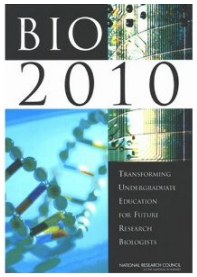
Active learning: tips for success

Jenny Knight
MCD Biology

Many Calls for Change in Science Education

- AAAS "Science for All Americans" (1989)
- NRC "How People Learn" (2000)
- NRC "Bio2010" (2003)
- NSF "Vision and Change" (2011)
- PCAST "Engage to Excel" 2012



Call for "Scientific Teaching"

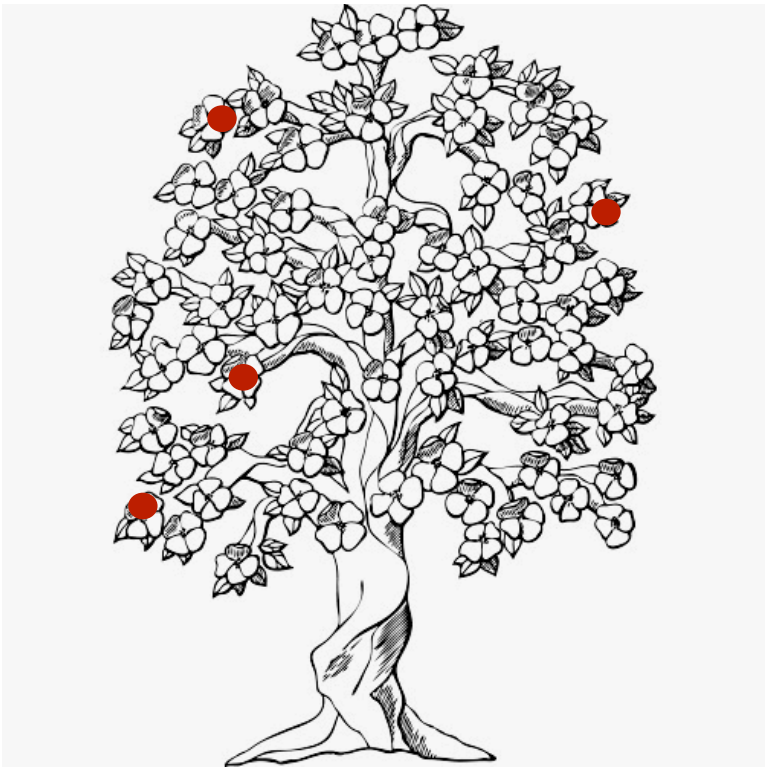
We should apply to our teaching the same approaches we use in our scholarly research.

- Use evidence from classroom (assessment)
  - to inform and change teaching
- Teach actively
- Embrace diversity
  - diverse approaches to learning through diverse ways of teaching

Handelsman et al., 2004; Handelsman et al. 2007

The constructivist view of learning:

Each of us must grow our own knowledge structure from experience.



Instructors can't put their knowledge into our heads. The process must be learner-centered.

Jean Piaget, John Dewey, D. Ausubel, etc., 1960s and 70s

Transmissionist vs Constructivist

Lecturer: I know a lot about this topic, so I will transfer my knowledge to you by telling you about it.

Facilitator: I know a lot about this topic, so I will create situations and present challenges for you, so that you can construct your own knowledge and understanding.

Compelling evidence supports the constructivist view of learning

Yet most instructors in large classes teach mostly by lecturing (because it's what everyone is used to… so it seems easier and better!)

Know what you can reasonably do, and how to do it

Sample of possible active learning tools

Active

- Socratic questioning
- Clickers/any form of in-class quizzing
- One minute paper
- Problem solving

Active and Cooperative

- Clickers with peer discussion
- Think-pair-share problem solving
- Brainstorming
- Constructing models/diagrams/graphs
- Concept mapping

Active and Collaborative

- Problem-based
- Case-based
- Jigsaw
- Group projects/posters, etc.

Clickers: "A gimmick that works" (Bill Wood)

1. Use questions that address key components of learning goals and are challenging

2. Students vote individually

3. Students discuss ideas with each other: "peer instruction" (Mazur, 1997)

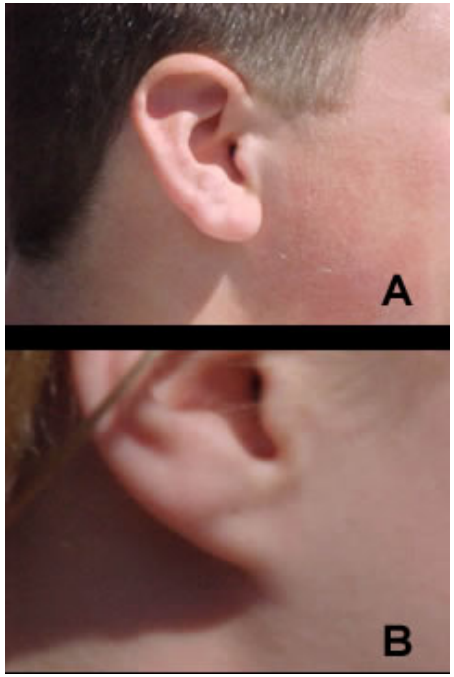
4. Students re-vote

5. Explanation of correct/incorrect answers

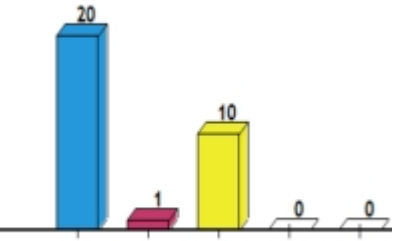
A student-centered approach is particularly useful if the question divides the class

dominant

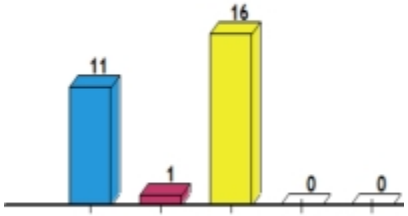
recessive



Initial



After discussion



Imagine that earlobe attachment is dictated by a single gene (a simplification), yielding two traits: unattached and attached.

Unattached earlobes are due to the dominant allele (top picture)
Attached earlobes are due to the recessive allele (bottom picture)

From this information, you can conclude:

a. Attached earlobes are seen less frequently than unattached earlobes in a population
b. Attached earlobes are seen more frequently than unattached earlobes in a population
c. Either phenotype could be seen more frequently in a population: you need more information

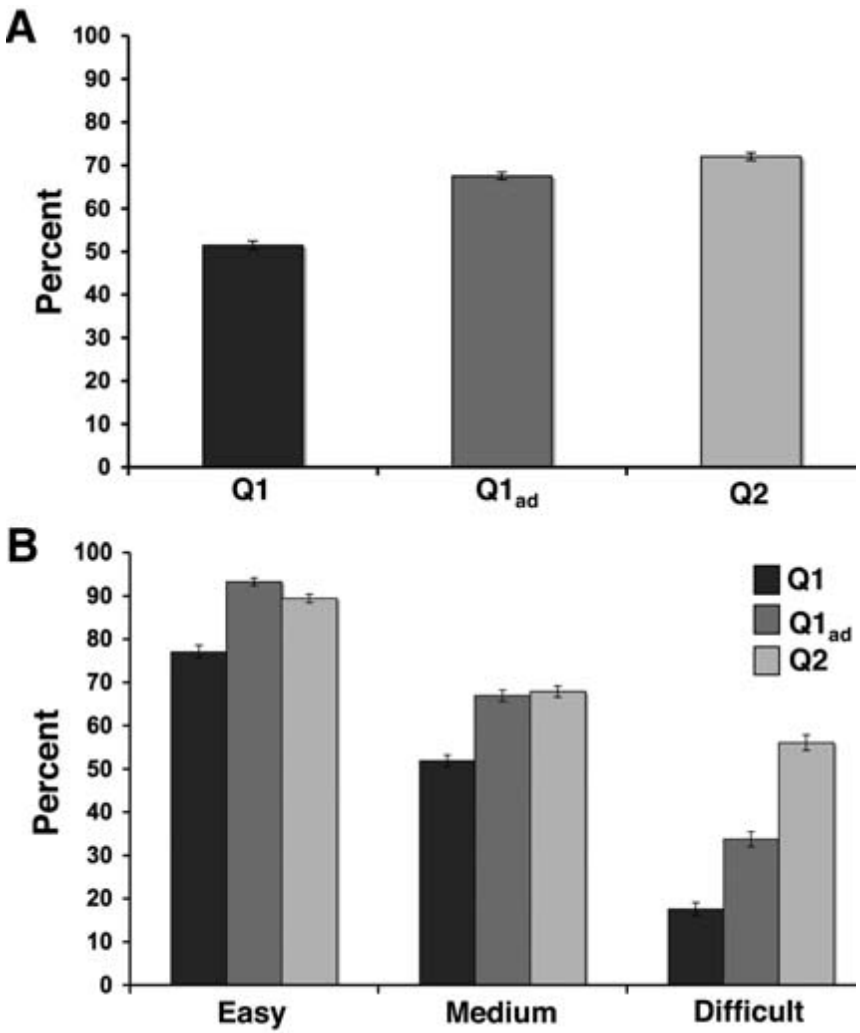
Some suggestions:

- Don't show the graph before student discussion UNLESS it's an equal or nearly equal split
- Follow up by asking someone (or choosing someone) to explain the reasoning behind an answer

Subtleties:

- **Instructor-centered:** I explain the answer to you after discussion
- **Student-centered:** I let you discuss the answer and volunteer the thinking of your group to the class

Evidence: Are students copying their knowledgeable neighbor rather than actually learning from the discussion?



Q1: individual
Q1ad: vote after discussion
Q2 (similar question): individual

Students can individually answer a new clicker question on same topic with as high a % correct as on discussed question.

Smith, Wood, Adams, Wieman, Knight, Guild, Su, Science. 2009, 323(5910):122.

Encouraging student thinking in class: white boards

*buy a board of melamine at Home Depot and ask them to cut it into pieces for you!

Brainstorm:

What do you already know about the structure of DNA and how RNA and protein are ultimately coded for by DNA?

What do you need to find out to fully understand how the process works?

Graph

Generate a graph showing the relative number of bacteria in a person over time, after exposure to Salmonella Typhimurium. Label the time point at which the adaptive immune system is likely to kick in.

Concept Map

Connect the following 10 terms, using linking sentences to describe their relationship. When you are done, share your map with your neighbor (or neighboring group)

Encouraging Problem Solving

Knowledge is
- Fragmented
- Mixed correct and incorrect
- May have strong alternate conceptions

Knowledge is
- Scaffolded
- Easily accessible
- Complex

Problem Based Learning (PBL)

- A specific technique that requires collaborative group work, often used in medical school
- Focuses on the process (as important as the answer)
- Student work in permanent groups, and may take very different trajectories
- Involves iterative cycle of question asking and knowledge integration

Problem Based Learning

seek a creative solution to a problem by <u>asking questions and/or making decisions</u>

Each new piece of information depends on questions asked

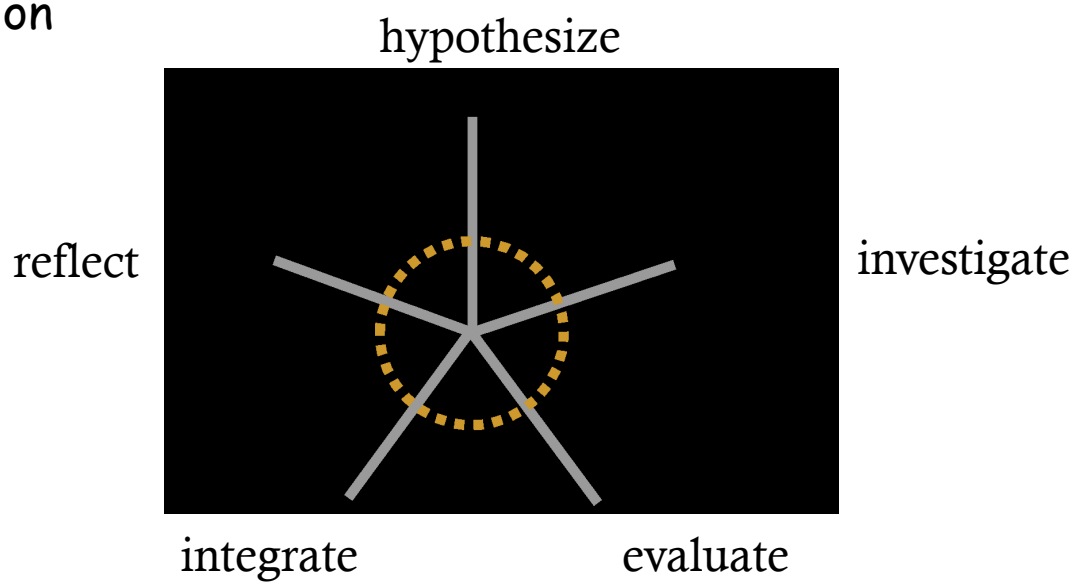
- Hypothesize "What do you think might be the underlying cause of the problem / situation?"
- Investigate: "What would you like to do to test your current thinking?"
- Evaluate: "How has this new information changed your thinking?"
- Integrate: "On a mechanistic basis, how does the underlying problem result in the current findings / situation?
- Plan: "What should we do next?"
- Reflect: "Does this make sense?"

Implementation

In a big class, you can use an on-line community.

- **-Students discuss and hypothesize online, then ask specific questions, proceed.**
- **-Instructor (or TA) monitors submissions, provides new information**

Assessment of individual contributions , or group progress as a whole can be mapped based on what they say on a plot that indicates "importance" of contribution



Marcy Osgood, University of New Mexico

A relatively simple yet effective example (could be done in 1-2 class periods)

The Case of the Mismatched Mother

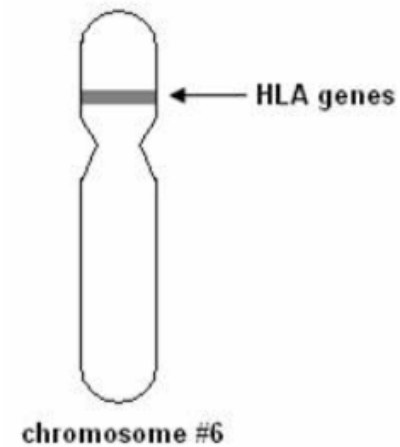
- 52-year old woman, Karen
- married, three sons, kidney disease
- needs a kidney transplant from someone who is a close genetic match

To determine suitability, her sons and husbands are tested to see what human leukocyte antigen (HLA) genes they have.

These genes encode cell surface recognition proteins that the body uses to distinguish its own cells from foreign material.

Because these genes are located in a group on chromosome #6, they are often inherited together in a block known as a haplotype. You can think of them as simply a set of genes that influence tissue rejection.

Figure 1. Location of HLA genes.



http://www.sciencecases.org/ and Jessica Hutchison

Karen's Doctor: "Something very unusual has happened here. We've taken blood samples and tested your sons because they were possible donors…but your sons' haplotypes do not match your haplotype. It seems these could not be your children."

Karen's haplotype (two sets of "alleles"): 1, 3
Sons' haplotypes: 2,5; 2,5; 4,6

Discuss with your group what further information you need to begin to solve this puzzle

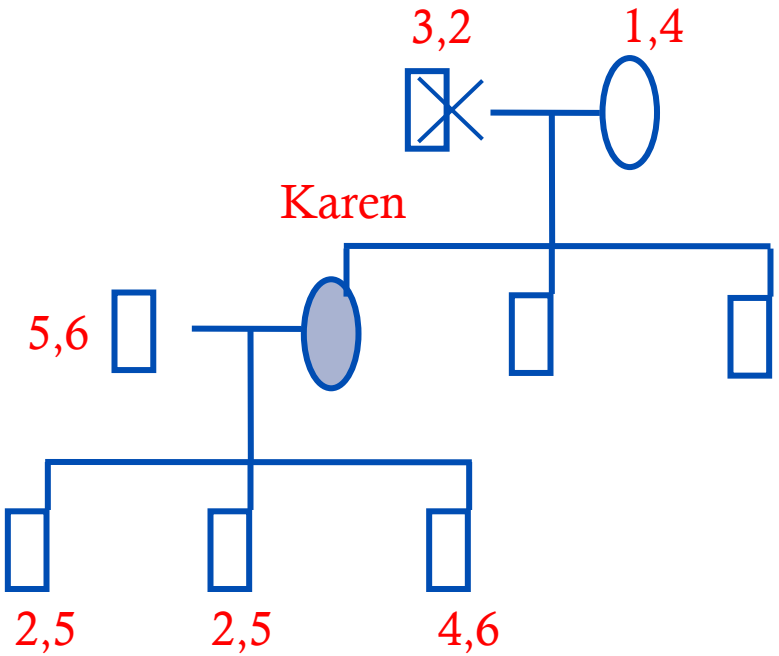
You can ask two questions. Submit your questions, one at a time. After each question, you will receive an answer, and then can ask the next question.

Some possible questions student commonly ask:

What is the father's haplotype?

Father's haplotypes: 5,6

What are haplotypes of other people in the family?



Could you test another cell type rather than blood?
(Is her DNA the same in all her cells?)
Sample cells from other tissues, see what the haplotypes are

For Karen's sons, as you would expect, the haplotypes are the same, no matter what cell type is tested

For Karen:

Blood	1,3
Thyroid	2,4
Hair follicles	2,4

What's your hypothesis at this point?

What else would you like to investigate?

Evaluate evidence

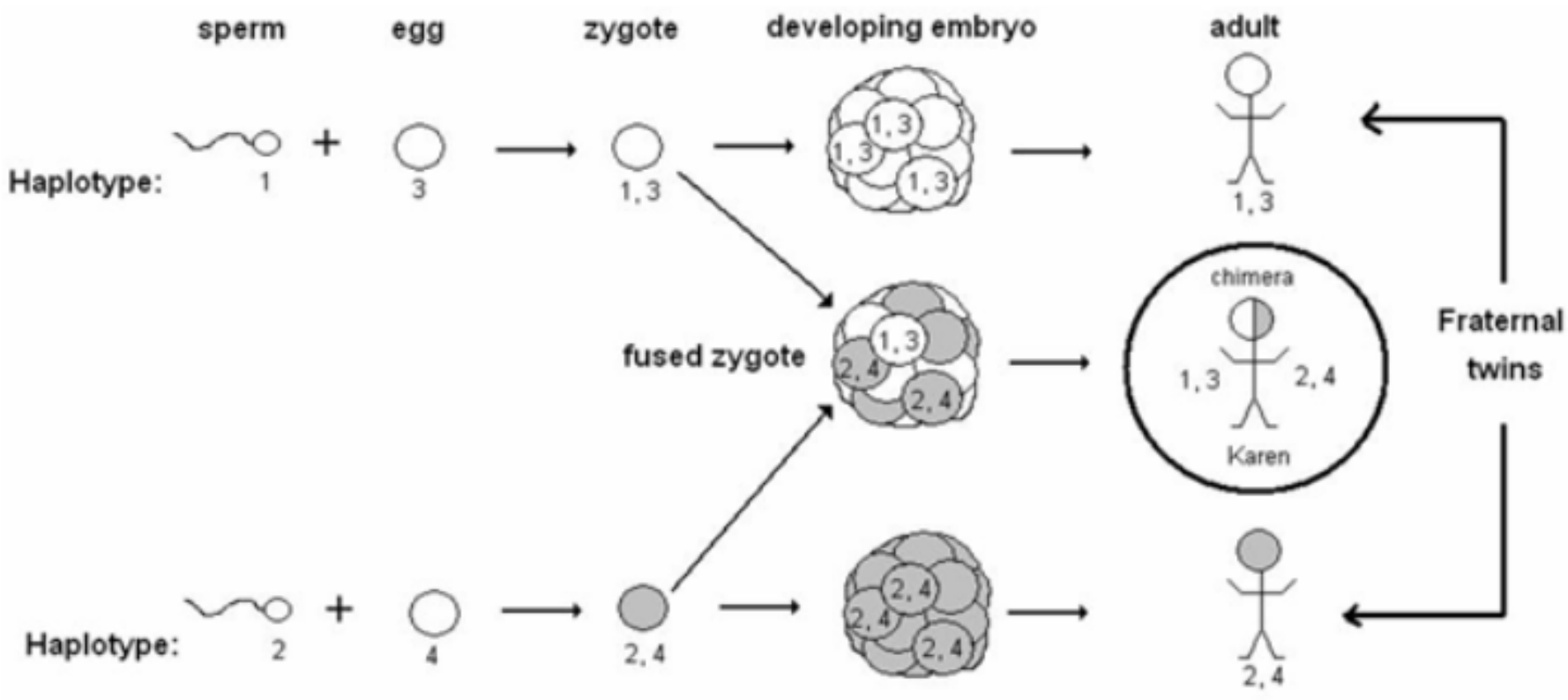
Reflect, iterate: Ask new question/revise hypothesis

Students could go on to request additional molecular DNA evidence, to request (or investigate on their own) how an individual could have two different genotypes of cells within one body.

Ultimately, they can make a proposal for what they think has happened, support their proposal with the evidence they have collected, and be ready to defend their idea.

The answer

Figure 3. Karen is the fusion of two zygotes, each resulting from the separate fertilization of two eggs by two sperm. If this fusion had not occurred, fraternal twins would have resulted. Therefore, different parts of Karen's body carry different sets of genetic information.



In Summary:

- Try something you think you can achieve
- Tell the students why you are taking this approach
- Use active learning more than once, but don't feel you have to change your entire course all at once
- Assess for yourself whether the new approach works!