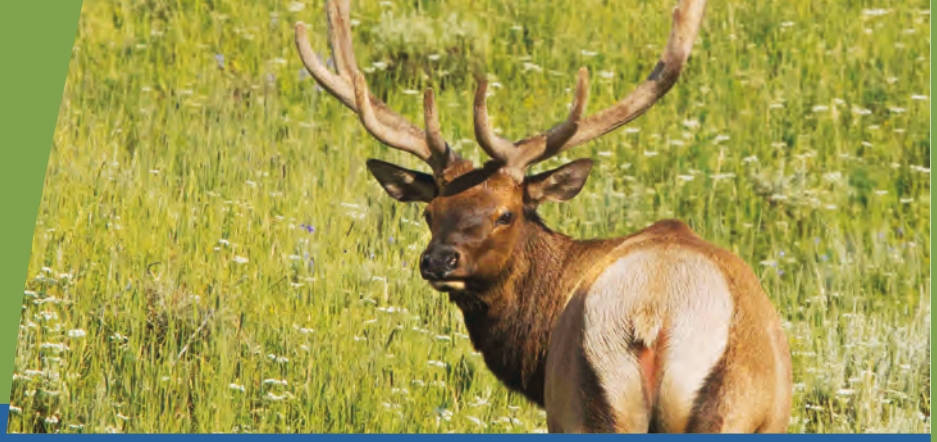

GUEST COMMENTARY

Vedham Karpakakunjaram,
Kristin Jenkins

"I Was Told There Would Be No Math Involved"

A colleague recently shared an article with us about Scottish high school students and their parents who were incensed because the high-stakes end-of-year biology qualifying exam was heavily quantitative. This situation serves as a demonstration of the entrenched misconception that biology is a math-free zone. Historically, biology began as an observational science. Even Darwin described evolution with minimal quantitative analysis in *The Origin of Species*. Things have changed drastically since 1859, and quantitative biology is now (or at least should be) an integral component of the life sciences. Modern biology has access to unprecedented amounts of exciting data, which can be managed only with quantitative tools, including those from emerging fields like data science. Staying on top of this rapidly changing field is a daunting task; keeping our teaching up-to-date is an even greater challenge.

At community colleges and beyond, supporting students' development of quantitative skills must occupy a growing position in the curriculum. *Vision and Change* and other recent reports have pointed out the importance of quantitative skills, even as additional studies reveal that students are often unprepared to engage with biological content quantitatively. Among college students, mathematical competency is a common challenge. For example, a National Center for Education Statistics 2016 report by Chen and Simone concludes that 59% of students starting at community colleges and 33% of students starting at four-year colleges are enrolled in at least one remedial math class. This means that many college-level students are spending time relearning mathematics rather than applying quantitative skills to solve interesting biology problems. In addition, math anxiety – the psychological belief that one is unable to do math – must be addressed before students can be successful. This crippling fear of failure prevents students from engaging with mathematics productively.

Community college faculty, in particular, face some of the greatest challenges in incorporating quantitative skills for several reasons, most notably because of open enrollment, which results in a student body with a wide range of preparation levels. Yet these faculty are in an excellent position to have an immediate impact on the success of a wide range of science learners, ultimately increasing the diversity of the STEM workforce. Despite the challenges of teaching an inclusive student body, the American Association of Community Colleges reported that the number of science and engineering associate degrees awarded by two-year institutions doubled between 2000 and 2012, to around 85,000. A National Center for Science and Engineering Statistics report on earned doctorates noted that 47% of all recent science and engineering graduates, and 12.5% of doctoral degree recipients, attended community college at some point in their education. This is a commendable start, but what more can be done to improve the success rate?

Some of our braver colleagues have used personalized learning systems to burnish their own math skills, making them more confident to teach these skills in class. Others seek out professional development to enhance their knowledge and skills in addressing math anxiety, growth mindset, and grit. For biology faculty who wish to engage students in quantitative biology as part of the curriculum using real-world data, there are effective pedagogical practices such as course-based undergraduate research experiences (CUREs) – for example, SEA-PHAGES (Science Education Alliance–Phage Hunters Advancing Genomics and Evolutionary Science). Programs such as CUREnet (Course Based Undergraduate Research Experience) and CCURI (Community College Undergraduate Research Initiative) provide resources and support for faculty implementing CUREs. Additionally, projects such as Data Nuggets, BIRDD (Beagle Investigations Return with Darwinian Data), and DryadLab provide access to real datasets for the classroom. All biology faculty can acquire these pedagogical skills and teaching materials at the annual NABT conference and through journals like *The American Biology Teacher*.

Other opportunities to develop quantitative biology skills are provided through NSF-funded synthesis centers such as Quantitative Undergraduate Biology Education and Synthesis (QUBES) and the National Institute for Mathematical and Biological Synthesis (NIMBioS), which offer professional development, access to resources, and support from like-minded peers. For example, we are members of the Quantitative Biology at Community Colleges (QB@CC) project, which began as a NIMBioS working group and is now hosted on QUBES. QB@CC has taken a multipronged approach to addressing the challenge of teaching quantitative skills, beginning with a survey of faculty at both two- and four-year colleges. Based on this information, the group is developing a matrix aligning core biology topics with relevant quantitative skills and underlying mathematical concepts to help faculty provide appropriate support for students. The group is also collecting and adapting open education resources (OERs) which apply quantitative skills in core biology areas. While the initial focus is on providing resources for two-year colleges, the materials will be easily adaptable for high school or four-year courses as well. We invite all interested faculty to join the group and make use of these resources (https://qubeshub.org/community/groups/qbcc).

To demonstrate the quantitative nature of biology, faculty at all levels must find ways to thoroughly integrate quantitative skills into their course curriculum or risk reinforcing the perception that math skills are distinct from biology skills and therefore not critical to success in this domain of science. Let's take a cue from Darwin himself, who expressed the value of math in understanding biology – "I have deeply regretted that I did not proceed far enough at least to understand something of the great leading principles of mathematics, for men thus endowed seem to have an extra sense." Let's ensure that our students have that extra sense.

Vedham Karpakakunjaram
Professor, Biology Department
Montgomery College
Rockville, MD
vkarpaka@montgomerycollege.edu

Kristin Jenkins
Director, BioQUEST Curriculum Consortium
Boyds, MD
kristin.jenkins@bioquest.org

This work was conducted as a part of the Quantitative Biology at Community Colleges (QB@CC) Working Group at the National Institute for Mathematical and Biological Synthesis (NIMBioS), supported by the National Science Foundation (NSF) through NSF award no. DBI-1300426, with additional support from the University of Tennessee, Knoxville, and by the Quantitative Undergraduate Biology Education and Synthesis (QUBES) project, supported by NSF award nos.1446269, 1446258, and 1446284.

DOI: https://doi.org/10.1525/abt.2019.81.7.465

American Museum of Natural History

Seminars on Science

Online courses for educators

NABT readers receive 15% off course fees using code **NABT19** at checkout!

BLM (CC BY 2.0)

6-week online graduate courses in the life, Earth, and physical sciences

- **Flexible**, easy-to-navigate, accessible anywhere, anytime
- **Access** to cutting-edge research, world-class scientists, and powerful classroom resources
- **Graduate credit** available through our partners

UPCOMING COURSES INCLUDE:

- *Climate Change*
- *The Diveristy of Fishes*
- *Evolution*
- *Genetics, Genomics, Genethics*
- *The Ocean System*
- *Space, Time, and Motion*

Upcoming Sessions

Fall Session 1

Sept. 16 – Oct. 27

Deadline to Register: Sept. 9

Fall Session 2

Oct. 28 – Dec. 8

Deadline to Register: Oct. 21

learn.amnh.org