DEVELOPING A STRATEGY FOR REMODELING BIOLOGY EDUCATION TO INTEGRATE MICRO- AND MACROBIOLOGY

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In the fall of 2024, I had the privilege of residence at the Wissenschaftskolleg (Wiko) in Berlin for a season of scholarship. This extremely precious opportunity allowed me to explore the horizons of education in the field of biology, in light of the dramatic technology-enabled shift in our view of the biosphere. A series of features of the experience provided the most intellectually supportive environment of my career. Most critical was the high quality of and interplay between the scholarship efforts and the

infrastructural framework that is created by Wiko's leadership. The Rector Dr. Stollberg-Rilinger and her staff have created the ideal balance between required interactions among the Fellows and free time for the development of each individual's goals for their stay at Wiko; i.e., the format for interaction between the Fellows was rich, but not so intense as to compromise the research efforts of each Fellow.

Academic goals while at Wiko

I had five interrelated goals for my tenure at Wiko that would lay the foundation for my continued advancement of these ideas through 2025 and into the future:

1) *To develop and refine a draft template for a new introductory biology course that, in unifying the field, will provide students with a strong foundation in the discipline.* The prototype must be broad and basic so that it can be developed further for a range of situations, i.e., high school, university, or medical school, with short-term courses (one quarter or semester) to longer-term courses (full academic year). In addition, the course should be formulated to allow integration of other science and engineering majors (i.e., from STEM disciplines); the incorporation of this aim is critical, as humankind's challenges, while having biology at their base, will have effective solutions only with the incorporation of expertise from other fields.

2) *To pivot the content around the organismal level of the biological hierarchy (i.e., molecule to ecosystems), with the microbial world as foundational.* For many years, the cells and/or genes of animals and plants have been the starting point for understanding biological systems. By incorporating the microbial world as foundational, students can build a framework for the field that explores topics from the origin of life to the basis of organismal, population, and community diversity.

3) *To develop a strategy for dealing with resistance to change in the curriculum.* Biology has been in separate silos for decades, with cell/molecular/development at one end and ecology/evolution at the other. These challenging intellectual barriers are accompanied by the narrow foci of expertise of the practitioners of biology, particularly the senior, most "politically" powerful members of the faculty communities. Further, the impact of this siloing is reflected in departmental structures, scientific societies, funding agencies, etc. These divisions are highly guarded, and change in the structures is perceived as

threatening. As such, it is important to address this "political" issue. A variety of approaches should be explored, e.g. teaching the teachers and/or offering traditional approaches along with the new ones in separate sections of existing introductory courses.

4) *To consider mechanisms to publicize this approach*. I have already given a number of seminars on this topic in the international arena. Such is one way to "plant a seed." I will continue to seek out such opportunities. For example, I have been invited at the end of this fall to Singapore for a two-week visit and next spring for a week-long visit in Vienna. In addition, I typically give 20–25 lectures at universities throughout a given year. I will request to provide two seminars at each venue where I speak, one on the need to remodel biology education and one on my research program. In addition, I hope to publish a perspective piece in a broad scientific journal, such as *Science*, *Nature*, or the *Proceedings of the National Academy of Sciences, USA*. The goal is to reach the audience across the disciplines of science.

5) *To gain a perspective from the other Wiko Fellows, particularly those in fields that have recently undergone major conceptual shifts.* What drives such shifts and how do the practitioners adapt? In biology, conceptual shifts occurred in the 19th century with Darwin, in the 20th century with the defining of DNA as the genetic basis of life forms, and in the 21st century by the discovery of a world we could not have known, the Earth's microbiomes. My efforts were significantly enriched by the interactions with my Co-Fellows. One interaction that I will never forget is the problem that the historians and philosophers in the group had with my referring to "revolutions" in biology. Scientists use this terminology to refer to major breakthroughs or changes in the intellectual framework of the field. These are considered "scientific revolutions"; however, it was clear that this terminology carries a strong political meaning, which should be acknowledged and respected.

In summary, my stay at Wiko, although short, was one of the most remarkable of my academic career. I will forever be grateful for the opportunity.