

The Value of Biofundamentals

Vignesh V. Palaniappan

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I entered the University of Colorado Boulder in the Fall of 2008 as a Biochemistry and MCDB major. That first semester here, I enrolled in Intro Molecular & Cellular Biology (MCDB 1150) with Dr. Guild and Dr. Martin and the rest is history. I loved my major, my teachers, and was fascinated with the whole topic. I still remember Dr. Guild's snowboarder analogy for topoisomerase and Dr. Odorizzi's crocs and socks and his whole-body demonstrations of voltage gated ion channels in Cell Biology; Dr. Stowell bleaching his hair and explaining thermoregulation of heat-shock proteins to me in Molecular Biology, and Dr. Winey's Genetics Class answering my questions about why brown people like myself did not often get sunburns. I was also very lucky and had the time in my schedule to take a whole host of MCDB electives: I learned about P-bodies and experimental techniques in Dr. Fillman's Experimental Design Class, Cancer Cell Biology in Dr. Espinosa's Class, Translational and Clinical Medicine with Dr. Leinwand in her Lab Bench to Bedside Class, and Developmental Biology with Dr. Knight. I will also be taking Animal Virology with Dr. Garcea and Cell Stress and Response with Dr. Shen next semester. One thing that I would like to note, is that there was a benefit afforded to me, that not all of my peers had. I actually took an intro molecular biology/biochemistry class at my high school - Fairview High in Boulder. Therefore, much of intro was a review for me. I wonder how well I would have done in this major without that strong background.

This semester, however, I had the opportunity to serve as a Learning Assistant for Dr. Klymkowsky's transformed Intro MCDB class known as Biofundamentals. When I first heard about the class, I was initially a little skeptical about its structure and curriculum. The whole text for the class is free and online and students are required to interact with the text prior to class through a web program known as highlighter. Class time is then spent as a review of the text and provides time for a plethora of clicker questions and group discussions. Though it seemed like a good idea in theory to get students to read before class I was not sure how on board the students would be with this idea. It admittedly puts more burden on the students. Furthermore, Dr. K is all about questioning and a small portion of student questions are redirected to the students so that there can be discussion. My skepticism was soundly proven wrong. The response of the students was truly amazing. Though initially fazed, most students jumped right on board and began to take much more active roles in their learning. Students who initially whined to me about the amount of work now are pleasantly surprised when they can still understand concepts from the first midterm without review. When asked to raise their standards, the students had very little trouble adapting to it. The number of highlights we get per page is truly staggering at this point in the semester and it is a lot of fun to see the students help each other via this online forum. It also provided a voice for students who were shy in class, to really flesh out their ideas. Though highlighter is far from glitch-free, its overwhelming success even with these glitches truly proves that an interactional text is a feasible and valuable teaching tool today.

Most interesting, however, is the curriculum of Biofundamentals. The class begins with an explanation of what science is, how it is done in the lab, and the limitations of scientific inquiry. The class then goes through evolution, the basic chemistry required to understand biology such as diffusion and osmosis, the basis of heredity, and finally how gene regulation works to create these elegant systems known as living organisms. However, the focus throughout all of these topics is the CONCEPTS! There is no memorization of the structures of glucose or chitin, because really, who cares? How many biologists need to know the structure of chitin? Why is the number of ATP generated by one glucose memorized by students in the traditional intro - under physiological conditions, it widely varies! Why do they also memorize the steps of cell respiration? These things are details that serve very little function except to force students to memorize numbers and names and then promptly forget them. Biofundamentals instead talks about the general idea of how ATP is generated without delving into the biochemistry and uses this as an example of how living systems. In addition, there is often not only one right answer to a discussion problem - just like in real life. Living systems devise multiple different ways to deal with similar

problems and the class constantly reinforces that. All that is required to do well in Biofundamentals is to really, truly, gain a basic understanding of the stochastic nature of the evolution of life. The students then must apply these concepts of stochastic systems and reproductive success to understand why DNA is the perfect molecule for heredity, or why convergent evolution often occurs, or why different organisms have different methods of reproduction. Though many of the examples used in the class are real, others ask students to come up with hypothetical scenarios. For example, one discussion question was how to design an oscillating pattern of protein expression while others asked students to provide how and why bird and bat wings may have convergently evolved. The tests are in a similar vein. Though they are all multiple choice, students must justify any answer they choose. Even with a wrong answer, students with correct reasoning can get a significant number of points. This emphasis on reasoning on the tests forces students to understand concepts if they want to do well in the class.

Biofundamentals is a lot of work - both on the part of the student and the professor. But the students who truly take advantage of this class walk out prepared to become scientists - instead of repositories for random biological facts. It is a vastly superior introductory biology course for all students than the current introductory course and provides a venue to get those really motivated students really involved in scientific thinking. By shifting introductory biology to become more like Biofundamentals, this department can truly revolutionize college-level biology education. Students will learn about the details of cell and molecular biology during their cell and molecular biology courses and biochemistry classes (I guarantee that no student will contend that they used the traditional Intro MCDB class's ATP synthesis and DNA replication sections as the basis for their cell and molecular classes). More important for introductory biology students, are the concepts and ideas that permeate the field: The idea that randomness can lead to vastly complex biological systems, that evolution is an undirected, stochastic process, the interactive nature of all living systems, that science is a constantly evolving field, and the ability to think critically about any so-called "facts" - these are among the ideas that students need to know to excel in this major.

Though my time in MCDB was great (the electives were the best classes I have ever taken), I wish I had had the opportunity to go through Biofundamentals as a freshman. Its focus on scientific thinking, is the single most important thing an MCDB student can walk out of CU with. This department should make it a priority to retool classes to achieve this standard. Many upper division classes already have this feature - two prime examples are Developmental Biology (Dr. Knight is all about combinatorial control) and Cancer Cell Biology (Dr. Espinosa's tests are open note - by definition it has to be a class about concepts). However, to get to these awesome classes, students have to slog through some not-so-efficacious classes. Not all students tough it out. Intro is currently a "weed-out" class. By using Biofundamentals as a model for these classes and truly thinking about what students need to learn and in what order, this major can become more accessible to more of the student population. Biofundamentals also constantly talks about experimentation and research and can help drive more students to consider careers in academia and industry as well as medicine. I hope that this testimonial from the perspective of a student who has gone through the traditional major provides a useful view into the value of Biofundamentals. I truly believe in this evolving class and I hope that more students in this major get the opportunity to experience it.

Vignesh is a Senior in at the University of Colorado Boulder. He will graduate in May 2012 with a B.A. in Biochemistry and Molecular, Cellular, and Developmental Biology.

Author's Note: This piece was written on my own initiative and was not solicited by Dr. Klymkowsky or any other entity.