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STUDENT-CENTERED LEARNING IN BIOLOGY

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National Geographic Biology is designed to facilitate more student-centered and cohesive ways of learning, while addressing the content-rich nature of biology. This is a shift away from centering the teacher to centering the learner. Each unit is built around an Anchoring Phenomenon that students revisit as they learn. At the chapter level, the program fosters curiosity and engagement for biology concepts using Case Studies, Connections, and Biotechnology Focus features that prompt reflections and lead to *Tying It All Together* at the end of each chapter. This integration is embedded in smaller yet connected sections that enable students to tap into relevant real-life phenomena that reflect the multidisciplinary and interdisciplinary nature of biology. With a balance between building skills and learning biology content, the program supports the development of College and Career Readiness skills and other essential skills for preparing the next generation to become scientifically literate citizens.

MAKING SENSE OF DATA

In today's rapidly changing world, students have access to more data than ever before. Understanding how to use data becomes more important than mere memorization of facts.

Now that I teach at the university level, I observe that students who enjoyed memorization because it was easier and did well because only memorization was required, struggle with the change to more meaningful learning. Think of the growing field of computational biology and other fields that continue to be created to address large amounts of data. That requires critical thinking and a certain level of comfort with uncertainty and exploration. National Geographic Biology provides you with opportunities for *Looking at the Data*, for *Math and English Language Arts Connections*, and *Minilabs* that hone in on skill building. Opportunities for skill building mean that students are more likely to carry over what they learn in biology into other contexts and into the subsequent years.

I had the unique opportunity to teach both tenth grade biology and then some of the same students in eleventh grade chemistry. Seeing what carried over from one year to the next led me to dramatically change the way I taught biology. For example, rather than place the photosynthesis equation on the board, I asked students to look at data and then to generate an equation showing what plants used and produced. I found that allowing students to take the time to construct meaning led them to remember what they learned, and their skills were more likely to carry over to the next year. If we only present information to students, the only skills they engage in is memorization and the only expectation we have of them is to remember or recall. If they don't make connections for themselves, then the information is only held in short-term memory and does not make it to long-term memory. In contrast, giving students the opportunity to engage with, derive, and construct meaning for themselves results in learning that lasts.

DIVERSITY AND INCLUSION

As biology teachers we're also called to address society's concerns for diversity, inclusion, and belonging. Our instructional materials should change to address the needs of all populations and to reflect the demographics of who will be tomorrow's scientists. Inclusion and Diversity is addressed through vignettes and illustrations from diverse scientists that are meaningfully integrated into the biology concepts. Students come to understand the variety of methods scientists use, and that scientists come from diverse backgrounds, which supports the NGSS *Understandings About the Nature of Science*. Vignettes such as *Blood Drive: Vaccinating Vampire Bats in the Peruvian Mountains*; *Under the Sea:*

Illuminating Unique Ecosystems in the Deep Ocean; and *Linking Healthy Chimpanzees to Healthy Children*, to name a few, provide engaging points of entry for exploring specific biology content—whether genetics, animal behavior, relationships in ecosystems, or diversity of living things. As students and teachers, we get pulled into their world in these features that give us a glimpse into what they are thinking—what led them to become interested in the work, why they are doing the work they're doing, the unique context and location, and questions they ask and pursue. One gets the feeling that we could also do what they're doing. This provides opportunity for all students, for diverse students, to see themselves in the field. Students also get to construct their own storylines as they themselves use science as a way of knowing. In the inquiry investigation labs students actively construct their own understandings by generating claims and gathering evidence using scientific practices. They not only collect and analyze data but use mathematical computations and reflect on their own thinking using the guided questions and self-reflective rubrics created specifically for students and teachers.

Imagine your students engaging in arguments about particular science concepts. Imagine all of these situations embedded in and facilitated by a well-organized text and program. Students can argue from evidence in small tasks or large tasks, or both. Students can discuss how they come to know ideas using evidence from the text and labs. In my own research into students thinking about science, I've learned that students not only connect differently with the information but also connect with different information. The benefits of confronting each other's thinking using evidence must be underscored. What's important about this is that as a biology teacher, you already have the buy-in and interest because your students are arguing in science. Students love to argue, but rarely get to do so in science, because of how we've taught science, and especially because of the content rich nature of biology. You'll be surprised to see that they will cover the content in their arguments and that your concern about covering the biology concepts required will be alleviated. Why? They look at the content to generate their claims, provide their warrants, and come up with their reasonings. When they construct their own meaning, they are more likely to retain the information. When they verbalize their thoughts, you have the opportunity to clarify and discuss.

The structure of the National Geographic program also scaffolds teacher facilitation of more student-centered approaches to teaching biology. This ranges from the inclusion of embedded questions for classroom discussions and arguments to opportunities for individual or small group research. The program provides teachers with ways to accommodate students while also accommodating teachers with limited access to lab resources. Questions and self-assessment rubrics help students to reflect on their own processes or prompt students to create their own questions, while providing teachers with alternate ways to assess progress and learning. In my 16 years of teaching ninth and tenth grade biology, I found that student-generated questions lead to very interesting discussions that reveal students' conceptions. These rich conversations not only provide opportunities to address students' understandings and misunderstandings but also encourage student engagement and active learning.

Explorer Dr. Carter Clinton, featured in Chapter 11, works to extract and analyze DNA samples from historical sites such as the African Burial Ground National Monument in New York City. His forensic analyses have helped shed light on the history of African Americans during colonial times.

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Dr. Catherine Workman develops and oversees the implementation and execution of the science components of the National Geographic Society's strategy and leads the science team. Trained as an evolutionary anthropologist, Catherine has extensive experience in the policy, strategy, management, metrics, and communication of biodiversity conservation, international grant-making, and combating wildlife trafficking. She collaborates with colleagues and partners to engage a range of audiences and stakeholders including nonscientific, underrepresented, and youth groups. Prior to joining National Geographic, Catherine worked in the Conservation Biology department at Denver Zoo, and was a 2014–2015 AAAS Science & Technology Policy Fellow at USAID, where she helped address issues from unsustainable fishing to illegal logging. Catherine has a Ph.D. in evolutionary anthropology from Duke University.

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Dr. Catherine L. Quinlan has over two decades of science-teaching experience in the K–12 and university settings, sixteen years of which were teaching high school biology. She holds a B.A. in English from Barnard College (premed), and an Ed.D. in Science Education from Teachers College, Columbia University. In her current position at Howard University School of Education, Dr. Quinlan prepares preservice teachers in science methods and education foundations for the K–12 classroom. Her research uses multidisciplinary and interdisciplinary approaches to look at the impact of cognitive, social, cultural, and historical factors on representation, and on Black students' persistence in STEM. Her research focuses on creating and evaluating a culturally representative science curriculum, with a pilot funded by NSF. Dr. Quinlan continues to bridge theory and practice with her representative chapter book series for children titled *Keystone Passage*, which grounds the realities of science, history, and culture in light fantasy. Her twitter handle is @ProfQuinlan.