Strategies for Active Learning ... from Workshops and Experience

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Lessons from Teaching Workshops

Indiana University Workshop in 2003
- identify a bottleneck in student learning
- identify misconceptions that impede student learning
- design a lesson to teach the bottleneck
- assess the effectiveness of the lesson

Summer Institute Workshop at CU-Boulder in 2015
- scientific teaching
- 3 themes: active learning, inclusivity, assessment
- design teaching modules “backwards”
- put more responsibility for learning on students
- encourage group work in class
My Bottleneck in Genetics: Chromosomes

The big questions:

- Which chromosomes in a nucleus are similar?
- Which are identical?
- Which are completely different?

- How do chromosomes align during mitosis?
- How do chromosomes align during meiosis?
Use pipe cleaners to represent the chromosomes in a fruit fly.

- **different chromosomes** (non-homologous chromosomes)
- **similar chromosomes** (homologs)
Add beads to represent genes (colors can show alleles)

different chromosomes (non-homologous chromosomes)

similar chromosomes (homologs)
Leave just the different color/allele beads... to mark the homologs.
Duplicate the chromosomes in preparation for division

duplicate chromosomes (sister chromatids)

after duplication

duplicate chromosomes (homologs)

duplicate chromosomes (non-homologous chromosomes)
Student activities

- Using pipe cleaners and beads:
  - Set up chromosomes in a 2n=6 cell in G1
  - Show me the homologs, etc.
  - Prepare chromosomes for mitosis or meiosis
  - Model mitosis and meiosis
  - Model tisomy vs triploidy

- Devise 2D drawings

- Practice going back and forth between pipe cleaners and drawings as needed

- Apply pipe cleaners and beads to new situations
Set up chromosomes in a 2n=6 cell in G1

Prepare chromosomes for mitosis or meiosis

Model mitosis

Model meiosis
Model trisomy vs triploidy

normal
Model trisomy vs triploidy

- Normal
- Trisomy
- Triploidy
Assessment

- Classroom assessment techniques (Angelo & Cross, 1993)
- Conceptests (Ellis, Landis, & Meeker, 2003)
- Pre-tests and Post-tests
  Students were asked to classify pictures of particular stages of mitosis or meiosis .... before the pipe cleaner exercise, after the exercise, and on the final
Percent of students who “nailed” the chromosome questions

<table>
<thead>
<tr>
<th></th>
<th>Pre-test</th>
<th>Post-test</th>
<th>Final</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mitosis</td>
<td>13</td>
<td>90</td>
<td>88</td>
</tr>
<tr>
<td>Meiosis I</td>
<td>10</td>
<td>85</td>
<td>90</td>
</tr>
<tr>
<td>Meiosis II</td>
<td>13</td>
<td>84</td>
<td>81</td>
</tr>
</tbody>
</table>
Using pool noodles to discuss crossing over and % recombinants

Locke & McDermid (2005) Genetics 170: 5-6
Pool noodles allow us to create many different cross-over events and see the consequences e.g. recombinant and non-recombinant chromosomes that will end up in gametes (egg and sperm). Below is one event:

**centromere**

<table>
<thead>
<tr>
<th>Parental (P)</th>
<th>Recombinant (R)</th>
</tr>
</thead>
<tbody>
<tr>
<td>b b</td>
<td>b b</td>
</tr>
<tr>
<td>A A</td>
<td>a a</td>
</tr>
</tbody>
</table>

- **homologs**
- **sister chromatids**

**P = Parental**

**R = Recombinant**
Activation of Gene Expression

How do genes get “turned on” in response to signals? This skit brings the process to life, and helps students think about dynamic processes and the importance of drawing cartoon renditions.
Example: How steroids (e.g. testosterone) turn on genes for maleness, a lesson designed by Roger Innes

A description of the process in words:

1) Steroids bind to proteins called “receptors”.

2) Steroid receptors dimerize and bind DNA.

3) Steroid receptors that are bound to DNA recruit other proteins that function as “co-activators”.

4) Coactivators recruit RNA polymerase, which binds to the start point of a gene and initiates transcription.
Scientists create dynamic cartoons
I ask the students to create a **living model** depicting how testosterone “activates” expression of specific genes!

I need a group of 4 ----> 2 folks are testosterone receptor  
1 is coactivator  
1 is RNA polymerase

Using the proper sequence of events, **act out** the process of gene activation according to the following rules:

- Testosterone must be perceived.
- A gene with the following sequence `GAGCGCATTATTATGCGCTC` must be found.
- Demonstrate the proper protein-DNA and protein-protein interactions.
- What is the end result?

The students not acting out the living model direct the activities (the “fishbowl technique”; Silberman, 1996).
testosterone receptors
testosterone receptors with their testosterone “caps”
coactivator
Assessment

All students were asked to

1) Depict the steps of gene activation by testosterone in cartoon form.

2) List 1 or 2 questions that this modeling exercise and their cartoon raised in their mind.

Outcome

1) Students realized the utility and importance of modeling ... and how it can help them identify what they do and don’t understand.

2) Many students posed intellectually sophisticated questions, similar to those that scientists would ask.
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Scientific teaching
- teach classes the way we do research
- inquiry-based, critical thinking, learning vs performing
- work & learn in teams

3 themes
- active learning (modeled in every session & in our teachable tidbit)
- inclusivity (teach to the diversity of students in a class)
- assessment (how do the instructor & students know the students have met the learning objectives)

Design teaching modules “backwards”
- define learning objectives
  -> then design assessments
  -> then design lessons
- align assessments (and exams) with objectives

Put more responsibility for learning on students
- tell students what the learning objectives are and the outcomes that will show they have met the objectives
- convey confidence in their ability to learn (Stanley Lo seminar)
For example, Jen Moon’s syllabus for Genetics includes:

**8 BIG IDEAS** with several class units for each

Learning Objectives for each class unit

**BIG IDEA I: TRAITS ARE TRANSMITTED BY GENES ON CHROMOSOMES**

[1] Mendel’s Principles of Heredity: Many organisms, for example humans, are diploid, meaning that they have two copies (alleles) of each of their genes, one from each parent, that interact to control individual traits.

*A. Explain Mendel’s laws of segregation and independent assortment, and how they predict the 3:1 dominant-to-recessive phenotypic ratio among the F$_2$ of a monohybrid cross, or the 9:3:3:1 phenotypic ratio in a dihybrid cross, respectively.

*B. Interpret phenotypic ratios of progeny in experimental organisms to infer how particular traits are inherited.

*C. Predict genotypic and phenotypic ratios among progeny of complex multihybrid crosses using simple rules of probability.

*D. Analyze human pedigrees to determine whether a genetic disease exhibits recessive or dominant inheritance.

*E. Cite the most common molecular explanations for dominant and recessive alleles.

[4] Linkage, Recombination, and Mapping Genes on Chromosomes: Genes close together on the same chromosome tend to travel together more often than not.

*A. Define linkage with respect to gene loci and chromosomes.

*B. Differentiate between parental and recombinant gametes.

*C. Conclude from ratios of progeny in dihybrid crosses or testcrosses whether or not two genes are linked.
SHARE …

- share lesson plans and ideas with each other
- share with your students your passion for teaching and your desire to help them learn
- encourage students to share their understanding and ways of learning and help each other learn