

# Using student-centered activities to promote a better understanding of how evolution applies to human health

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## Introduction

Recently, the biology department has embarked upon an initiative to include Evolution Across the Curriculum through student-centered learning modules in all of our core courses. A large number of biology majors and non-majors enroll in the two course anatomy and physiology sequence; therefore, providing an opportunity to educate students about the role of evolutionary processes in shaping human health and disease. Modules were developed for this series course to give students an appreciation for how an understanding of evolution is key for advancing the field of medicine. Here we present a set of student-centered activities developed to address key gaps in student understanding of evolutionary processes and how they pertain to human health and disease. We will be focusing on those modules developed for the first course in the series, Human Anatomy & Physiology I (Human A&P).

## Learning Objectives

Topics deemed most appropriate for the Human A&P course were determined based upon a departmental survey that evaluated the amount and type of coverage of evolution content coverage across the core courses.

Course-specific Learning Objectives for Human A&P:

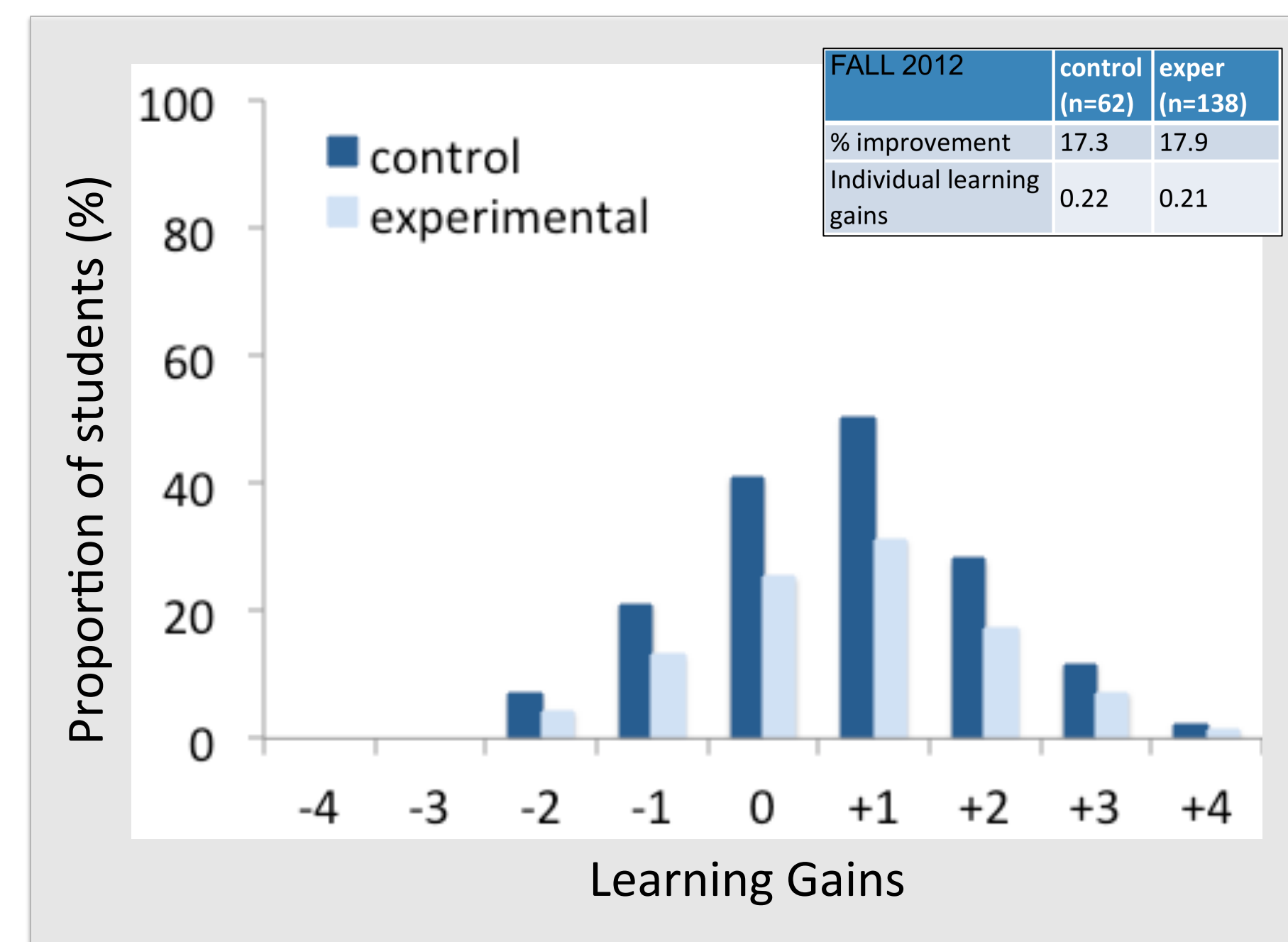
- Students should be able to explain the role natural selection plays in human evolution with specific regard to human health and disease.
- Students should be able to acknowledge that evolutionary processes are random and do not lead to perfection.

## Approach

- Student-centered content modules and assessments for these modules were developed.
- Modules were deployed in control & experimental sections in Fall 2012.
- Effectiveness of assessment questions were evaluated.
  - Individual learning gains were compared across sections.
  - Difficulty & discrimination analyses used to evaluate the quality of assessment questions.
- Assessment questions were modified modules & assessments deployed again in two sections of Bio 312 Spring 2013 semester.

## Module Promoted a Better Understanding of Evolution

### Module & Assessment Tool Evaluation:



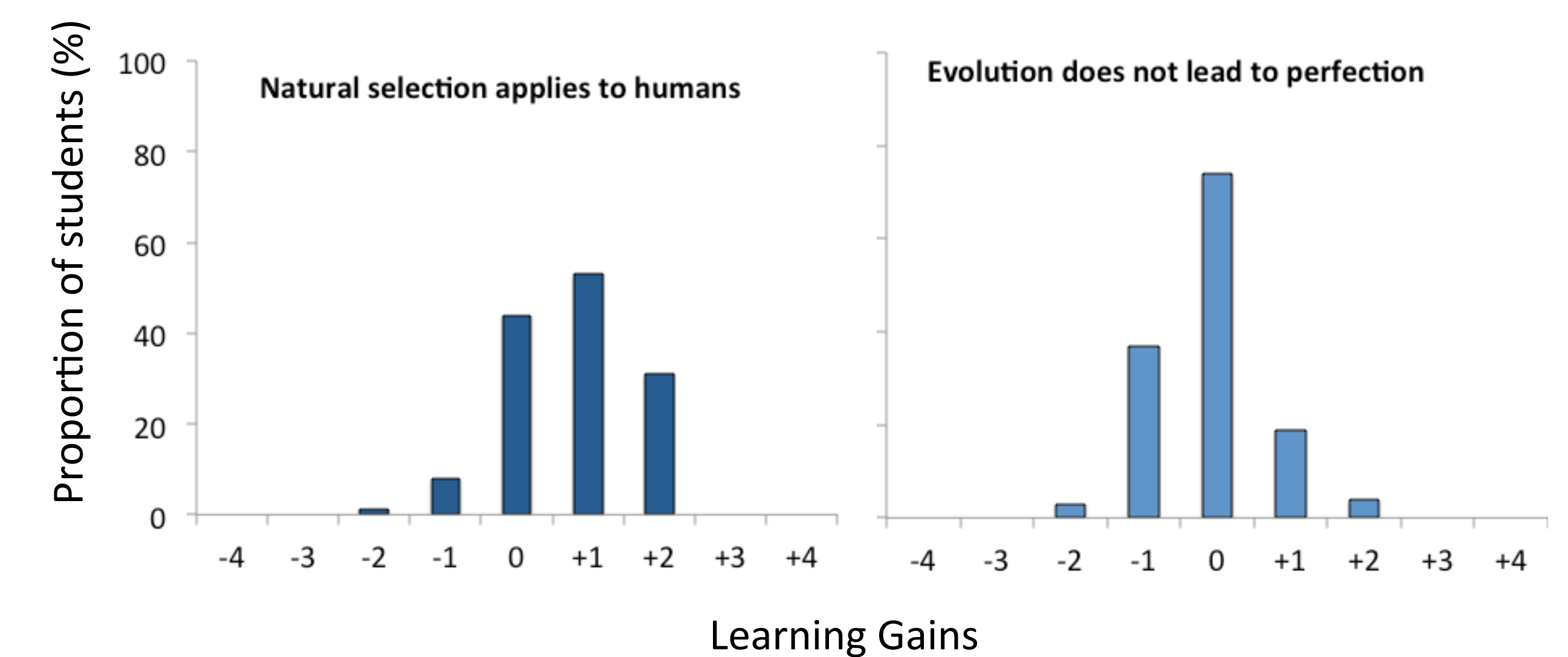
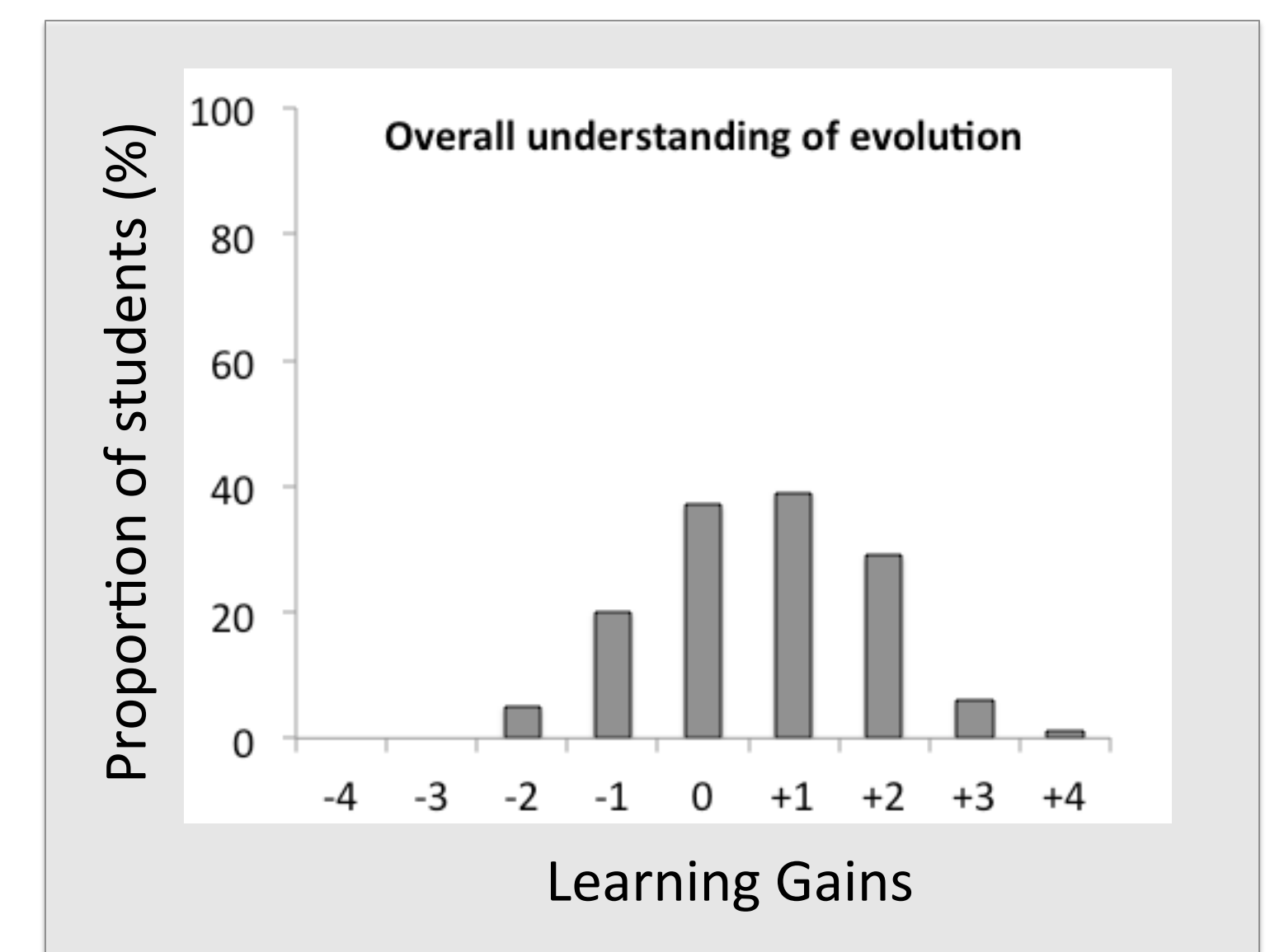
FALL 2012	Natural selection applies to humans				Evolution does not lead to perfection			
	pre-test	post-test	pre-test	post-test	pre-test	post-test	pre-test	post-test
difficulty	0.29	0.53	0.35	0.43	0.58	0.83	0.59	0.32
discrimin hi-lo	0.91	0.79	0.73	0.87	0.81	0.50	0.90	1.00

## Pilot Findings

- Showed negative learning gains in experimental population
- It was determined assessment tool was not reliably assessing evolution concepts.
- Assessment tool was modified and study repeated

### Implementation:

SPRING 2013	All	Natural Selection	Evolution is not perfect
% improvement	22.6	31.9	13.3
Individual learning gains	0.13	0.37	-0.49
Majors (39%)	0.32	0.38	0.21
Non-majors (61%)	0.002	0.36	-0.94

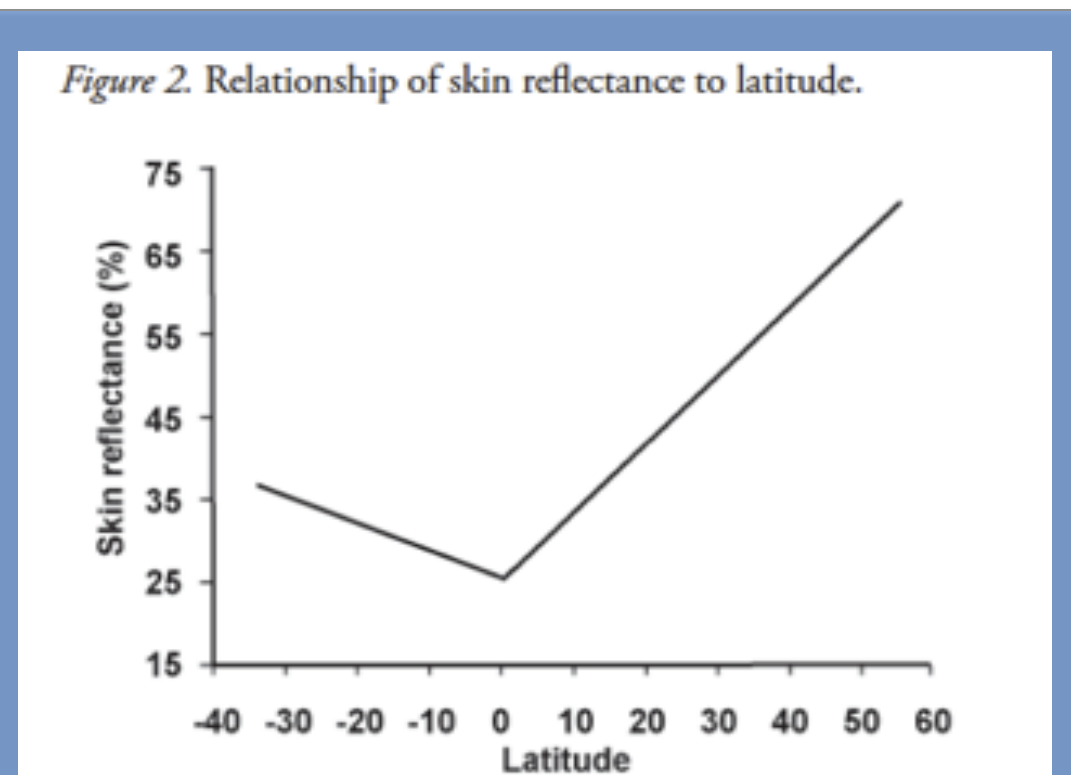
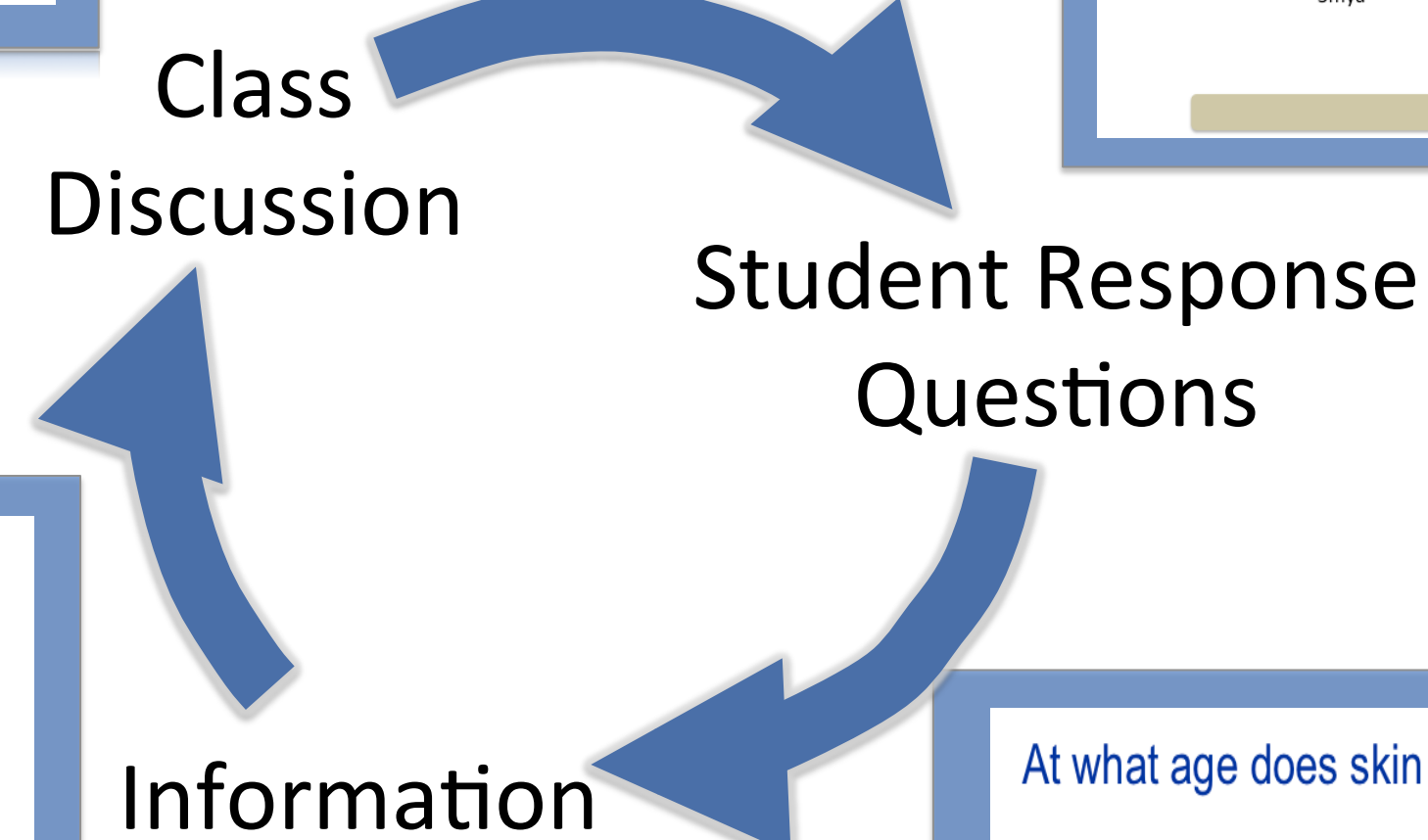
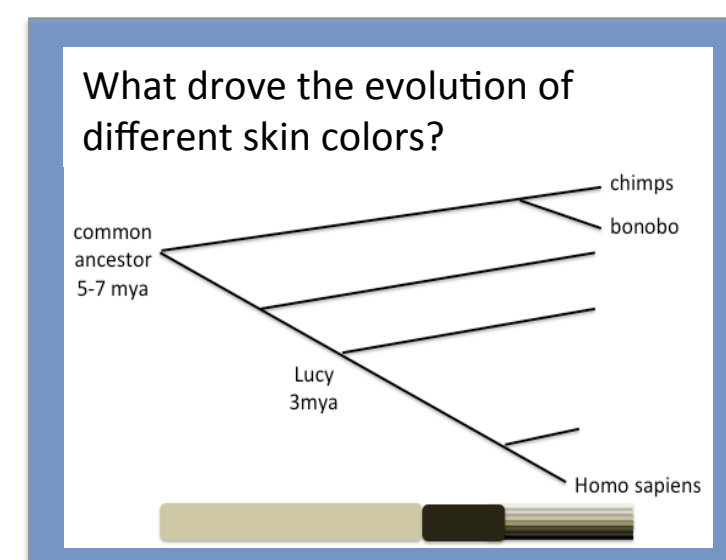


## Major Findings

- Modules were effective at promoting a better understanding of evolution, particularly applying natural selection to human health
- Majors showed greater gains as compared to non-majors (possibly due to prior exposure to evolution concepts?)
- Students, particularly non-majors, struggled with the concept that evolution does not lead to perfection

## Learning Module: Evolution of Skin Color

Re-think your hypothesis. Do you think that protection from UV-damage could drive the evolution of skin color? Why or why not?



- At what age does skin cancer typically occur?
- Infancy
  - Early childhood (teen years)
  - Early adult hood (20-30)
  - Later in life (>40 years)

## Assessment Tool: Pre- & Post Test

Humans are unique primates in that they have nearly naked skin. All other primates have a dense covering of fur, as do most mammals, while even the hairiest person you know is comparably bare. To better understand why human ancestors lost their hair, we must consider why mammals have fur in the first place. Fur provides insulation and protection from water loss, damaging rays of sunlight, protection from abrasion, and potentially protection from harmful parasites and microbes. Fur can also be useful camouflage, and allow members of the same species to recognize and communicate with one another. But not all mammals are covered in fur; some of the largest terrestrial mammals like elephants have evolved naked skin. Large animals have a very low surface area to volume ratio, and struggle to retain sufficient heat. But remember, their early ancestor the woolly mammoth lived in a cold environment. Similarly, human hairlessness is an evolutionary adaptation resulting from our early ancestors moving from the forest to the savannah.

- During the evolution of humans, what were the primary changes that gradually occurred over time?
  - The amount of fur on each individual human within a population gradually changed.
  - The proportion of humans with less fur within a population gradually increased.
  - Mutations occurred to meet the needs of humans as they moved to a new environment.
  - Individuals learned to adapt to their new environment and passed those behaviors to their offspring.
- Since fur does provide protection from the elements, a lack of fur could impact health. Then how could humans have evolved bare skin?
  - Individuals with less fur must have been best-adapted for their environment and had more offspring.
  - Loss of fur was not guided by Natural selection because it would have provided less protection and they would have gone extinct.
  - Genetic changes that allowed individuals to survive without fur were induced, giving them greater fitness.
  - Humans learned to make clothing to better protect themselves from the environment.

- Pre- & Post-tests were vignette-style multiple choice questions delivered through D2L at the beginning & end of each semester
- Each learning goal was evaluated with at least two questions
- Distractors were common misconceptions
- To decrease pre-test questions influencing students' answers on the post-test, different sets of questions were used
- Item difficulty & discrimination were used to evaluate assessment tool
- Gain scores were calculated as averages of individual student learning gains

Item difficulty (correct answer).	
Below 20%	Unacceptable – revision to be more attractive or others less attractive
Between 20-47%	Needs revision to be more attractive
Between 47-78%	Acceptable (62% is optimal for correct answer)
Above 78%	Needs revision to be less attractive, or other distractors need revision to be more attractive

Item Discrimination.	
Negative	Unacceptable: check item for error
0-24%	Unacceptable: item should be improved
25-39%	Good question
40-100%	Excellent question

Individual learning gains formula:	
$(\text{post-assessment} - \text{pre-assessment}) / (100\% - \text{pre-assessment})$	
*If a student scores 100% on the pre-assessment, then must record 99% as pre-assessment scores.	
*If same student scores 100% on both pre- and post-assessment, record 99% for both	

## Where do we go from here?

- Continued assessment of student learning gains
- Development of a new module to reinforce the concept of evolution not leading to perfection
- We have developed smaller "mini-modules" to address different learning goals for the second of the A&P series course
- Comparison of extensive modules (described here) with shorter, less active modules to foster deeper understanding of impact of evolution on human health and disease

## Acknowledgements

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