Louisa A. Stark, Ann Lambert, Sheila Homburger, Molly Malone, Jen Taylor, Kristin Fenker, Dina Drits-Esser, Kristin Bass, Kevin Pompei

Genetic Science Learning Center
University of Utah

Genes, Traits & Change over Time:

Developing and Testing a **3D Middle School Unit** that Integrates **Heredity & Evolution**

CONTEXT

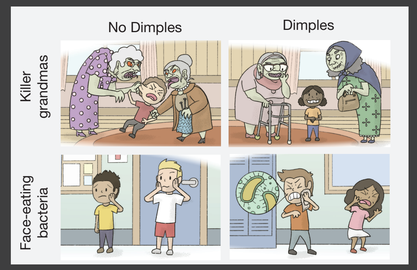
Evolution is central to biology but challenging to learn. Research shows that students have an easier time learning evolution concepts when they understand related ideas from genetics. We are developing a new NGSS-friendly heredity and evolution unit, plus related assessment measures. We will use them to understand the mechanisms of 3D student learning and misconception change in heredity and evolution

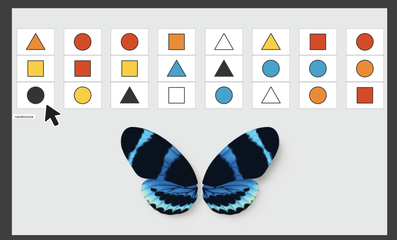
HYPOTHESES

- An evolution unit that integrates heredity ideas will **increase students' understanding** of the mechanisms of evolutionary change.
- Novel assessment measures will **quantify 3D learning & implicit misconceptions**.
- Qualitative measures will help **assess student thinking**, including whether they incorporate heredity concepts in their explanations of evolution.

Unit Modules & *Essential Questions*

- **Traits**: *How are traits made?*
- **Inheritance**: *How are traits passed down?*
- **Reproductive Success**: *How do traits affect who reproduces?*
- **Natural Selection & Adaptation**: *How do species' traits change over time?*
- **Evidence for Evolution**: *How do changes in traits provide evidence for evolution?*





EXAMPLE LESSONS

UNIT FEATURES

- Focus on the **mechanisms** that drive **genetic variation** and **natural selection**
- Scaffolded practice working with **models**, crafting **explanations**, and identifying **cause and effect** relationships
- Embedded **formative assessments**
- Easy-to-implement **multimedia & paper-based** activities
- **Teacher supports**
- ~4–6 weeks of classroom time

POTENTIAL IMPACTS

Improve STEM education for students by:

- Providing an example of a cohesive pair of curriculum units for middle and high school
- Integrating all three dimensions of NGSS

Advance knowledge of:

- How teachers & students use embedded formative assessments
- How 3D curricula lead to 3D learning gains
- Potential differential change in explicit vs. implicit misconceptions of heredity and evolution

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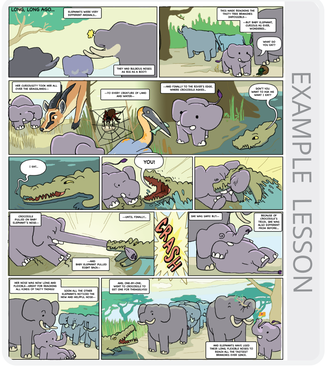
NGSS Connections



1 DISCIPLINARY CORE IDEAS

LS1.B: *Growth & Development of Organisms*

LS3.A+B: *Inheritance & Variation of Traits*

LS4.B: *Natural Selection*

LS4.C: *Adaptation*

LS4.A Evidence of Common Ancestry

2 SCIENCE & ENGINEERING PRACTICES

Constructing Explanations

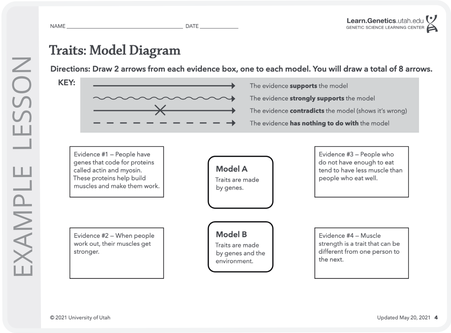
Using & Building Models

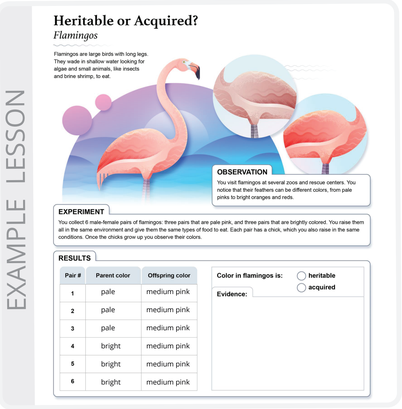
(Analyzing & Interpreting Data)

3 CROSSCUTTING CONCEPTS

Cause & Effect

Structure & Function





PERFORMANCE EXPECTATIONS

MS-LS1 — From Molecules to Organisms: Structures & Processes

MS-LS3 — Heredity: Inheritance & Variation of Traits

MS-LS4 — Biological Evolution: Unitity & Diversity

MIXED METHODS RESEARCH PLAN

Quantitative approaches: measure student learning gains & implicit misconception change

- 1D multiple choice items
- 3D item cluster
- Implicit misconception tests

Qualitative approaches: probe student thinking

- Formative assessments
- Classroom observations
- Student & teacher interviews

TESTING PROCEDURE

- **Pretest**: 1D multiple choice items & implicit misconceptions tests
- Students experience the unit, including embedded formative assessments
- **Posttest**: 1D multiple choice items, implicit misconceptions tests & 3D item cluster

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EXAMPLE EXPLICIT MEASURE OF MISCONCEPTIONS

Which of the following statements best describes new genetic variations?

A. They are usually helpful to the organism.

B. They do not make a difference to the organism.

C. They are usually harmful to the organism.

D. They can be helpful, harmful, or not make a difference.

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Example Implicit Association Test