Active Learning in Biology Education

Why and How?

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Why use Active Learning Methods?  
Why not stick with tradition?

Lecture Style Classes

Large amounts of information can be presented  
Class Size doesn’t matter
Why use Active Learning Methods?
Why use Active Learning Methods?

- Increases feedback between student and teacher
- Active students gain deeper understanding of topic
- Facilitates ‘secondary’ skill training (e.g., problem solving)
Why use Active Learning Methods?

Lecture style classes tend to be designed to feed students information.

But, information changes!
Technology is introducing new tools very quickly and changing the way we work...
Rate of articles indexed in PubMed (research articles in biology and medicine) is growing on average 2.5% per year.
Given rapid changes in methodology and the ease of finding information, where should our focus be?
The Scientific Method

Background Information

Hypotheses are drawn

Experiments Designed

Results Analysed

Conclusions made and hypotheses changed if needed
Confidence building

Students need to be encouraged to use their critical thinking skills and to learn that they have the ability to analyse. This can be done progressively.

eg, just because it was written in a paper, doesn’t mean it is true.
The scientific method is not just for researchers...

Are Vaccines Safe?

Measles Outbreak Triggered by Unvaccinated Child

Vaccine Ingredients:
- mercury
- aluminum
- antifreeze
- formaldehyde
- aborted human fetus cells
- chick embryos
- monkey kidney cells
- fetal bovine serum, etc.

www.safevaccines.org
Why use Active Learning Methods?

In summary, we should aim at being sure our students understand the process of science ‘above’ the content. This allows them to learn not only our topic but future topics.

Students ability to be analytical and critical are influenced both by a lack of knowledge of the scientific process, but also a lack of confidence in their own critical thinking.

How we teach can influence how well we teach these skills.
How to introduce Active Learning into Science Courses

- within lectures
- case studies
  - presentation style
  - interrupted case studies
  - internet courses
- labs
Active Learning in a Lecture Setting

Students have received lectures/reading on molecular methods in other courses. Most of them could give an answer if I ask:

*What is this method called ’protein gels’?*

However, try reframing the question:

*How would I measure protein levels in the cell under different conditions?*

*Answer: a protein gel*

This is a much more relevant question but more difficult.
Active Learning within a Lecture

Example:
Today we are going to talk about bacterial cells’ responses to increased temperature. How would you find proteins or genes that changed in their expression at high temperature?

What experiments would you do?
Split into groups of 3 and discuss this for 10 minutes.

Aim: Train the students to connect what they already know about methods in molecular and cell biology to a new problem
→ Integration and experimental design
Active Learning within a Lecture

*Example:*
After a short lecture about DNA Replication, the students are given this problem:

- Some bacteria can divide as fast as every 20 minutes.
  
  AND
  
  It takes 60 minutes to copy the chromosome.

How can this be? What experiments would you do to test your ideas?

After small group discussion and discussion of their ideas with the whole class, the real experiments are presented.

The scientific method: making hypotheses and designing experiments
Case Studies

Many variations, but essentially use specific ’cases’ to illustrate more general principles.

Keeps students’ interest better than simply learning generalities.

Very easy to modify to illustrate critical thinking and scientific method.
Case Studies

First Type:

Students are divided into pairs. Depending on the level of the course, students are given original research articles or review articles.

Each pair is responsible for presenting one paper to the remainder of the class. In the advanced courses this means, they need to prepare a 45 minute presentation. The students are given specific questions or 'hints' as to what to present for each paper.
Aims of this for the presenters:
• How does one approach a research problem?
• How does one analyse research data?
• Teaches critical thinking.
• Teaches the students to read research articles.
• Teaches the students to search for more information (background material or related topics) on their own.
• Practice in presenting/explaining material to others

Presenters are graded on clarity, understanding, effort and a written summary.
The presentations alone would be a total failure for the class as a whole.
(been there, done that!)
Questions!

The remainder of the class is expected to have read the article also and come to class prepared to ask questions. Students are randomly chosen at the start of class and they **must** ask several questions. Up to 15% of their grade for the course depends on their asking questions. In addition, the remainder of the class may also ask questions.
So why does it work?

The presenters are motivated by wanting to do a good job in front of their peers—the Fear Factor. (and to get a good grade)

The questioners are motivated at first by grades. But as they get more comfortable with each other and the format, they really want to know the answers to their questions.

Confidence building is key to this approach.

Case studies are chosen to progress in difficulty.

Case studies are sometimes chosen because there is an incorrect interpretation of data in the work. Some of the students see this (or are led to it by the teacher) and further learn to trust their own critical thinking.
The scientific method

The interrupted case study is modelled on this scheme.

Background Information

Hypotheses are drawn

Experiments Designed

Results Analysed

Conclusions made and hypotheses changed if needed
Students are presented with background information to the students for a ‘real’ significant research study.

The students tasks:
- Identify the research question
- Identify the hypothesis
- Design an experiment
- What results will be obtained if the hypothesis is right/wrong?
- What conclusions can be drawn from the real data?

Background Information

Hypotheses are drawn

Experiments Designed

Results Analysed

Conclusions made and hypotheses changed if needed
• The interrupted case study method is done in one class period (1-2 hours) or over many classes.
• Students are given information in 'pieces' and need to analyse and discuss each part before continuing on to the next part.
• Almost any research article can be adapted for this type of case study.

http://ublib.buffalo.edu/libraries/projects/cases/ubcase.htm
Internet based Case Studies

Presentations substituted with wiki page presentations.

**Deinococcus**

_by Jennie Ginnarsson_

**Abstract**

The resistance to radiation in the bacterium *Deinococcus radiodurans* is unique. When being exposed to high levels of radiation, the genome is shattered into 1000-2000 double-strand break fragments. Despite these extensive damages, the bacterium survives and the genome is skillfully repaired. The ability to repair such a broken genome seems to depend on several different mechanisms. By making sure to have several copies of the genome present, it can use homologous fragments for overlapping and as templates. Other factors involved are the protein RecA and an unusually high intracellular level of Mn(II). The repair mechanisms of *D. radiodurans* do not only protect it from radiation, but also from desiccation, which could be an important aspect of its evolution. Some experiments show that a recombinant *D. radiodurans* can be used for degrading harmful radioactive waste products.

**Introduction**

Imagine your genome shredded into 1000 pieces by radiation. Impossible to repair? For us, yes, but not for *Deinococcus radiodurans*. This remarkable species has become famous for its ability to survive extreme levels of radiation and desiccation. *D. radiodurans* was first found 1956 in canned meat which had been exposed to 400'000 rad of γ-rays, which is a dose of radiation several hundred times higher than what is required to kill *E. coli*.

*Fig 1: Deinococcus radiodurans* (1)
Internet based Case Studies

Questions posed/answered in an online forum.
Active learning and the scientific method can be incorporated into many different formats.

Should also be used when designing laboratories.
Most labs are demonstrations (or at least repeating something that is going to work a certain way if the student does it correctly). This is fine, but often eliminates the most interesting part of doing science: Discovery!

Why eliminate the most exciting part of doing science?

(Answer: because it’s hard to design/manage a good lab otherwise!)
Some guidelines in writing labs:

Don’t tell them everything! Make them think!
If possible, have them write answers to questions before the lab.

Predictions! Ask the student to predict the outcome of the experiment.
In conclusion, using active learning methods can increase the students knowledge integration, problem solving and critical thinking.

Thank you for your attention!