?v=5NkwLJgoYFO

Laos


CHINA
CHINA
BURMA
VIETNAM
Phongsali
Louang Namtha
Xam Nua
Louangphrabang
Xiangkhoang
Phu Bia
Ban Nape
VIENTIANE
Mekong
Muang Khammouan
Savannakhet
Gulf of Tonkin
THAILAND
Salavan
VIET.
Pakxe
CAMBODIA
0 50 100 km
0 50 100 mi
100
104
108
20
16

UXO: A major problem

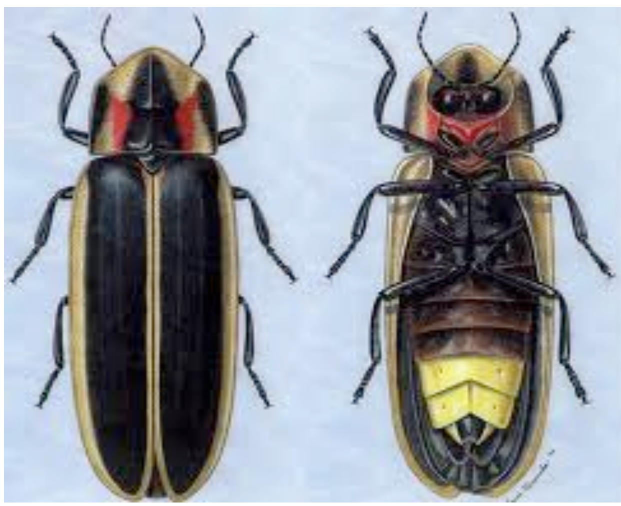
- UneXploded Ordinance
- From 1964-1973, US forces dropped roughly two million tons of ordinance on Laos (more than in all of WWII).
- With 37% of the country's total surface area contaminated by UXO, Laos is considered the most UXO-affected nation in the world.

What can be done?

- We are a team of volunteers who have offered our services to Engineers Without Borders
- The mission of EWB is to "support community-driven development programs worldwide by collaborating with local partners to design and implement sustainable engineering projects”
- EWB has assigned us to tackle the landmine challenge in Laos

No Free Lunch

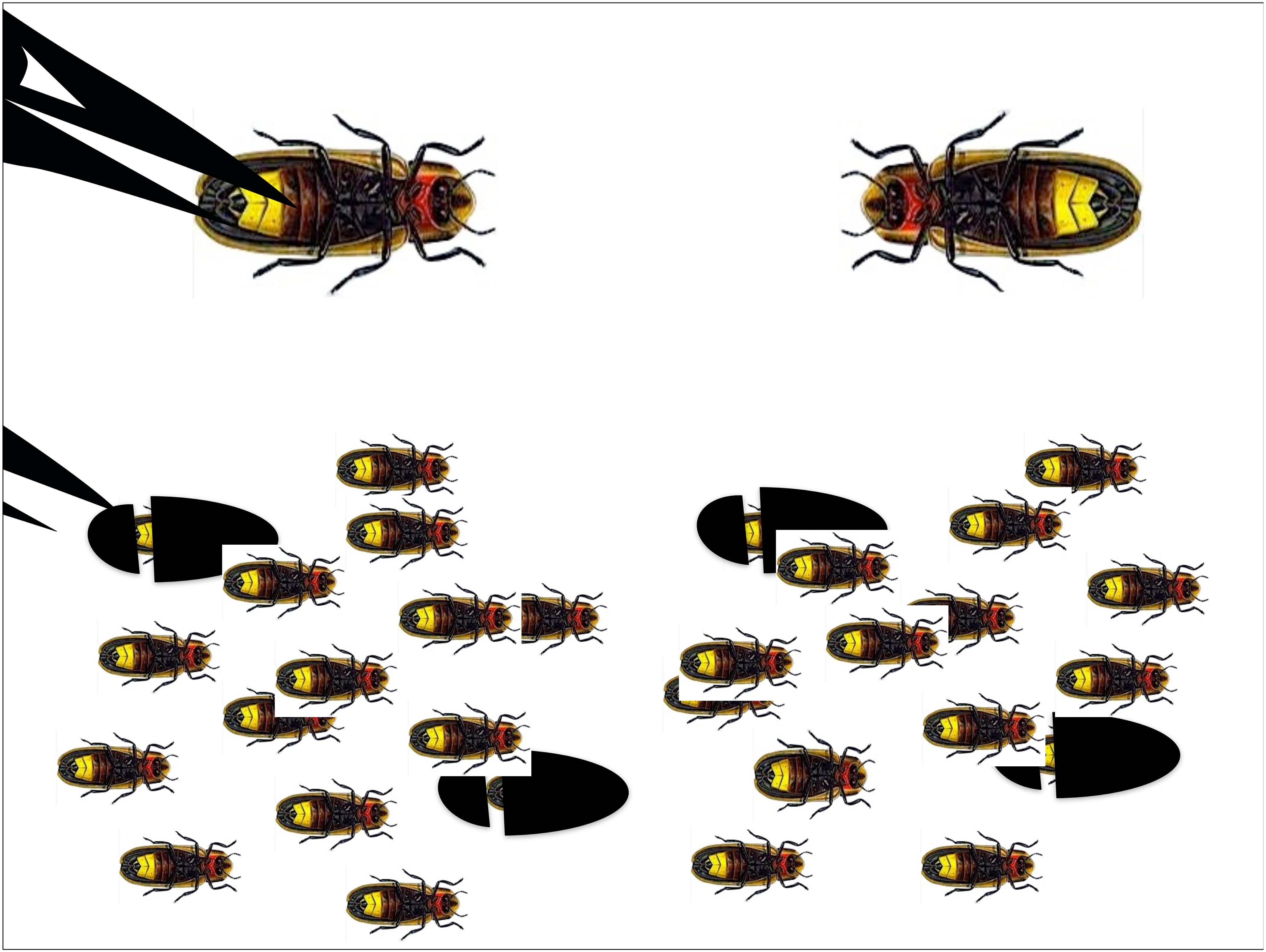
- Our project is financially supported by Phil, who has an idea:



Student Activities

- Identify resources and constraints
- Generate problem statement
- Conduct background research on fireflies
- Develop a plan to purchase and breed flies in order to get more special fireflies

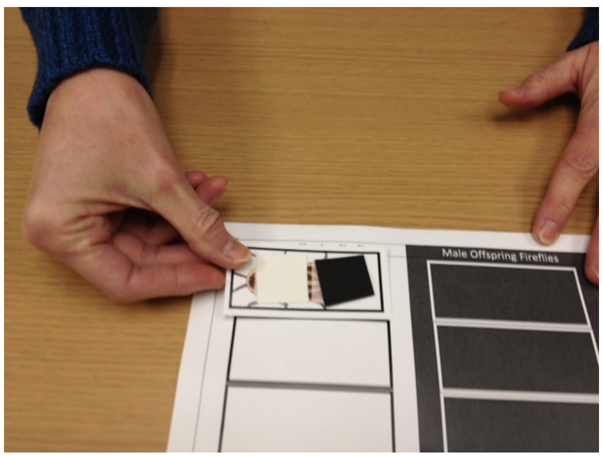
BUT: We don't really know much (anything?) about firefly reproduction!

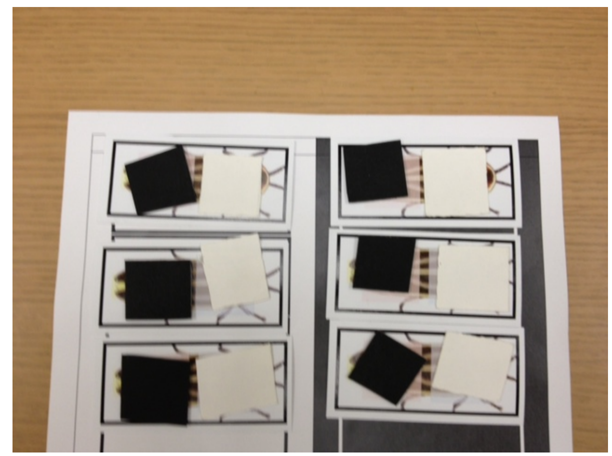


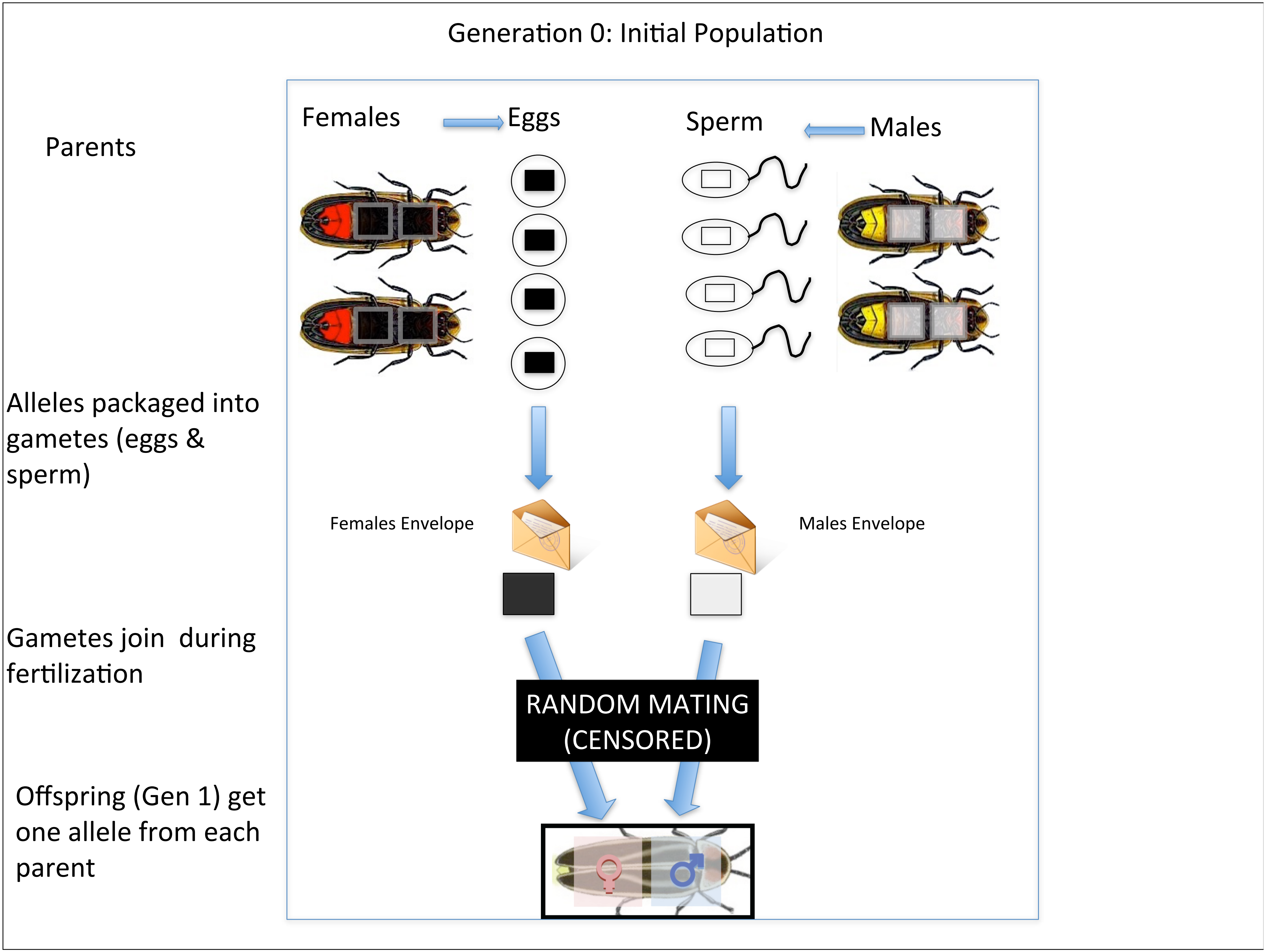
What would happen in a sealed environment?

Testing the simple case

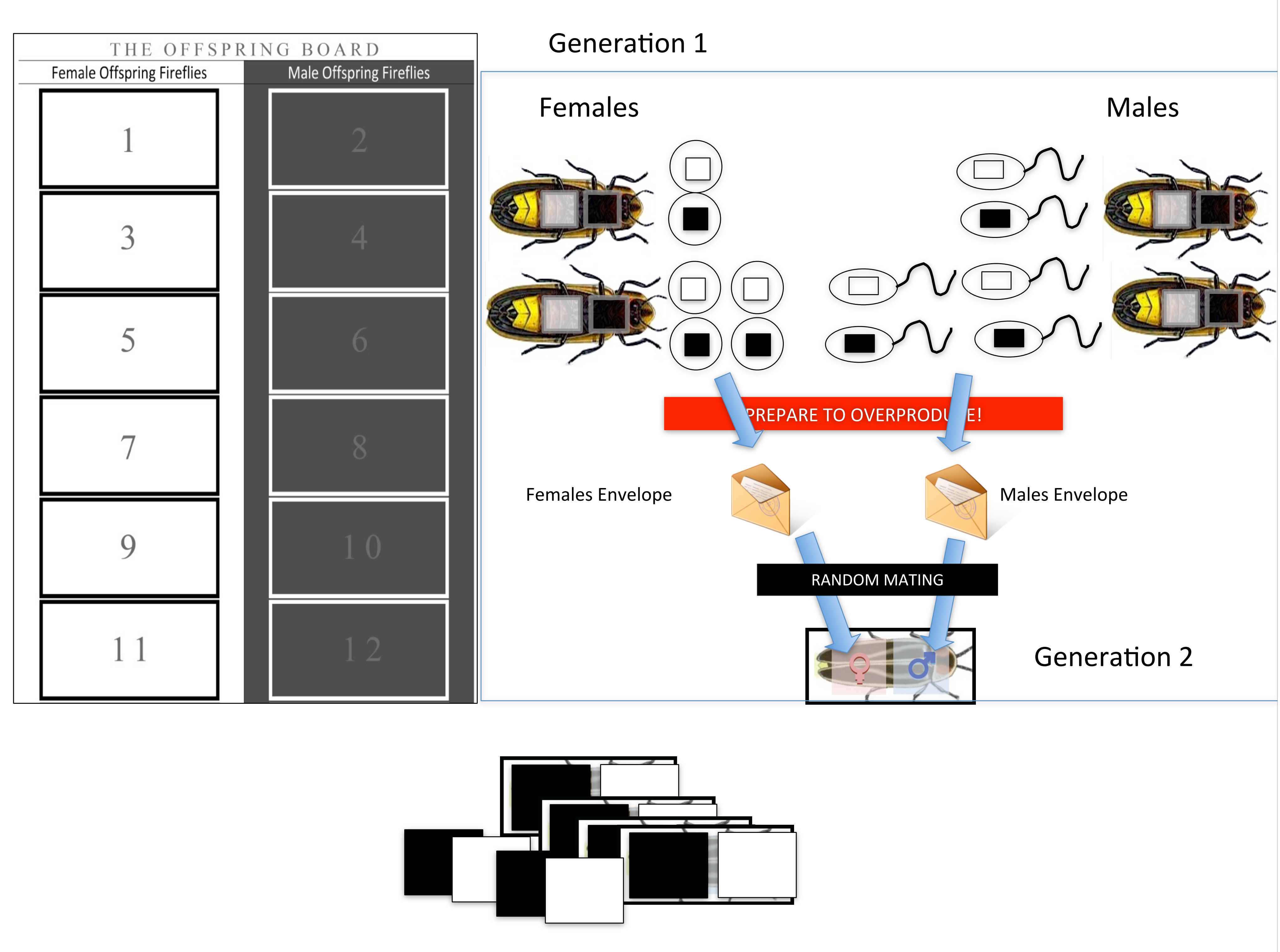
- Use a simulation!







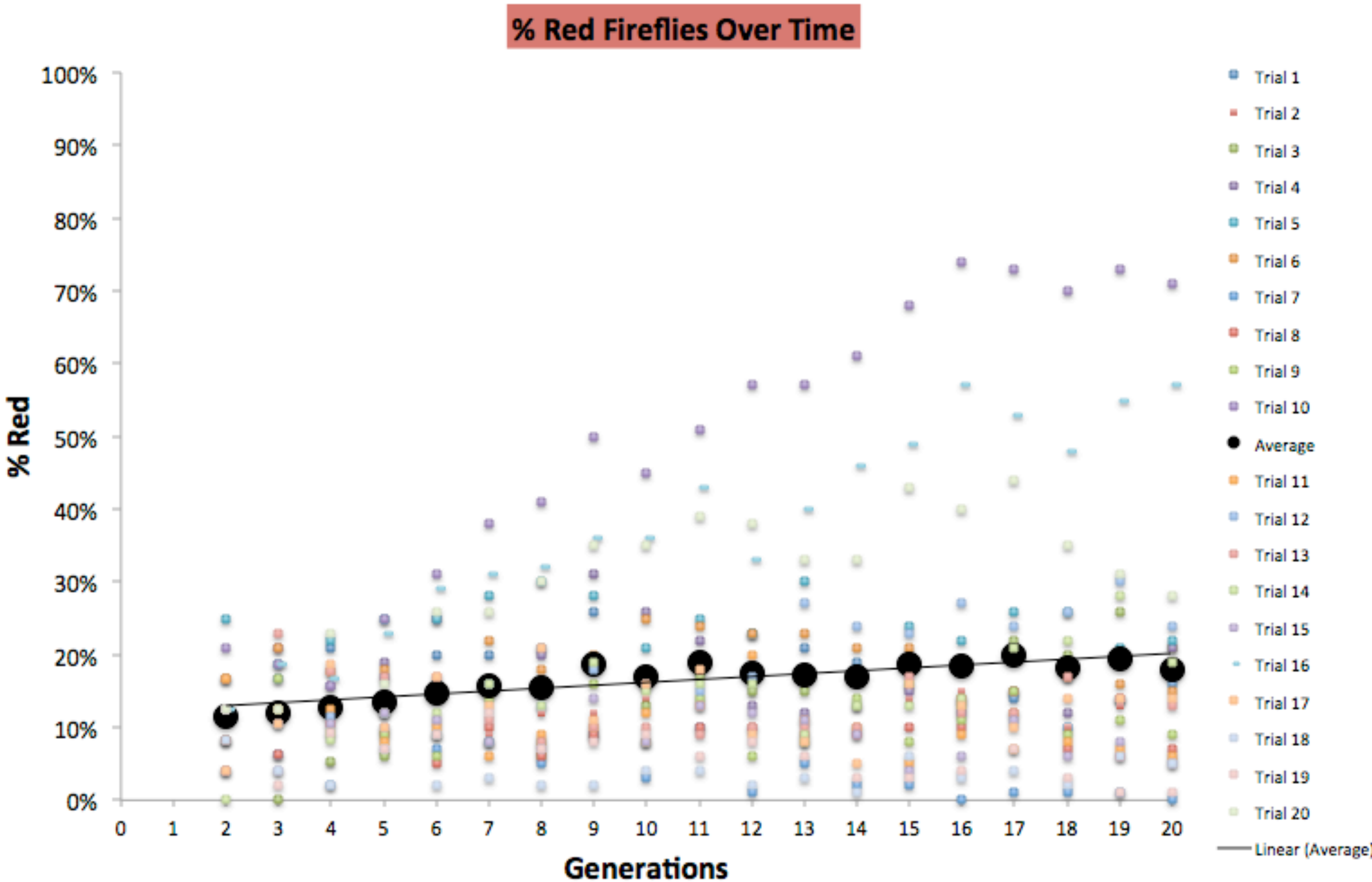
Generation 0: Initial Population
Parents
Females
Eggs
Sperm
Males
Alleles packaged into gametes (eggs & sperm)
Females Envelope
Males Envelope
Gametes join during fertilization
RANDOM MATING (CENSORED)
Offspring (Gen 1) get one allele from each parent


THE OFFSPRING BOARD
Female Offspring Fireflies
Male Offspring Fireflies
1
2
3
4
5
6
7
8
9
10
11
12
Generation 1
Females
Males
PREPARE TO OVERPRODUCE!
Females Envelope
Males Envelope
RANDOM MATING
Generation 2

SO WHAT HAPPENS?

DATA ANALYSIS!

Excel + Computational Thinking

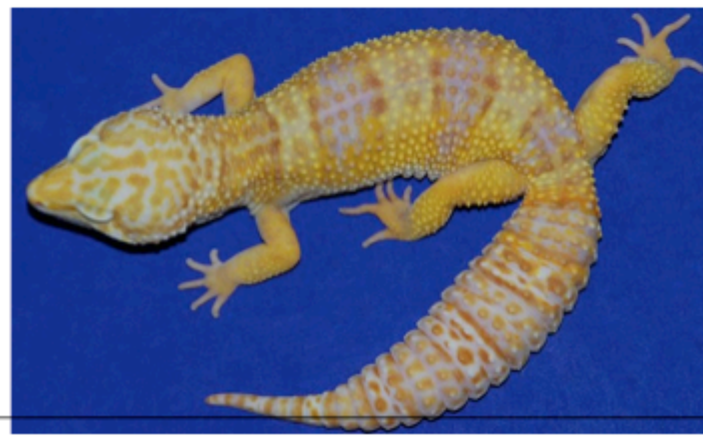


Biology Content

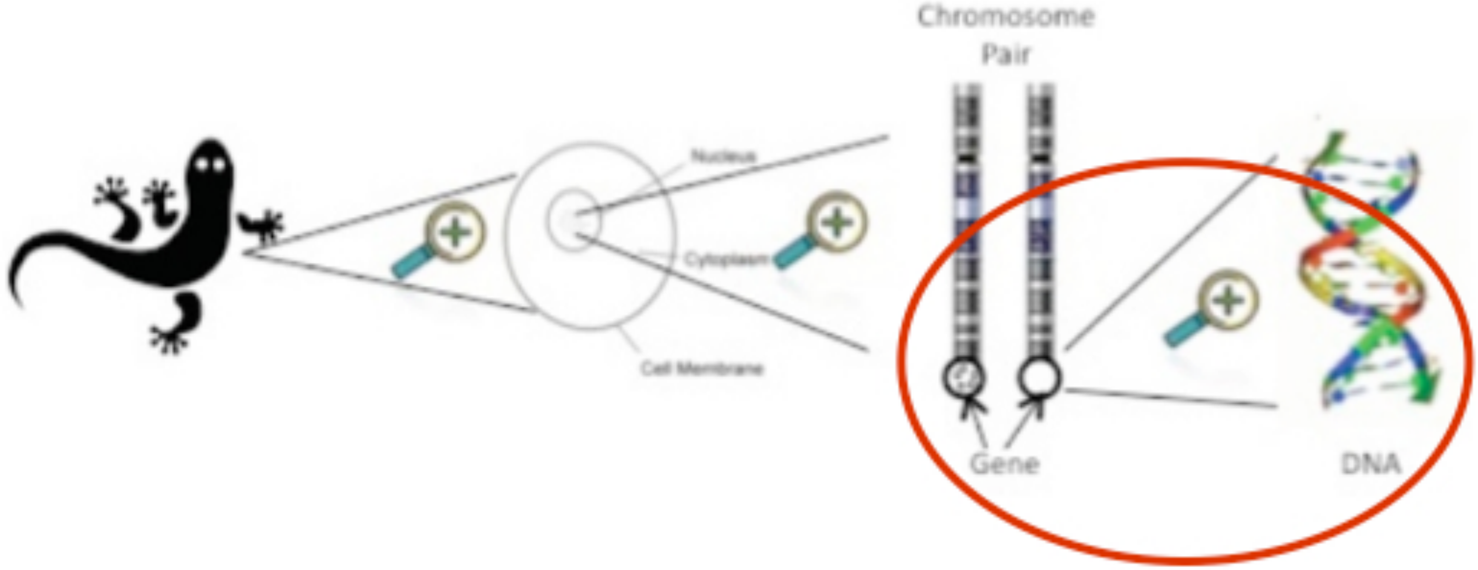
- Goals:
  - Environmental factors (selective pressure) acts on the phenotype.
  - When selective pressure differentially affects survival of one phenotype in a population versus the other phenotype, the proportions of alleles and phenotypes within the population changes.
  - As selective pressure acts on a particular phenotype. then,
    - the phenotype with a higher pressure will decreases at a certain rate, but
    - the phenotype with lower pressure will increase at the same rate.
- This is Evolution by Natural Selection!

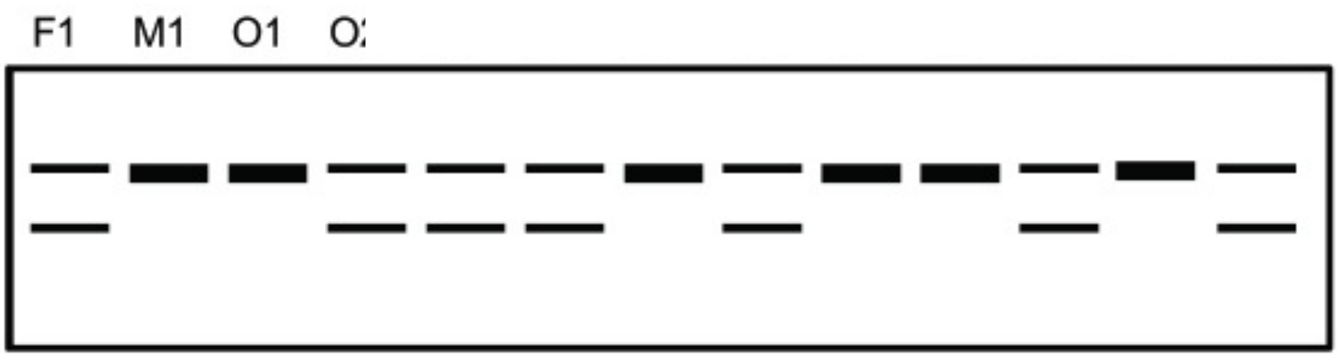
Math Content

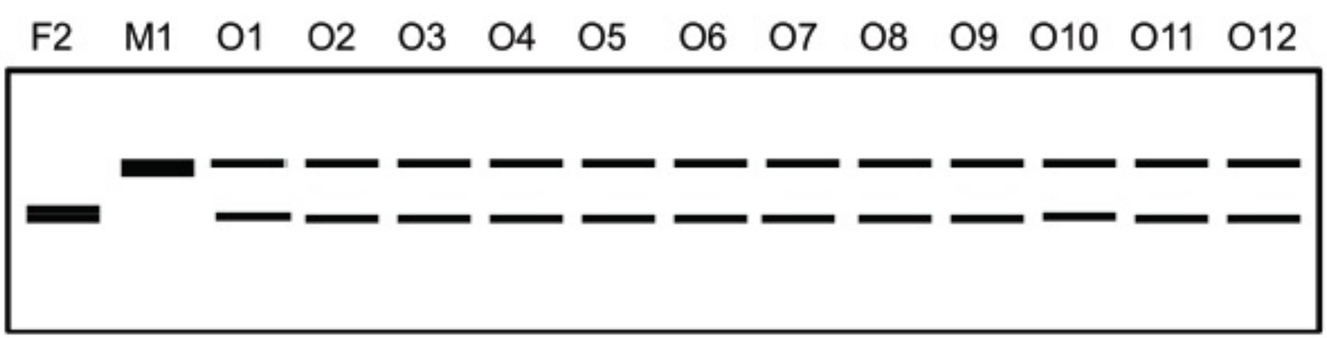
- Goals:
  - The change in percent phenotype/alleles which is expressed on the y axis divided by the change in time (expressed on the x axis) is a measure of the rate of change (slope) in the population.
  - Across multiple trials, the best model fit can be captured with the slope of the best fit line, which is the average of the slopes of all the trials
  - A positive slope indicates that the variable on the y axis is increasing over time. A negative slope indicates that the variable on the y axis is decreasing over time. (x-axis represents time)
  - The steeper the line, the larger the numerical value of the slope and the faster the rate of change.

Type of Leopard Gecko	Picture	Gene	Cost
Normal		N/A	$35 or $70
Albino		Albino	$80
Blizzard		Blizzard	$80

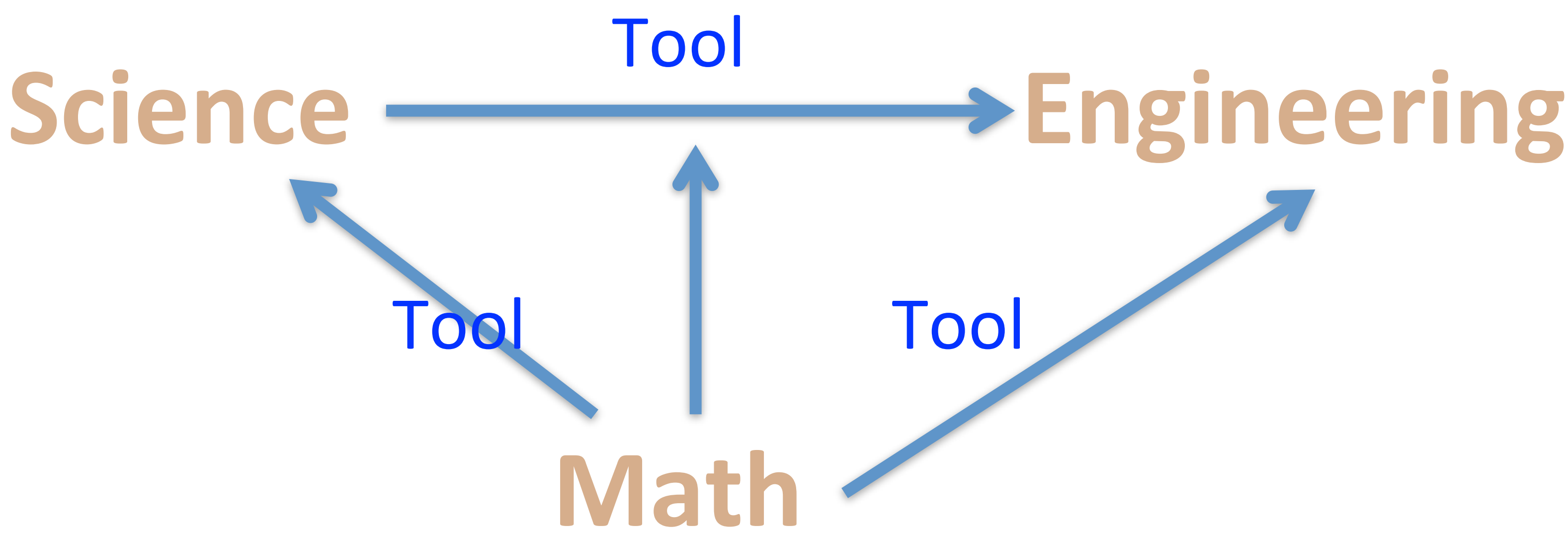
PCR data

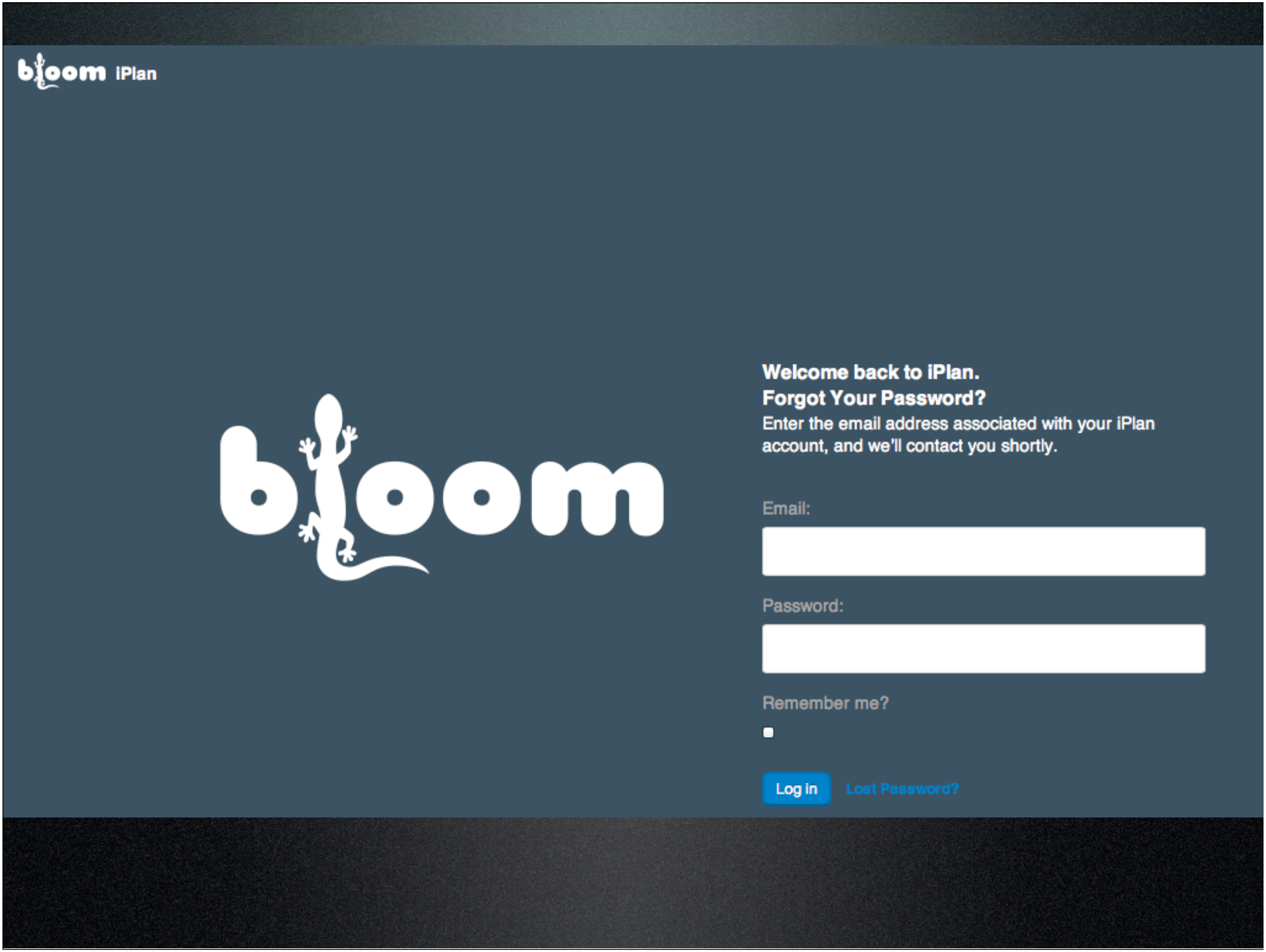

Chromosome
Pair
Nucleus
Cytoplasm
Cell Membrane
Gene
DNA


F1 M1 O1 O:


F2 M1 O1 O2 O3 O4 O5 O6 O7 O8 O9 O10 O11 O12

STEM?





bloom iPlan
bloom
Welcome back to iPlan.
Forgot Your Password?
Enter the email address associated with your iPlan account, and we'll contact you shortly.
Email:
Password:
Remember me?
Log In
Lost Password?

Unit Overview

Task A: The Landmine Crisis

2 class periods

Working like engineers to understand a societal problem about landmines will motivate students to learn about growing a population of fireflies.

Task Segments

- A.1: The Landmine Design Challenge
- A.2: Exploring a Potential Solution
- A.3: Clarifying the Problem
- A.4: Conducting Background Research
- A.5: Planning For Design

Task B: Modeling Population Growth

3 class periods

Through collaborative discourse with the teacher, students explore concepts about population growth using a reproduction simulation.

Task Segments

- B.1: Introducing Concepts about Population Growth
- B.2: Exploring Population Growth with Simulation

Task C: Analyzing Simulation Results on Population Growth

3 class periods

Students explore data generated from the simulation by using mathematical tools to understand that growing a population increases the number of all types of flies in the population proportionally.

Task Segments

- C.1: Generating Graphs
- C.2: Fostering Proportional Reasoning
- C.3: Discussion on storyboards and graphs
- C.4: Discussion about Constructing Design Criteria

Task D: Extending the Simulation

3 class periods

Students use a computer simulation to explore in what ways selective pressure influences the proportion of a particular trait in a population of fireflies.

Task Segments

- D.1: Introducing the Devices
- D.2: Using the Excel Simulation
- D.3: Interpreting Simulation Data

Task E: Proposing a Solution to the Challenge

2 class periods

Students use a computer simulation to explore in what ways initial population influences the proportion of a particular trait in a population of fireflies.

Task Segments

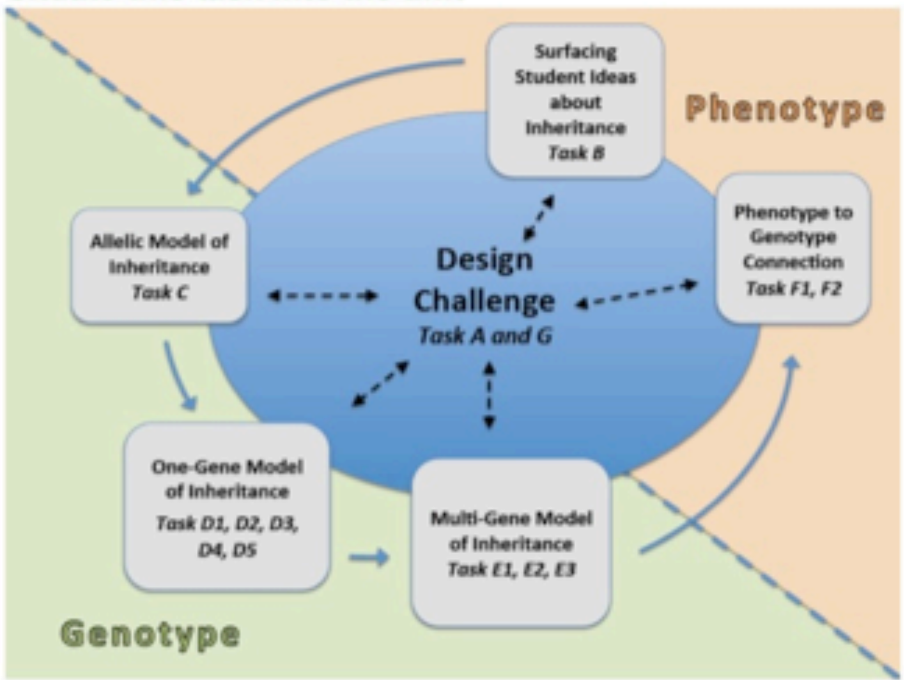
- E.1: Reviewing and Brainstorming Options
- E.2: Reporting Back to Phil

Task A: Design Challenge: First Exposure

Task Description:

Exploration of the zoo's design challenge sparks interest in learning about inheritance and probability.

Situate this task into the unit



Tools & Worksheets for Each Task Segment:

A.1: Making Sense of Breeding Challenge Information

- Worksheet 1A (pages 1-4)

A.2: Brainstorming Initial Solutions

- Worksheet 1A (page 5)

Why this task now?

By tapping into students' ideas about zoos and breeding as well as their entrepreneurial interests, the design challenge helps students see genetics knowledge as useful in a real world context. This initial task is meant to help students begin brainstorming a solution so they can take ownership over their work in this unit.

Content Goals

Biology Content Goals

Although this task has no specific biology content goals, it lays the foundation for future content by motivating students to learn how traits are inherited.

Mathematics Content Goals

This task sets the stage for the unit's mathematics work. In particular, it encourages students to begin thinking about rarity as an infrequent occurrence.

Scientific/Engineering Practices

NRC Practice-1: Defining Problems (Engineering Practice)

"(Engineers begin) with a problem, need, or desire that suggests an engineering problem that needs to be solved.…(They) ask questions to define the engineering problem, determine criteria for a successful solution, and identify constraints." (NRC, 2012)

Students will define the problem about the gecko breeding challenge by:

- identifying the engineering problem posed by the zoo's challenge,
- identifying resources available for solving the challenge,
- defining constraints imposed within the description of the challenge presented by the local zoo, and
- generating questions that reflect knowledge or information needed in order to solve the design challenge.

Moving on from here

By engaging in engineering practices of defining the problem, students will recognize a need to understand how inheritance works and how to define rarity in order to solve the zoo's challenge. Some questions from this task to motivate the work in the rest of the unit:

- What offspring do we get when we breed what we can afford? (addressed in exploration of inheritance patterns)
- How do we determine what counts as rare? (addressed in development of mathematical expressions)

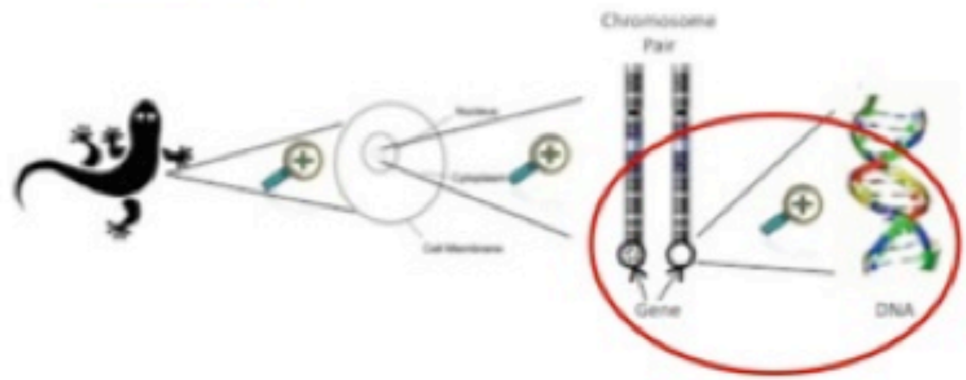
Segment C.1: PCR Data

Resources: Worksheet 3A (pages 1 & 2)

Setting Up Task by Connecting Back: Whole Class [5 min]

Purpose: To help students understand that, to learn about hidden factors, they need to explore inheritance at the gene/DNA level.

- Revisit the need to learn about hidden factors inside geckos (from Task B).
- Teacher presents the Gecko Zoom video and leads a brief review of levels of organization.
- Teacher hands out pages 1 and 2 of Worksheet 3A.
- Students circle the level they think the worksheet is addressing. [NOTE: Students should recognize that, in this task, they will be working at the gene/DNA level.]



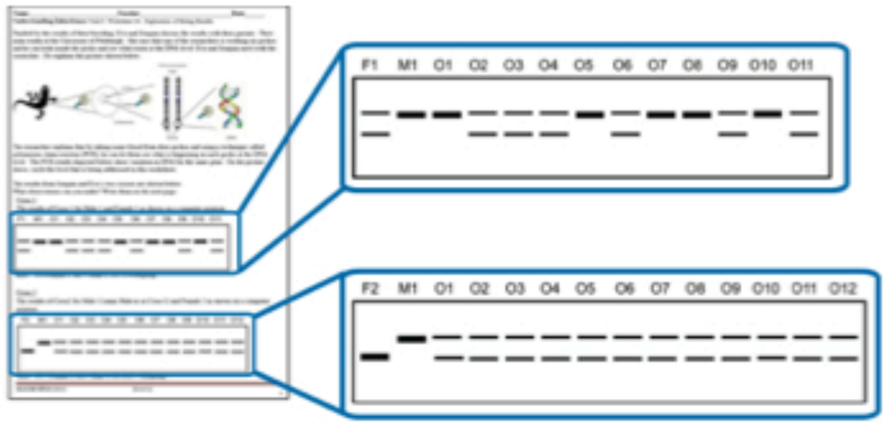
Monitoring Student Thinking and Seeding Ideas: Small Groups [10 min]

Purpose: To help students observe patterns in the PCR data that will support development of rules of inheritance in Segment C.2.

- Teacher sets up activity by asking, "What is an observation?"
- Student groups record observations about the PCR data to share with

Important

With seeding, you can avoid having to provide the same support to all groups during group work. Instead, you can "plant" an idea (concept or process) within one or two mid-level groups. During the class discussion, you can use the "seeded" groups to get the same idea across to the rest of the class.



Observations	Inferences
All the offspring in cross 2 have the same PCR.	All the offspring in cross 2 look like a blend of the two parents.
In cross 1, some offspring PCRs match the mom's and some match the dad's. In cross 2, none of the offspring PCRs match either parent.	In cross 2, offspring 1, 5, 7, 8, and 10 are boys because their PCRs look like the dad. The others are girls. In cross 2, all the offspring are girls.

Guiding Students to Consensus: Whole Class [10 min]

Purpose: To enable students to agree on a list of PCR observations that they will use to develop rules of inheritance in segment C.2.

- Teacher asks students for observations.
- Class decides whether each contribution is an observation or inference.
- Teacher records the observations on chart paper for use in generating the rules of inheritance.

How other teachers customized this Segment for their classroom

Laura
Ploughe
Classes: Environmental Science (Grade 9th),
Wednesday, February 13, 2013 at 7:43 am

In order to incorporate geography into the unit, I utilized Google Earth and maps to show students where Laos is.

Also, my students were having some difficulties understanding why exactly they were looking at the key features, so I also had the students identify their problem statements on their whiteboards in addition to the 4 features. When they did this, they were able to generate their key features easier as they understood the purpose for the task.

Denise
Davis
Seton LaSalle Catholic High School
Classes: General Biology (Grade 10th), Honors Biology (Grade 9th),
Thursday, February 7, 2013 at 5:50 am

I showed the film first and then brought up a google map of Laos with the sattelite view. The topography of the land help the students to see the lay out of the land. I feel this enabled them to see the difficulty in locating the landmines and brought a better sense of isolation.

DISCUSSION: Device 3 with full vials

1 Comment

After working with Device 1, 2 and 3, I had a group that requested to have more flies to breed with device 3 since their extinction percent was present. I allowed them and they got above 75% red flies surviving by generation 4 with 0% extinction. Do I push them to ask for heterozygous flies if they think they have solved the issue or let them write their conclusion. They won't realize they could have slightly better results with het flies until other groups present their conclusion. So they aren't wrong just not as efficient.

Curriculum Developer

kdp5@pitt.edu
Curriculum Developer
Wednesday, February 27, 2013 at 11:11 am

Hi Angie,

C.1: Generating Graphs | C.2: Fostering Proportional Reasoning | C.3: Discussion on storyboards and graphs | C.4: Discussion about Constructing Design Criteria

DISCUSSION: Is Orange Color Ok?

1 Comment

My one class wanted to vote on 60% red flies being a strong enough color change in the vial from the yellow. Is orange ok?

Curriculum Developer

Mary Sartoris
Curriculum Developer
Monday, February 11, 2013 at 8:01 am

schunn@pitt.edu