Primary Literature in Analytical Chemistry Teaching

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Trinity College, Hartford CT
Why teach the literature?

NIH IRACDA Program

Institutional Research and Academic Career Development Awards

Program goals:

• train postdoctoral scientists for research and teaching careers in the biomedical sciences

• motivate a diverse group of new scientists at partner institutions and to promote collaborations in research and teaching

For more information about the SPIRE program: spire.unc.edu
Why teach the literature?

Student Benefits

Improvement in writing skills
Knowledge transfer
“Critical thinking”
Attitudinal changes

Students who read
write better.

Students who write
read more.

R Mortellite, “Writing in Response to Reading,”
http://languageeducation.pbworks.com/w/page/61203992/Writing%20in%20Response%20to%20Reading
Why teach the literature?

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Improvement in writing skills

Knowledge transfer

“Critical thinking”

Attitudinal changes


Why teach the literature?

Student Benefits

- Improvement in writing skills
- Knowledge transfer
- “Critical thinking”
- Attitudinal changes


How do I do this?

Challenges

Finding time
Choosing articles
Scaffolding
Assessing outcomes

<table>
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<tr>
<th>Week 8</th>
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<tr>
<td><strong>Oct 20</strong></td>
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<td><strong>Oct 22</strong></td>
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<td><strong>Oct 24</strong></td>
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<th>Week 9</th>
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<td><strong>Oct 27</strong></td>
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<td><strong>Oct 29</strong></td>
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<td><strong>Oct 31</strong></td>
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<table>
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<tr>
<th>Week 10</th>
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<tr>
<td><strong>Nov 3</strong></td>
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</table>
How do I do this?

Challenges

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How do I do this?

Challenges

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Photo credit: Kerry McQueeney / Solent News and Photo Agency, Daily Mail, 19 Sept 2011
## Analytical Chemistry Assignments

<table>
<thead>
<tr>
<th>Assignment</th>
<th>Article</th>
<th>Topics Included</th>
</tr>
</thead>
</table>

Assignments freely available at: home.asdlib.org
## Instrumental Analysis Assignments

<table>
<thead>
<tr>
<th>Assignment</th>
<th>Article</th>
<th>Topics Included</th>
</tr>
</thead>
</table>
Wavelength selection  
Signal processing  
Signal-to-noise ratio  
Limits of detection |
Electrospray ionization  
Ion mobility  
Mass analyzers  
Resolving power  
Tandem MS  
Quantitative MS  
Bioinformatics |
Cyclic voltammetry  
Redox chemistry  
Signal-to-noise ratio  
Selectivity and controls |

Assignments freely available at: home.asdlib.org  
Out-of-Class Questions

Remembering
What are the two overall factors contributing to plate height ($H$)?

Understanding
The authors use silanes to polymerize the packing material and to form what is likely to be a very thin layer of short carbon chains on the surface (i.e., $d_f$ is extremely low). If the stationary phase is so thin, how do the authors know that chromatography, rather than just electrophoresis, is occurring?

Applying
Estimate the value of $H$ for the lysozyme peak in Figure 2. Show your work to receive credit. Does your estimate match the authors’?

Capstone Assignments

Analytical Chemistry

In-Class Questions

**Analyzing**
Why would the $A$ and $C$ terms be negligible under the conditions used in this work? What evidence supports the authors’ assertion that the efficiency of their separations is limited only by diffusion?

**Evaluating/Creating**
The authors specifically state that their goal for this work was not to achieve a practical method for protein separations. Imagine that an instrument manufacturer wants to use columns like these in a commercial HPLC instrument. What changes to the instrument and practical improvements in the column would be needed?

Articles in lieu of Textbook

Bioanalytical Elective

Course Structure:

Thursday – lecture on course topic
   homework: read article on this topic, complete worksheet

Tuesday – discussion of article

Thursday – brief student presentations on related articles
   lecture on next course topic
# Articles in lieu of Textbook
## Bioanalytical Elective

### Week 10

<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
<th>Reading</th>
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</table>

### Week 11

<table>
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<th>Date</th>
<th>Topic</th>
<th>Reading</th>
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### Week 12

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<th>Date</th>
<th>Topic</th>
<th>Reading</th>
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</table>


### Articles in lieu of Textbook

**Bioanalytical Elective**

<table>
<thead>
<tr>
<th>Name:</th>
<th>Author/Year:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Round and Campbell, “Figure facts: encouraging undergraduates to take a data-centered approach to reading primary literature,” <em>CBE Life Sci. Educ.</em> 2013, 12, 39-46.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name: Sara Student</th>
<th>Author/Year: Ripley 2011</th>
</tr>
</thead>
</table>

| Broad Topic: Synapse Stability | Specific Topic: Retrograde signaling to axon |
| What is Known: Postsynaptic side talks to presynaptic side | Experimental Question: Does retrograde AMPA signaling stabilize synapses? |

<table>
<thead>
<tr>
<th>Panel</th>
<th>Technique:</th>
<th>These data show:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1</td>
<td>Panel A</td>
<td>Transfected neurons w/ GFP</td>
</tr>
<tr>
<td></td>
<td>Panel B</td>
<td>Immunostained for PSD95</td>
</tr>
<tr>
<td></td>
<td>Panel C</td>
<td>Counted stable vs. transient puncta</td>
</tr>
<tr>
<td></td>
<td>Panel D</td>
<td>Stained for AMPA receptors</td>
</tr>
<tr>
<td></td>
<td>These data show:</td>
<td>Transfection was successful</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Synapses were formed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>80% of synapses were transient</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stable synapses are AMPAR+</td>
</tr>
</tbody>
</table>

| Figure 2 | Panel A | Transfected dominant-neg form of AMPARs |
|         | Panel B | Stained for DN-AMPARs and PSD95 |
|         | These data show: | Transfection was successful |
|         | | DN-AMPARs localize to the postsynaptic membrane |

| Figure 3 | Panel A | Counted stable puncta in DN-AMPAR+ neurons |
|          | Panel B | Overexpressed STG in wild-type neurons and counted stable puncta |
|          | These data show: | Neurons with DN construct had fewer stable puncta. AMPAR contributes to synaptic stability |
|          | | More stable puncta observed. STG contributes to synapse stability |
Journal Club as Class

Senior Seminar: Wine Chemistry

- Weeks 1-3
  - Video introduction and readings on the chemistry of wine
  - Workshop on searching the literature
  - Sample presentation

- Subsequent weeks: Student Presentations
  Student presenter is responsible for
  (1) selecting a peer-reviewed article relevant to the class theme
  (2) recruiting a faculty sponsor whose expertise complements the article topic
  (3) grading your classmates’ article summary worksheets
  (4) presenting an overview of the article along with background information and supporting data from at least four other peer-reviewed articles or reviews.
How do I do this?

Challenges

Finding time

Choosing articles

Scaffolding

Assessing outcomes

Image credit: Bill Watterson
What did they learn?

Assessment

1. In 2012, British researchers deployed a miniaturized “lab-on-a-chip” in a tidal estuary and used it to derivatize nitrates in the water and measure nitrate concentrations by UV-Vis absorbance as tides came in and out over several weeks. The authors equipped the device with two different flow cells with path lengths of 25 mm (plot A) and 2.5 mm (plot B). Data from *Environ Sci. Technol.* **2012**, *46*, 9548.

![Graph A](image1.png)

![Graph B](image2.png)

a. Report the calibration sensitivity for each cell. (3 pts)

b. Why is the calibration sensitivity different for these two cells? (2 pts)

c. For the longer flow cell, the authors measured a solution of 0.05 μM nitrate ten times over the course of an hour and obtained absorbance values of 0.0011 ± 0.0001. What is the concentration LOD of the method? (4 pts)

d. What is the dynamic range of the method using the longer cell? (3 pts)
What did they learn?

Assessment

7. The mass spectra below were recorded on a portable mass spectrometer designed to discover human smuggling rings by detecting volatile organic components exhaled in human breath. (doi: 10.1021/ac403621c)

(a) Estimate the resolving power of the instrument based on the lactic acid peak. (3 pts)

(b) What mass analyzer do you think is used in this application? Justify your choice. (3 pts)

(c) What ionization method do you think is used in this application? Justify your choice. (3 pts)
8. The following articles were published in the most recent issues of *Analytical Chemistry*. For each, explain why the instrumentation used was an advantageous choice for the application/sample/analyte(s) studied. A word bank of potentially unfamiliar terms is provided on the next page. (3 pts each)


[The authors looked at the lipid composition of plaques on blood vessel walls that cause blockages and examined how their chemical composition changed after treatment with drugs.]

b. Behavior and Determination of Titanium Dioxide Nanoparticles in Nitric Acid and River Water by ICP Spectrometry


[The authors studied proteins that cross the cell membrane and peptides that are covalently bound to lipids.]

d. Continuous and Simultaneous Electrochemical Measurements of Glucose, Lactate, and Ascorbate in Rat Brain Following Brain Ischemia
2. Amphibians (such as frogs, newts, and salamanders) get skin infections caused by the fungus *Batrachochytrium dendrobatidis* (abbreviated *Bd*). Ecologists have suggested that endangered amphibian species could be protected from *Bd* by adding fungus-fighting bacteria to their normal skin microbiome; however, it has been difficult to identify which species of bacteria would be effective because many factors are involved (see figure). **Propose a study to identify anti-fungal bacteria on amphibian skin and the chemistry behind their anti-fungal properties.** A complete answer should include the methods/instrumentation you would use, the information you would obtain from each method, and your rationale for obtaining this information. (9 pts)

*Figure from Rebollar, et al. Frontiers in Microbiology, 2016, http://dx.doi.org/10.3389/fmicb.2016.00088.*
What did they learn?

Assessment

2. In 2011, Jack Szostak wrote an article titled “An optimal degree of physical and chemical heterogeneity for the origin of life.” The abstract of this article is reproduced below. Read and respond to the abstract, drawing on the themes of this course and using at least three specific examples. At least one of your examples should support Szostak’s position and at least one should be used to develop a counter-argument to the author’s position. (9 pts)


The accumulation of pure, concentrated chemical building blocks, from which the essential components of protocells could be assembled, has long been viewed as a necessary, but extremely difficult step on the pathway to the origin of life. However, recent experiments have shown that moderately increasing the complexity of a set of chemical inputs can in some cases lead to a dramatic simplification of the resulting reaction products. Similarly, model protocell membranes composed of certain mixtures of amphiphilic molecules have superior physical properties than membranes composed of single amphiphiles. Moreover, membrane self-assembly under simple and natural conditions gives rise to heterogeneous mixtures of large multi-lamellar vesicles, which are predisposed to a robust pathway of growth and division that simpler and more homogeneous small unilamellar vesicles cannot undergo. Might a similar relaxation of the constraints on building block purity and homogeneity actually facilitate the difficult process of nucleic acid replication? Several arguments suggest that mixtures of monomers and short oligonucleotides may enable the chemical copying of polymers of sufficient length and sequence complexity to allow for the emergence of the first nucleic acid catalysts. The question of the origin of life may become less daunting once the constraints of overly well-defined laboratory experiments are appropriately relaxed.
What did they learn?

Assessment

In evaluating the presentation, rate the following on a letter grade scale, from A+ to F.

_____ The speaker provided context to relate the article to the themes of this course.

_____ The significance, methodology, and major findings of the paper were presented thoroughly and accurately.

_____ Additional peer-reviewed sources were used effectively to supplement the information from the article being presented.

_____ The visual aids used were professional-looking and effective, and the speaker’s delivery was well-paced, clear, and easy to follow.

_____ The speaker’s ability to answer questions about the work demonstrated a high level of understanding of the article being presented.
### Things I’d Like to Try

#### Future Work

**Annotation Skills**

<table>
<thead>
<tr>
<th>Nutritional Regulation of Yeast Δ9 Fatty Acid Desaturase Activity</th>
</tr>
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<tbody>
<tr>
<td><strong>RGD</strong></td>
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<tr>
<td>&quot;The desaturase is the only component of the enzyme system that appears to be regulated...&quot;</td>
</tr>
<tr>
<td><strong>RESPONSE</strong></td>
</tr>
<tr>
<td>Why would it be advantageous to have the cytochrome b_{5} and its reductase levels high even when there is no need for the enzyme?</td>
</tr>
</tbody>
</table>

| "Although 18:2 is not normally found in S cerevisiae it was readily incorporated at high levels."
| I think it’s interesting that it incorporated the 18:2 fatty acid at a high level even though 18:2 is not normally found in S. cerevisiae. If it is incorporated why isn’t 18:12 also made normally? |
| "Addition of 16:1 and 18:1, together or individually, strongly suppressed the Δ9..."
| Thus seems to be the main conclusion from the experiment. The addition of unsaturated FAs synergistically suppresses the desaturation enzyme. (Makes sense). |
| "Inadequate enzyme activity is not a result of inhibition caused by presence of increased product..."
| This is an interesting point because 15:2 repressed the enzyme even though it isn’t a product of the enzyme. |

Photo credit: Katherine Nightingale
Things I’d Like to Try

Future Work

Skimming Strategies


Illustration credit: James Baxter, https://askabiologist.asu.edu/explore/anatomy-of-an-article
Acknowledgments

Thanks!

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