REFERENCES

Connecting Undergraduate Plant Cell Biology Students with the Scientists About Whom They Learn: A Bibliography

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Name the best scientists the world has ever known. Have you ever read anything by them? Perhaps not. Certainly most students would answer "No," and yet as Albert Einstein said, "Everybody ought to . . . and . . . become directly acquainted with the best."

We teach an undergraduate Plant Cell Biology class (BioPL 444) in the manner proposed by Jean Baptiste Carnoy (1884) when he established the first institute of cellular biology. That is, we integrate mathematics, astronomy, physics and chemistry as well as anatomy, physiology, ecology and evolution with cell biology. Thus, the students are expected to understand a wide range of sciences. We feel that the best way to understand cell biology and its corollary sciences is to take a historical approach and give the students a working knowledge of the scientists involved. Often students remember the science when it is accompanied by an anecdote, and we tell many stories about the scientists as we lecture. Where do we get all the stories? From books written by the scientists themselves. We provide the students in our course with a list of these books for them to read at their leisure. The students are not required to read any of these books during the semester.

The books we selected were written for the lay public or a general scientifically literate audience. They provide the students with an enjoyable entré into the lives of the scientists, their personal philosophies, their senses of humor, their outside interests, the theories and experimental techniques they used, the results of their research, and the relationship between their results and those of the past and future.

Most importantly, students learn the excitement of discovery firsthand from the pioneering scientists. They also learn the human elements that may capture their attention. For example they can learn that Humphry Davy, the discoverer of calcium and potassium, loved salmon fishing, wrote poetry, and experimented with the mood-altering effects of nitrous oxide. They will find that Svente Arrhenius barely passed his doctoral exam. They learn how many scientists had to escape the tyranny of Hitler and how others, including Linus Pauling, were harrassed by the House UnAmerican Committee in the United States for their views on nuclear fallout. They can see that had Martin Kamen not been persecuted by the government for his leftist politics, we might be calling the photosynthetic carbon reduction cycle "The Kamen Cycle" instead of "The Calvin Cycle." They can discover how important microorganisms have been in our understanding of photosynthesis in plants. They can discover why George Beadle decided to work on *Neurospora* and why Albert Szent-Györgyi began work on Hungarian peppers and potatoes. They can contrast Erwin Chargaff's perspective about the discovery of the double helix with that of James Watson or Francis Crick. They can learn how Per Scholander developed an understanding of the cohesive properties of water from walking on the beach. They can learn that Alfred Wallace, the cofounder of the idea of evolution by natural selection, was a defender of and a believer in spiritualism. They can also discover that Joseph Priestley, a discover of oxygen, was a founder of the Unitarian Church. They may be surprised to find that while Mathias Schleiden, the cofounder of the cell theory, attempted suicide many times, Ludwig Boltzmann, Rudolf Schoenheimer, and Emil Fischer succeeded. They can also read about Jacobius van't Hoff's views on imagination in science.

The book list that follows is not exhaustive and is updated yearly as we read more. Most of these books are available from the libraries at Cornell University and can occasionally be found at a used bookstore.

Today, many scientific works are dry and hard to read, perhaps intentionally. Easy-to-read scholarly works are usually not included in classes for science majors or even known to the students. They are not referenced in textbooks. Thus, students may get the opinion that difficult-to-read works are the hallmark of good science. We want the students in our class to write clearly and creatively when they communicate science. Thus, we find it important to acquaint the

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students with easy-to-read works of great scientists. This gives them the realization that many of the great scientists communicated their work through understandable, interesting and imaginative writing and thus makes this kind of science writing acceptable to the student.

This year we gave the students a creative writing project as a final exam. This was the first time we had given such an assignment and the first time any of the students had even heard of such an assignment. Yet they accepted it warmly and performed exquisitely. We feel that they were open to this assignment and empowered to do it, in part, because they were exposed to the following bibliography which provided substantial evidence that many of the scientists about whom they learn were comfortable writing creatively about science. The text of the 1995 final exam follows:

> "I have been very impressed with this class as a whole and would like to try a different kind of final exam. You can use your notes or any other reference.
>
> For the final, begin by writing an introductory page describing to your reader the dimensions of time, space, force and energy encountered in the cell. Perhaps you could start with values known to the reader and work your way down progressively.
>
> Then write a creative story, using as much cell biology as you can. Let us know what it is like for a vesicle to move through the cytoplasm, and how easy it is for a proton. Let us know what it feels like to pump out 1000 protons per second at the expense of ATP, while other proteins get to make ATP as the protons passively move through them. What is it like for a gene that will create a flower to sit there, unreplicated, while the housekeeping genes replicate? How would a protein feel, when its best friend, synthesized like itself, is rushed into the chloroplast because it was born with a transit peptide? Is this fair? What was it like when the first cell evolved, or when another cell was captured to make energy for the victor? I would rather that you discuss many aspects of cell biology than limit yourself to one. I hope that a layperson can learn a lot about the cell from the cell's point of view from your story. I'm sure that you have hundreds of ideas.
>
> Although there is no length requirement, perhaps 10 double-spaced pages would be optimal. I suggest that you speak with me as you write this so that we know what each other is thinking. It is due in class at the time of the final exam. Of course you have the option to take a 'regular final'."

The response was overwhelming. One student wrote a story from the point of view of a chloroplast in a tobacco plant outside a cell biology meeting. Another wrote a children's story book. Still another wrote about a cellular theme park, where each organelle was a ride, and an actin monorail took the visitors around the park. One student passed in a personal journal of a protein; another the memoirs of a ribosome; still another wrote a series of short stories about each organelle; and we even got a transcript of a cellular musical and a poem.

We hope that this bibliography will also be useful for high school and freshman biology teachers as a source of anecdotes and stories about the adolescent years of the scientists. This may help the students identify with the scientists as people and instill in the students a love for science and an appreciation of the human aspects, humor and beauty of science.

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EPPERSON AND AGUILLARD TO BE HONORED AT ANNUAL BANQUET

At this year's Annual Banquet in Reno, NABT will honor two biology teachers whose courage has left a lasting impact on their profession. In 1965, **Susan Epperson** became the first person to challenge an antievolution law since the trial of John Scopes in 1925. Epperson's lawsuit, ultimately decided by the U.S. Supreme Court (*Epperson v. Arkansas*), legalized the teaching of evolution.

In 1981, **Don Aguillard** challenged Louisiana's "balanced treatment" law. Aguillard's case (*Edwards v. Aguillard*), also decided by the U.S. Supreme Court, announced that (1) it is unconstitutional to mandate or advocate creationism in public schools because creationism is inherently a religious ideal; and (2) "balanced treatment" and "equal time" laws are unconstitutional because they advance a religious belief. (*Note: Epperson and Aquillard are also scheduled to speak during the Convention. Check your program in Reno for exact day and time.*)