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BIOGEOGRAPHY COMPENDIUM

On teaching “... *that grand subject, ...*”

In a letter of February 10, 1845, written to his young colleague and one of his most successful protégés, Charles Darwin congratulated Joseph Dalton Hooker on his impending professorship position (Chair of Botany, University of Edinburgh), but also warned him that the demands of a university teaching position might distract him from his destiny of becoming “... *the first authority in Europe on that grand subject, that key-stone of the laws of Creation, Geographic Distribution.*”¹

The above passage from Darwin’s letter is often quoted by contemporary biogeographers as a landmark recognition of the fundamental importance of the field of biogeography for understanding, not only species distributions, but the origins and diversification of life as well. Darwin’s ambivalence for university teaching positions may be traced back to early in his career when he was warned by one of his most esteemed mentors and the ‘father of geology’ – Charles Lyell – to avoid official scientific positions that may distract him from his quest to understand the origins of species. Few of us would doubt that Darwin made the right decision in focusing his time and energies outside universities and scientific societies. On the other hand, while Darwin never taught in any official capacity, through his books, papers and letters to numerous colleagues, he mentored a seminal generation of scientists pursuing studies on the geography of life – many of them, in turn, producing their own transformative insights on the origins, distributions and spatial and temporal dynamics of biological diversity.

Despite the transformative contributions of Darwin and his successors, biogeography did not achieve its deserved status as a broadly respected science until the latter decades of the 20th Century. Throughout this period and arguably until very recently, the training of biogeographers was seldom the product of an integrated program of study on the geography of nature. I am unaware of any available data on the history of course offerings and degree programs in ‘biogeography’, but there were none available to me at the graduate and undergraduate colleges I attended in the 1970s and 1980s. Many of us, including numerous founding members of the *International Biogeography Society* and some of its past presidents admit, albeit sheepishly, that we never took a course in biogeography during our training: for most of us, such courses simply were not offered where and when we attended college (see also Erkens 2013).

Although it is impossible to quantify trends without adequate surveys across colleges and universities, it is clear that our colleagues have made strides toward increasing the variety of course offerings on the geography of life, while also fostering training opportunities through other means. This includes offering graduate seminars, graduate assistantships and postdoctoral positions, and publishing in an expanding and impressive collection of scientific journals and books – these contributions serving as continuing reaffirmations of Darwin and Hooker’s shared appreciation for the transformative insights to be gained by studying how life varies from place to place.

The recent decades of advances and expanded opportunities for instruction and research in our discipline culminated in 2001 with the founding of the *International Biogeography Society* (IBS²), whose mission includes

- fostering communication and collaboration between biogeographers in disparate academic fields - scientists who would otherwise have little opportunity for substantive interaction and collaboration,
- increasing both the awareness and interests of the scientific community and the lay public in the contributions of biogeographers, and
- promoting the training and education of biogeographers so that they may develop sound strategies for studying and conserving the world’s biota.

My purpose here is to enlist the assistance and visions of colleagues in addressing the third initiative – to develop an integrated strategy for expanding and enhancing the teaching of biogeography across the world’s colleges and universities and to a broader span of disciplines, with the ultimate goal that this training will become an integral component of undergraduate programs for all students interested in the natural world (see Erkens 2013, 2018).

Why teach the Grand Subject and the compelling stories of Nature?

Although I am preaching to the choir, it is important that we make explicit the perhaps unrivaled values of an education in the geography of nature if we are to

¹ “Surely lecturing will in a year or too, with your great capacity for work (whatever you may be pleased to say to the boontrary) become easy & you will have a fair time for your Antarctic Flora & general views of distribution. If I thought your Professorship would stop your work, I should wish it & all the good worldly consequences at el Diavolo:” – Letter from Darwin to Hooker, February 10, 1845.

² <http://www.biogeography.org>

convince our colleagues, administrators and students that it should form a core component of science training at the graduate and undergraduate levels.

First, there are few if any disciplines as integrative and as holistic as biogeography. Today, we define it as the study of spatial variation in *all* characteristics of life, from the levels of organelles and cells to geographic populations, species, biotic communities and regional biotas. Its central mantra, borrowing from Theodosius Dobzhansky's (1973) prescient observation – "Nothing in biology makes sense except in the light of evolution" – is that the many compelling and insightful patterns of biological diversity make little sense unless placed in an explicit geographic context. From the early observations of Buffon that regional biotas (even those with similar climatic and environmental conditions) tend to share few species, to those of Darwin and Wallace on patterns of variation among insular biotas – patterns that led to their independent development of the theory of evolution by natural selection – the geography of nature was fundamental for the most revolutionary insights on how life originated and diversified across the planet. Spatial relationships are central, not only for understanding evolutionary processes, but for providing fundamental insights in ecology where species interactions and other ecological processes depend on the geographical distribution of biological diversity. The geography of nature, including that of fossils and extant biotas, also provided fundamental insights to Alfred Wegener and subsequent generations of geologists and paleontologists who eventually advanced continental drift and later incorporated it within the theory of plate tectonics, the central theory explaining Earth's past and present geology (see Sousa 2016).

Therefore, biogeography may have an unparalleled potential to make sense of the compelling yet often daunting mysteries of earth history, evolution and biological diversity. The lesson that evolution occurs across space as well as over time should be an integral and unifying theme of science education. Courses in biogeography present us with a singular opportunity, and in another sense an obligation, to teach what I view as 'the compelling stories of nature' – on how this planet works; how it came to be and how all its features – geological, atmospheric, climatic, environmental and biological – have been influenced by the fundamental laws of physics, evolved in complex synergies, and ultimately produced the patterns of geographic variation that constitute the fundamental patterns of biogeography and biological diversity.

Whether taught at undergraduate or graduate levels, courses in biogeography may best start with an introduction to subjects that are fundamental to an understanding of the dynamics and geography of life. By 'fundamental' I do not mean trivial or simple, but instead refer to information that is essential for a comprehensive understanding of the processes influencing biological diversity across space and time. Given the diverse backgrounds of students likely to take biogeography courses – drawing from majors in geography, geology, anthropology, environmental sciences, etc. – this may be their only exposure to the grand subject and nature's most compelling stories.

This, I believe, is information that all learned people of the 21st Century should be aware of, and likely will be fascinated by. My personal rendering of such a list of invaluable lessons on how nature works at a grand scale includes the following:

1. **The History of Science** – any genuine student of science should have at least an introduction to the succession of visionary scientists and the progression of seminal ideas on how nature works, from ancient explorers who first developed a global view of nature, to contemporary figures in the fields of earth and biological sciences.
2. **Geography of Earth's Climates, Soils and Aquatic Environments** – descriptions of/and causal explanations for regular patterns of variation in environmental conditions across the Earth's principal geographic gradients (latitude, elevation, depth); e.g., why the tropics bracket the Equator, why deserts are located near 30 degrees N and S latitudes; why environmental characteristics (temperature, pressure, precipitation, light, etc.) exhibit consistent gradients with elevation above and depth below sea level?
3. **Earth History and Geological Dynamics** – theories on the origins of the planet, storage and generation of heat energy in the planet's core, and how this drives plate tectonics and resultant patterns of spatial and temporal variation in the planet's geological and geographic template.
4. **Geographic Clues to the Origins and Diversification of Life** – the lessons that evolution is a fundamental feature of nature, an indefatigable force and the product of fundamental laws of physics; that every species has come into existence coincident both in time and space with a pre-existing closely allied species; and that evolution occurs across space as well as over time.
5. **The Biotic Distinctiveness of Place** – the first and most fundamental pattern of biogeography, Buffon's Law – that different regions, even those with similar environmental, climatic and edaphic conditions, are inhabited by different species.
6. **Geographic Variation in Diversity and in the Nature of Life Forms** – the patterns and causal explanations for why biological diversity varies with latitude across the globe, and with elevation in the terrestrial realm and with depth in the oceans; how and why the nature of life forms (their size, growth forms, physiology, behavior, life histories, etc.) varies across the Earth.
7. **Hotspots of Evolution and Endangerment** – why large, tropical and mountainous islands and other isolated systems often are hotspots of diversity, endemism and endangerment.
8. **Red Queens and the Ecology of Evolution and Biogeography** – an understanding of how the species themselves influence patterns in biogeography and biological diversity; that ecological feedback in the form of interactions among species affects the fundamental biogeographic processes of immigration, extinction and evolution and, in turn, all features of biological diversity and biogeography.

9. **Humans as Products of Nature** – the perhaps humbling lesson that the same geographic, topographic and environmental characteristics that influence other life forms in their distributions and dynamics across space and time have also influenced our ancestors and surviving populations of our species.
10. **Humans as Transformers of Nature** – the equally important and sobering lesson that, through our effects on the geographic template and on each of the fundamental processes of biological diversity and biogeography, ecologically advanced populations of humans have fundamentally altered the natural patterns in distributions and diversity of life across the planet, justifying the designation of a new period of life on Earth – The Anthropocene (Lewis and Maslin 2015, Zalasiewicz et al. 2013).

A preliminary plan for expanding the teaching of biogeography

There likely are many strategies we can develop, and many existing skill sets and expertise we can marshal to achieve the goals of expanding and enhancing the teaching of the grand subject and the compelling stories in the geography of nature. I will list a few suggestions here, if only to stimulate my colleagues to join in this initiative to provide more cogent, more inspired and more promising strategies for advancing the teaching of biogeography.

As with any major endeavor in science, it seems essential that we first gather information – in this case, by initiating surveys across colleges, universities and relevant disciplines (for a similar project in providing resources for teaching evolution, visit <https://evolution.berkeley.edu/evolibrary/home.php>). As I alluded to above, we know precious little about the history of course offerings on the geography of nature, let alone on the current status of education programs in the field. The preliminary questionnaire in Supplementary Appendix S1 provides a sampling of the information that may be readily obtained by online surveys of members of IBS and other relevant, scientific societies.

The next logical step would be to make this information available in an online registry of instructors and courses, and educational resources in biogeography – constituting a *Biogeography Instructor's Toolkit* for those developing new courses and training programs on the subject. Some valuable resources in such a toolkit would include syllabi of existing courses, compilations of available illustrations and related resources (e.g., digital files of figures, tables, maps, aerial photos and DVDs), and links to open access software and georeferenced databases (e.g., software for phylogeographic reconstructions and analyses; GIS, statistical and spatial data analyses, and visualization software).

In addition to these online surveys and instructor's resources, I envision a series of workshops to launch and guide the development of this teaching initiative. Such workshops may provide an excellent opportunity to produce an especially attractive set of resources for our colleagues and all those interested in the spatial and temporal dynamics of biological diversity – a series of *Distinguished Lectures in Biogeography*. These recorded, open-access lectures by distinguished biogeographers would ideally span a variety of topics across the field (e.g., The History and Seminal

Contributions in Biogeography; Earth History, Plate Tectonics and Spatial Dynamics of Life; Biogeography of the Marine Realm; Paleontology, Paleobiogeography and Phylogeography; Conservation Biogeography; Biogeography of Humanity; Biogeography of the Anthropocene; see Erkens 2013, 2018).

While the above attempts at framing an initial plan for launching this initiative reflects my experiences and my biases, much if not most of it borrows from informal discussions with my mentors and colleagues over the past few decades. In his characteristic humility and sage wisdom, my most influential mentor – James H. Brown – shared with me that any success he may have had in launching new initiatives in science was largely a function of the energies and dedication of those who joined his efforts. As Chair of *International Biogeography Society's ad hoc Committee on Education*, I am following Professor Brown's lead and inviting members of the society along with our colleagues in other disciplines to join in this initiative to develop strategies for training the next generation of students of the geography of life.

Supplementary Materials

Supplementary Appendix S1.– Preliminary questionnaire for assessing current status of biogeography teaching worldwide.

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