The Florida State University
School of Computational Science and Information Technology
Dirac Science Library
Tallahassee, Florida 32306-4120

Telephone: 850.645.0308
Fax: 850.644.0098
Email: swofford@csit.fsu.edu

M E M O R A N D U M

To: Students in Biocalculus Computer Lab (MAT3930)

From: David L. Swofford
Francis Eppes Professor of Biological Science
Director, Howard Hughes Undergraduate Program in Mathematical and Computational Biology (as of October 1, 2004)

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Subject: Why biologists should embrace mathematics!

It is a well-established fact that every scientific discipline becomes increasingly mathematical as it matures. Astronomy, physics, and chemistry, are perhaps the three most obvious examples. Geology, meteorology, and psychology are also becoming quite mathematical as increasing emphasis is placed on modeling natural systems and extracting complex, multivariate patterns from data.

Biology is no exception; we have entered a new era. Incredible technological advances have paved the way for determining the complete genomic sequences of dozens of organisms. We are learning more every day about how genes are controlled and regulated, thereby increasing our understanding of why things sometimes go wrong. As we enter the post-genomic world, the job market now favors a fundamentally different kind of biologist than was the case only a few years ago.

The new biology has become an increasingly interdisciplinary science and is demanding quantitative skills more than ever before. New sub-disciplines, such as image processing, computational molecular biology, micro-array analysis and medical modeling have emerged in biology, where mathematics and computing have become important tools to be used throughout a scientific project. Even in ecology and evolutionary biology, mathematical modeling has become a critical component of many, if not most, meaningful studies. Medical doctors and other health professionals need to be able to understand and interpret the many kinds of mathematical and statistical analyses that will shape the course of their treatments. Consequently, there is a recognized need by private and federal research funding agencies, as well as the private sector, that biologists need more quantitative skills. In short, biologists now have little choice but to be competent in mathematics if they want to be competitive for the best jobs.

Employment skills come in many kinds and forms. Skills you learn while taking a mathematics and computing course such as this Biocalculus lab include analytical skills (use of calculus, graphs, statistics, computers), reasoning and problem-solving skills (organization, problem synthesis, hypothesis construction, analysis) as well as observation, writing, and communication skills. All of these acquired skills will make you more competitive in professional school applications and employable in the job market. And even if that isn't enough to convince you, researchers have discovered a statistical correlation between the amount of math you learn and how much money you earn later in life, *regardless of your final*

career choice (see "More math means more money," Science 243, p. 314, 1989)—possibly worth remembering the next time you are wondering why you should (or are required to) take that next math course! Possibly a more noble motivation is that mathematics provides practice in clear thinking—expressing one's assumptions, testing them out, and predicting their consequences. Many biological problems seem sooner or later to yield to mathematical formulations.

I will close with a personal anecdote, and I promise I am not making this up. I was once given a nice award by the university where I obtained my M.S. degree in biology. Prior to receiving the award, I was interviewed by someone from the university public relations office, who asked: "If you could go back and start all over, what would you do differently?" I immediately answered, "I would take more math courses." As an undergraduate, I never realized how critical mathematics would be to my future development as a scientist. I was good in math, but I didn't take even one course that I wasn't required to take. As a result, I've been catching up my entire career. It would have been so much easier to learn math from university faculty—who are genuinely interested in your progress and dedicated to helping you prepare for your future needs—than to learn everything the hard way as I did. The effort you put in now, painful as it might seem at first, will be worth it. I would not say that if I did not honestly believe it.