Bio102L: Introduction to Genetics and Evolution

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Main changes

• No more “General Biology” class (Bio 25): students begin the Bio major with the Gateways
  – Bio101L: Molecular Biology
  – Bio102L: Genetics & Evolution

• Include laboratories that complement the lecture material

• Engage students in “active learning”
What do we do (Bio102L)?
BEFORE CLASS

• Students read chapter or paper before every class

• Students take online pre-lecture quiz before every class
  – Short, simple, multiple choice questions, mostly to identify important parts
  – Also long-answer on what they didn’t understand
  – The occasional ungraded long-answer question

• Professors post slides for class online beforehand
What do we do (Bio102L)?

DURING CLASS

• Professor presents material

• Active learning components
  – Think-pair-share on questions
  – In-class non-multiple choice problem solving and data interpretation
  – Audience response system (*PollEverywhere: multiple choice*)

• Class is videotaped and link made available
Example: timing differences

- Cicadas - some species emerge every 13 years, and some every 17 years
  - Until that time, burrow underground and eat off tree roots
  - Then emerge, drop exoskeleton, and call
  - Only overlap once every 221 years!

Example: habitat differences

- Rhagiana fruit flies
  - Native to North America, feed exclusively on apple or hawthorn berries
  - Survive and reproduce better on "new" food
  - Genetic differences

Example: timing differences

- Cicadas - some species emerge every 13 years, and some every 17 years
  - Until that time, burrow underground and eat off tree roots
  - Then emerge, drop exoskeleton, and call
  - Only overlap once every 221 years!
What do we do (Bio102L)?

AFTER CLASS

• “Friday review sessions”
  – Students both submit questions ahead of time (anonymously via a survey system or over e-mail)
  – Professors respond to submitted questions and go over material again that wasn’t clear
  – Students ask more questions during the session

• Weekly problem sets, designed just like test

• Other materials made available
  – Podcasts to relevant recent findings every week
  – Other links of interest/ relevance
What do we do (Bio102L)?

LABORATORY

• Most labs are multi-week
  – Start a project, then continue it (over generations)
  – Match (as possible) coverage in lecture

• One lab exercise is “primary research”
  – Students work with genomic DNA sequences and test for natural selection
  – Output is of potential interest to the research community, in addition to pedagogy
What do we do (Bio102L)?

**ASSESSMENT – 2 way**

- All assignments and tests are open-book and open-notebook
  - Emphasize understanding and NOT memorization

- Mid-semester formal course evaluation
Examples from class: in-class problem solving
An example of altruism: Helpers at the nest

In Florida scrub jays, some individuals forego breeding in a given year and instead help raise the young of other nesting pairs.

An example used by K. Donohue (this case study was also discussed by M. Rausher in Bio 102L in autumn 2010)
Altruism can evolve if:  
\[ B \bar{r} > C \]

Nests that have no helpers have on average 0.5 chicks surviving. Nests that have helpers have on average 1.3 chicks surviving. Helpers increase fitness by 0.8 chicks.

\[ B = 0.8 \]

The helpers do not reproduce at all. They forgo producing 0.5 chicks on average.

\[ C = 0.5 \]

What is the minimum average relatedness of the recipient that would permit helping to evolve?

G. Wolfenden
What is the minimum average relatedness of the recipient that would permit helping to evolve?

THINK-PAIR-SHARE ACTIVITY:

Students first consider the question alone, then discuss it with a neighbor, then provide an answer when called upon.

Several groups provide answers.

We then go over how to get the correct answer as a class, as follows.
Altruism will evolve if:

\[ B \bar{r} > C \]

\[ \bar{r} > C/B \]

\[ C = 0.5; B = 0.8 \]

\[ C/B = 0.625 \]

\[ \bar{r} \text{ must be } > 0.625 \text{ for the trait to evolve under this scenario.} \]

WE CONTINUE WITH THIS EXAMPLE, COMPARING OUR PREDICTION WITH REAL DATA…
Banding studies and continued monitoring showed that helpers assisted at the following nests:

<table>
<thead>
<tr>
<th>Recipient</th>
<th>( \bar{r} )</th>
<th>Number of nests helped</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parents</td>
<td>0.5</td>
<td>48</td>
</tr>
<tr>
<td>Father and stepmother</td>
<td>0.25</td>
<td>16</td>
</tr>
<tr>
<td>Mother and stepfather</td>
<td>0.25</td>
<td>2</td>
</tr>
<tr>
<td>Brother and his mate</td>
<td>0.25</td>
<td>7</td>
</tr>
<tr>
<td>Unrelated</td>
<td>0.0</td>
<td>1</td>
</tr>
</tbody>
</table>

\( \bar{r} = 0.409 \)
Altruism will evolve if:
\[ B \overline{r} > C \]

C = 0.5; B = 0.8
\[ \frac{C}{B} = 0.65 \]
r should be > 0.625

But
\[ r = 0.409 \]

What’s going on here? What could be an explanation for the difference between the predicted and the observed relatedness?
Altruism will evolve if:  
\[ B \bar{r} > C \]

\[ C = 0.5; B = 0.8 \]

\[ \frac{C}{B} = 0.65 \]

\[ r \text{ should be} > 0.625 \]

But
\[ r = 0.409 \]

In fact, \( C \) is not 0.5. Helpers actually benefit directly from helping. They gain experience and also have a higher probability of inheriting the territory.

What is the predicted cost?
Altruism will evolve if:

$$B \bar{r} > C$$

$$B = 0.8; \ r = 0.409$$

What is the predicted cost?

$$B*r = 0.327 > C$$

How could you test this prediction?
An example using PollEverywhere
Do we see optimal feeding in humans? Case of *spices*

- Caloric content very low
- Why do we like them?
  - Random (or correlated response to other smell/taste selection)
  - Direct selection
    - Antimicrobial property?
Many spices known to have antimicrobial properties

- **Strong antimicrobial effectiveness in:**
  - Cinnamon, cloves, mustard

- **Medium antimicrobial effectiveness in:**
  - Allspice, cumin, oregano, rosemary, sage, thyme

- **Specific inhibitory effects:**
  - Garlic: *Salmonella, E. coli, Staphylococcus, Bacillus*
  - Cloves: Mycotoxigenic *Aspergillus*
Generate a prediction-
If spices are used because *antimicrobial*,

Surveying these populations, which should use the most spices?

- India: **278437**
- Hungary: **278438**
- Norway: **278439**
- No idea: **278440**

Text a **CODE** to **37607**  
Submit a **CODE** to [http://poll4.com](http://poll4.com)
Using PollEverywhere, students submit their answers. After the class has voted, students see the proportion of the class that voted for each option.

**Surveying these populations, which should use the most spices?**

- India: 82%
- Hungary: 7%
- Norway: 11%
- No idea: 11%

Text a **CODE** to 37607 or Submit a **CODE** to [http://poll4.com](http://poll4.com)
Expectation:

• More antimicrobials needed in environments that favor growth of microbes

<table>
<thead>
<tr>
<th>Mean Temp</th>
<th>Mean Precipitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td>26.9 C</td>
</tr>
<tr>
<td></td>
<td>117.6cm</td>
</tr>
<tr>
<td>Hungary</td>
<td>10.3 C</td>
</tr>
<tr>
<td></td>
<td>56.3cm</td>
</tr>
<tr>
<td>Norway</td>
<td>2.8 C</td>
</tr>
<tr>
<td></td>
<td>96.0cm</td>
</tr>
</tbody>
</table>
Spices used!

- WAY more spices used in Indian food than other two

- Red arrows designate use of garlic & onions in particular
Antimicrobial effectiveness of spices

• Almost complete inhibition of bacteria by garlic and onions!
What did the students like?

“Please rate the following activities with regard to their usefulness in enhancing your understanding of the material and/or performance on the tests.”

<table>
<thead>
<tr>
<th>Activity</th>
<th>Extremely</th>
<th>Very</th>
<th>Useful</th>
<th>Not Very</th>
<th>Not useful</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-class quizzes</td>
<td>8%</td>
<td>17%</td>
<td>42%</td>
<td>25%</td>
<td>7%</td>
</tr>
<tr>
<td>In-class problem solving</td>
<td>25%</td>
<td>27%</td>
<td>39%</td>
<td>8%</td>
<td>2%</td>
</tr>
<tr>
<td>PollEverywhere</td>
<td>18%</td>
<td>31%</td>
<td>36%</td>
<td>12%</td>
<td>3%</td>
</tr>
<tr>
<td>Problem sets</td>
<td>65%</td>
<td>26%</td>
<td>9%</td>
<td>1%</td>
<td>0%</td>
</tr>
<tr>
<td>Friday reviews</td>
<td>12%</td>
<td>30%</td>
<td>42%</td>
<td>11%</td>
<td>4%</td>
</tr>
</tbody>
</table>

They also REALLY liked having all the lectures taped and online……
What did the students like?

“What in-class activities engaged you most?”

- In-class problem solving: 25%
- PollEverywhere: 28%
- Watching videos: 10%
- Lecture material: 28%
- Asking questions: 7%
- Listening to others’ questions: 1%
What did the students like?

“Pre-class quizzes should be given:”

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Twice per week</td>
<td>69%</td>
</tr>
<tr>
<td>Once per week</td>
<td>18%</td>
</tr>
<tr>
<td>Not at all</td>
<td>13%</td>
</tr>
</tbody>
</table>

“Friday readings/podcasts:”

<table>
<thead>
<tr>
<th>Description</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enhanced a lot</td>
<td>6%</td>
</tr>
<tr>
<td>Were interesting</td>
<td>70%</td>
</tr>
<tr>
<td>Didn’t pay much attention</td>
<td>21%</td>
</tr>
<tr>
<td>Were distracting</td>
<td>3%</td>
</tr>
</tbody>
</table>

“Should problem sets include non-multiple-choice problems?”

<table>
<thead>
<tr>
<th>Description</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>No: just like midterm</td>
<td>53%</td>
</tr>
<tr>
<td>Not necessary: lab</td>
<td>20%</td>
</tr>
<tr>
<td>Yes</td>
<td>15%</td>
</tr>
<tr>
<td>Don’t care</td>
<td>12%</td>
</tr>
</tbody>
</table>
What did the students like?

“Where did you go to get your questions answered?”

Professors in person (Lecture or after class) 19%
Professors in e-mail 7%
TA’s 18%
Academic Resource Center help desk 0%
Other students/study groups 55%

“Were you able to get your questions answered?”

Always 55%
Sometimes 43%
Infrequently 2%
Never 0%
Take-home messages

Students LIKED in-class problem solving, especially when they could submit answers anonymously (PollEverywhere).

Students LIKED out-of-class problem solving.

Students generally seemed to like open-book/note, but verdict is still out.

Need more input on the lab (will come with course evaluations) but students seemed to LIKE having labs.

In general, students did well in the course....
What students liked vs what worked?

**Problem solving and proficiency:** Students LIKED problem solving, especially when in the identical format as the midterm. Problem solving as more than drilling for midterms....

**Reinforcement of lecture material:** Students LIKED having lectures online, but class attendance atrophied accordingly.

**Interest in the material:** Students DID seem to find the class interesting, and the fact that many did feel comfortable with the material made it more engaging to them.

**Goals of an introductory Biology class:** Evolution and Genetics in human biology and a pre-med curriculum (what most students seem to want), BUT ALSO exposure to the rich field of biology and the richness of biodiversity beyond the initial (pre-med oriented) expectations of students.