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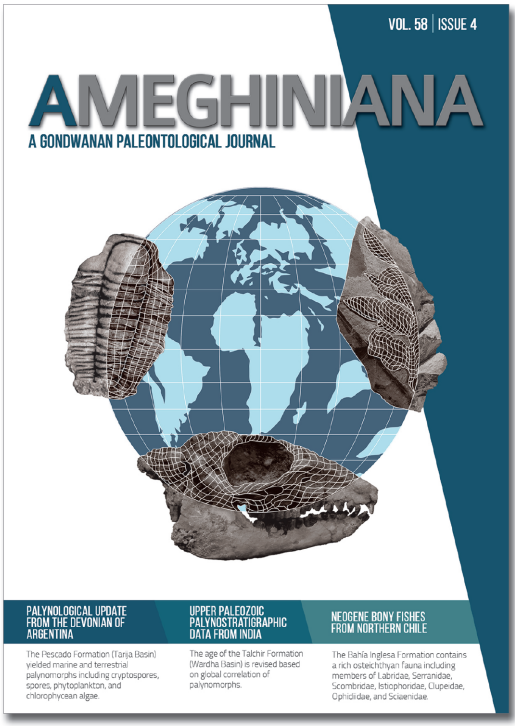


# FORWARD TO THE PAST: A ROMP THROUGH THE NATURE OF THE LAST HALF-BILLION YEARS

Review of "Nature through time", *E. Martinetto, E. Tschopp, and R. A. Gastaldo* (Eds.). 2020. 462 pp. + supplemental digital resources. Springer Textbooks in Earth Sciences, Geography and Environment. Springer. ISSN 2510-1307 and 2510-1315 (electronic). ISBN 978-3-030-35057-4 and 978-3-030-35058-1 (eBook).

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PALYNOLOGICAL UPDATE FROM THE DEVONIAN OF ARGENTINA

The Pescado Formation (Tarija Basin) yielded marine and terrestrial palynomorphs including cryptospores, spores, phytoplankton, and chlorophycean algae.

UPPER PALEOZOIC PALYNOSTRATIGRAPHIC DATA FROM INDIA

The age of the Talchir Formation (Wardha Basin) is revised based on global correlation of palynomorphs.

NEOGENE BONY FISHES FROM NORTHERN CHILE

The Bahía Inglesa Formation contains a rich osteichthyan fauna including members of Labridae, Serranidae, Scombridae, Istiophoridae, Clupeidae, Ophidiidae, and Sciaenidae.

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# FORWARD TO THE PAST: A ROMP THROUGH THE NATURE OF THE LAST HALF-BILLION YEARS

**REVIEW OF "NATURE THROUGH TIME"**. *E. Martinetto, E. Tschopp, and R. A. Gastaldo* (Eds.). 2020. 462 pp. + supplemental digital resources. Springer Textbooks in Earth Sciences, Geography and Environment. Springer. ISSN 2510-1307 and 2510-1315 (electronic). ISBN 978-3-030-35057-4 and 978-3-030-35058-1 (eBook).

How do you go about teaching the succession of floras, faunas, and the environments that hosted them throughout the biological history of the planet? The question has no unique answer, but in "Nature through time", Martinetto, Tschopp, Gastaldo, and their collaborators have come up with a comprehensive and original way to address it. Like any first attempt at such an ambitious scale, the book is not without flaws but, by-and-large, it is an impressive achievement and unique in its area of science. While sketches of the history of life, in some form or shape, occupy a chapter (or a few chapters) in many an introductory geology, biology, or evolution textbook, "Nature through time" is, to our knowledge, the first attempt to address the topic head-on and for its own sake, unapologetically and without ulterior motive, in an entire volume.

The declared goal of the volume is to provide a travel guide for virtual visits to the nature of the past 450-or-so million years, emphasizing the biological systems—plants and animals—and the ways and reasons of changes in these systems over time, and focusing mainly on terrestrial environments (with a few incidental visits to the marine realm). In doing this, the volume aims to provide the materials, as well as a pedagogical approach, for a course targeted primarily at an audience of early undergraduate students.

To achieve these goals, Martinetto, Tschopp, and Gastaldo enlisted the help of more than 90 international authors who are leading authorities in different fields of paleobotany and paleontology. Split into multi-author teams, this team divided the last 450 million years into intervals individualized by their distinctive biomes, which are presented in separate chapters. If this sounds like a standard treatment, "Nature through time" deviates from the norm established by all other comparable works in two important ways. One is the organization of the chapters (more on this later), many of which try to simulate walks through the nature of the respective intervals at different locations around the world, as reconstructed based on virtual tours at key fossil sites. Second, and perhaps more important, in what some would regard as blasphemous deviation from the canon of ascension through time that dominates biostratigraphic and evolutionary biology narratives, the volume is deliberately organized as a descent through time from the present day toward the depths of the history of life and of Earth's landscapes. In justifying this unorthodox approach, the editors argue that an account that goes counter to the arrow of time has the pedagogical benefits of maximizing learning outcomes by highlighting the discoveries and excitement of paleobiology in ways that are more inspiring to students. The underlying reasoning is that a narrative that takes the reader from the familiar biomes and landscapes of present-day progressively deeper in time, toward increasingly less familiar and less relatable (or non-analog, in the volume's terminology) "Lost Worlds", provides a more powerful narrative of how and why the world around us today differs from the past, and a more effective vehicle for conveying the magnitude of the changes that transformed the planet.

In practical terms, the volume is organized into 15 chapters that follow a preface, which introduces briefly climate types, the extraterrestrial parameters that influence climate at planetary scales, and the concepts of extinction and extirpation that appear throughout the volume. Each chapter is accompanied by image-rich supplementary material (organized as a slide show), together with which it forms an educational module or unit of a potential college course.

The chapters—outlined below—are structured, for the most part, following a common scheme. An opening section



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introduces the main attributes and events of the respective time interval and summarizes the questions that will be addressed. This is followed by snapshots of different ecosystems and landscapes presented as "field notes" or "time-travel postcards", as illustrated by fossil localities or fossil assemblages of entire rock units that are significant for the interval. These data are then integrated into bigger-picture interpretations of the important events (environmental change, biological evolution, extinction) or other facts (paleogeography, biogeography) about the interval. The concluding sections of each chapter address how or why those deep-time events and processes are relevant to the way earth systems interact and to nature in our current world. Nevertheless, some of the chapters (*e.g.*, chapters 3, 4, and 10) deviate from this scheme, taking a "forward" approach on critical intervals for which an "ascending" perspective is more effective in contextualizing certain major changes in the biosphere. Below, we summarize the content of each chapter, pointing out strengths and shortcomings, and suggesting ways to improve them in future updates of this volume.

Chapter 1 covers the Quaternary reviewing a plethora of fossil localities from all continents (shown on a useful distribution map) to reconstruct floras and faunas of different biomes, with their commonalities and differences from those that populate the planet today. The authors also introduce the different types of data used to reconstruct the climate and, overall, produce a thorough synthesis of that state of nature during the Quaternary. One useful addition to this chapter would have been a review of the most up-to-date discussions concerning the factors that have led to the plunge of the Pliocene Earth system into the high-frequency (at a geologic scale) alternation of glacial and interglacial stages.

Chapter 2 presents a well-supported case, based on data from all around the world, for the most diverse temperate forests (with thermophilous elements) that developed from the Oligocene into the Neogene. In a few spots the writing can be rambling, and in a few others, it is drowned in details that make reading fastidious. Tighter organization of all the interesting information around a few more clearly defined threads would make the narrative easier to follow. Nevertheless, there are many inspiring topics. For instance, the parallels and differences between the Neogene and extant diversity of Europe and East Asia are fascinating. In a future update of the volume, it would be interesting to see these and other phytogeographic data presented in the chapter, discussed in the context of G.L. Stebbins' "cradle" *vs.* "museum", originally proposed in debates about the nature of current tropical forest diversity. Such a discussion would be that much more fitting since this is the very fossil evidence that can illuminate the veracity of such scenarios in other parts of the world.

Chapter 3 covers a longer period of time—Cretaceous to Quaternary—tracking a specific set of ecosystems: open habitats and grasslands all around the world. The spread of these ecosystems is followed in an ascending timeline, from the Late Cretaceous origin of grasses and throughout their Cenozoic diversification—initially in the shade of the warm forests that dominated early Paleogene biomes, followed by the spread of open habitats and evolution of $C_4$ grasses in the Oligocene, the rise to dominance of $C_3$ grasses in the early Neogene, and that of the $C_4$ grasses in the Pliocene and Quaternary. These vegetation changes are traced against the background of progressive global climate cooling and in parallel with the evolution of herbivorous mammals. A focused section addressing in a more direct way the different types of evidence used to document the presence and extent of open habitats and grasslands would benefit the readers in an introductory course. Additionally, a diagram synthesizing the parallel but differently-timed spread of the different types of vegetation and of the associated faunal assemblages, in different major regions of the world, would promote this chapter from its state of valuable compilation of data on faunas and floras to that of a global-scale synthesis.

Chapter 4, the last to review nature in the Cenozoic, opens a spatially and temporally narrower window, looking at the Paleocene–Eocene Thermal Maximum in western North America. The chapter is well organized, beginning with a thorough overview of proxies and methods used to infer past climates based on plant fossils, followed by a detailed account of the floral changes that occurred in western North America before, during, and right after the thermal maximum. The chapter concludes with a brief discussion of the impacts of vegetation changes on herbivore diversity and evolution, and a section exploring how fossil data can be incorporated into models (ecological niche modeling) to

predict plant responses to climate change.

Chapter 5 reviews the Cretaceous fossil record of angiosperms, after two introductory sections that discuss the potential ancestors and closest relatives of angiosperms, and how angiosperms are recognized in the fossil record. The chapter is titled "When and why nature gained angiosperms" and we learn much about the "when" from the continent-by-continent account of earliest and subsequent angiosperm occurrences and diversity. Informative text boxes provide up-to-date reviews on angiosperm origins: when, where, in what type of environment. However, "why"-questions are difficult (or impossible) to answer in evolution, and the origin of angiosperms is no exception, so the "how" question would have been, instead, more worthy of asking in the second part of the title and addressing in this chapter. Like Chapter 3, this chapter could gain in value from a final section that pulls together all the threads wound under its umbrella, and from one (or a few) accompanying diagrams that synthesize the considerable amount of useful information corroborated here. We also feel that this chapter would be the right place, and even begs for a discussion of the recent "controversy" about the timing of the origin of angiosperms and the earliest angiosperm fossils. Such a discussion would be a timely opportunity to postulate the importance of rigorous, evidence-based inferences that paleobotanists and, more generally, paleobiologists need to strive for, in order to produce credible new knowledge.

Chapter 6 is a series of postcards from a walk back in time through most of the Mesozoic. Some of the places visited are classic fossil localities, while others are less famous, but nevertheless important by their fossil content and location. The excursion starts in the early Paleocene of New Zealand, where we contemplate the aftermath of the end-Cretaceous Chicxulub impact, and continues through Late Cretaceous southwestern USA, Early Cretaceous southeastern Australia, Late Jurassic Morrison Formation, Middle Jurassic Yorkshire, the Late Triassic Petrified Forest of Arizona, and the Middle Triassic Molteno flora of South Africa. The focus of the chapter is on forest biomes and the main distinctions emphasized are those between pre-angiosperm and angiosperm-dominated forests, and those between different floristic provinces dynamically delineated by the movement of tectonic plates.

Chapter 7 explores the vertebrate diversity of the Mesozoic, especially dinosaurs. After a brief introduction that explains broad phylogenetic patterns within Dinosauria and the causes and effects of the Cretaceous/Paleogene (K/Pg) mass extinction, this chapter reviews some of the most remarkable evolutionary paths within Dinosauria, specifically gigantism (sauropods), herbivory (therizinosaurs, ornithomimosaurs, etc.), and quadrupedality and its associated limb morphology (within Ornithischia, a section which will be especially interesting for students of Comparative Vertebrate Anatomy). The chapter then covers the transition from non-avian to avian dinosaurs; however, this section seems to spend significant time on the transition between the musculus ischiotruncus *vs.* the pubocaudalis muscles, instead of the (potentially more familiar) transitional theropod-to-avian traits like the loss of teeth and appearance of a furcula and feathers. That particular section seems truncated, given the attention given to this transition in most textbooks—this may be intentional, however, perhaps to emphasize early mammals or non-theropod dinosaurs instead. Section 7.6 then delves into Mesozoic mammals, debunking the concept that all early mammals were little insectivores: instead, it introduces mammals of a wide array of morphologies and emphasizes the evolution of sense organs, diphyodont heterodont dentition, and other traits. The chapter does a wonderful job describing the radiation of mammaliaform groups that survived the end-Permian extinction, however, the introduction of clade names such as the Multituberculata and Tribosphenida (alongside other non-dentition-based terms like the Placentalia) would benefit from a figure showing the dentition that characterizes these groups. The section on Mesozoic aquatic reptiles has a fantastic section on turtles (including a figure correlating turtle evolution with the evolution of flowering plants!), as well as crocodyliforms and plesiosaurs. The final section on Mesozoic fish diversity is focused wholly on bony fishes, except for a few chondrichthyans in a single figure. Frustratingly (for a paleobiology-focused volume), the phylogeny of fishes only shows extant groups, leaving out the context of placoderm, ostracoderm, and acanthodian fishes along the stems of the groups we are familiar with today. Even so, the fish section does a good job emphasizing radiation events and survival across extinction events, and the final figures of the chapter are especially good at showing

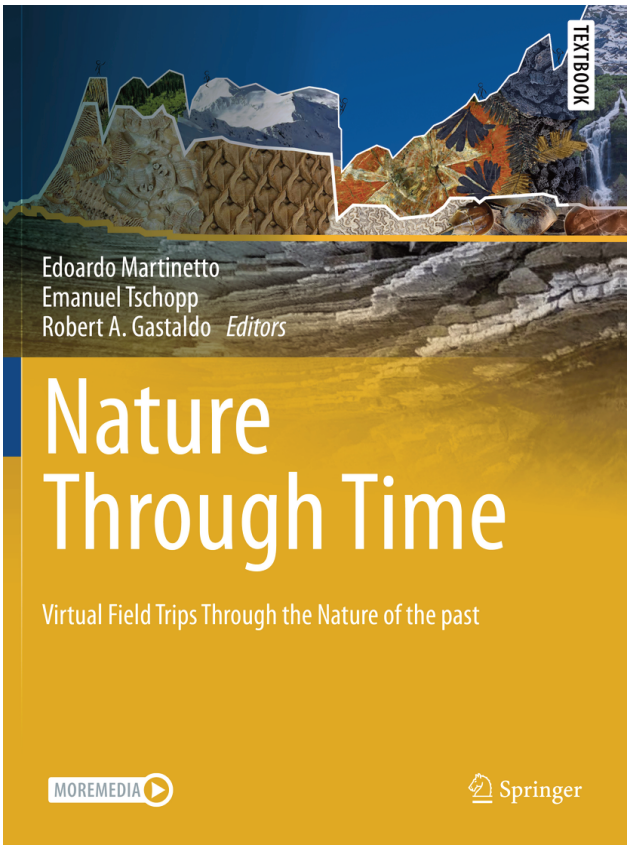


**Figura 1.** Cover of the textbook entittled Nature through time - Virtual field trips through the nature of the past - Springer.

some of the morphological diversity of Mesozoic and Permo-Triassic fishes. Nevertheless, the discussion of whether fishes were affected by the Mesozoic mass-extinction could have presented a more balanced set of views, since fossil-calibrated studies of actinopterygian radiations conclude the K/Pg extinction impacted teleost diversification, in contrast to studies relying wholly on molecular dating, which tend not to find a significant effect at the K/Pg boundary.

Chapter 8 reviews the paleoecology of Mesozoic vertebrates, framed by the regions and localities that host exceptional assemblages of terrestrial vertebrate fossils, including the southern Pyrenees, Australia, and especially Mongolia. The Gobi region is thoroughly explored in this chapter, providing a tour of dinosaur and non-dinosaur life across the Cretaceous. This section also shows readers how conclusions are drawn about ancient ecology and stratigraphy, which is particularly valuable for students. The chapter then delves further back in time to the Late Jurassic Morrison Formation, showcasing the diverse vertebrate fauna, paleobotanical record, and invertebrate fossils. We then journey into the Middle Jurassic of Argentina: a smorgasbord of sauropods, but also home to all sorts of other vertebrates. Sauropod diversification here is used as an example of potential niche partitioning, which is especially interesting. Then the chapter addresses the Triassic of what is now Switzerland (specifically the Klettgau Formation), home to early dinosaurs including specimens preserved with gut contents. The chapter, overall, shows a bit about the research itself (how it is done, how decisions are made) and how exceptionally preserved paleofloras and paleofaunas can provide information about extinct ecology.

Chapter 9 takes a more narrowly circumscribed look at life in the Mesozoic, in a series of postcards depicting nature on the western side of the Tethys basin in Europe. The chapter emphasizes the terrestrial and aquatic faunas and their living environments, as reflected by body and trace fossils, as well as the lithology and sedimentology of the fossiliferous rock units, with occasional cameos by plants. With a couple of exceptions, the localities visited are "classics" of the Alps and Dolomites and descend in time from the Early Jurassic Calcari Grigi to the Triassic of Monte San Giorgio and other Alpine localities, of the Grès à *Voltzia* and the Dolomites, with a sneak peek into the Permian Sicilian marine faunas of the Sosio Limestone, which preceded the end-Permian mass extinction. The narrative seems a bit rushed, at places, where only brief floral or faunal lists are provided; these could have used a bit more detail and depth. Nevertheless, the ecosystem reconstructions are vibrant and one of the main messages conveyed concerns the connections between the Carnian Pluvial Episode and a surge in dinosaur diversification.

In Chapter 10, the end-Permian mass extinction is discussed in terms of timing and duration, as reflected by different proxies, magnitude of species loss in different environments and realms of life, possible causes, and patterns of recovery. The text contains a useful review of the different types of data that demonstrate the diachroneity of events and processes that comprise this biotic crisis, and of current discussions relative to these patterns. Some of the data involved in these discussions could have been added to the useful graphic summary provided at the end of this chapter. The terrestrial and marine realm get slightly un-

even treatment, with more detail provided on the terrestrial biota in terms of extinction, while the recovery section focuses more on the marine data. Primarily for pedagogical purposes, but also for easiness of reading, the few sections of this chapter could have been organized into subheadings.

Chapter 11 presents a brief history of ferns through the Phanerozoic, in postcards from eight European localities and one in China. These localities span the Middle Devonian to Holocene interval and host fern-dominated floras. The localities were selected because they preserve autochthonous or parautochthonous plant assemblages that reveal the living environments of the plants and their position in the respective communities and landscapes. "Ferns" are notoriously hard to define. The authors recognize this as a significant conundrum in pointing out that, as you look at increasingly older biotas, the main seemingly defining feature of ferns—leaves with characteristic morphology and sporangial positioning—vanishes into a Devonian blur of undifferentiated organography, as seen among the cladoxylopsids. Indeed, pteridophyte-grade euphyllophytes do not form a natural group. When all living and extinct representatives are considered, the plants referred to as ferns or monilophytes form a paraphyletic (if not polyphyletic) plexus whose members share only a set of reproductive biology traits, which bridge the gap between bryophytes and seed plants. This fern/monilophyte conundrum has been discussed most thoroughly in the recent literature, with special reference to the fossil record, by Rothwell and Stockey (2008), whose paper would be well worth referencing in future updates of this chapter. Along the same lines, if considering the entire Phanerozoic record of "ferns", one could argue that they demonstrate anything but the morphological stasis implied in the chapter title. Following trajectories parallel to those of the lycophytes and radiatopsids, seed-free moniliformopsid lineages started with simple body plans that lacked stem-leaf differentiation and evolved all the main features of plant complexity: leaves (which may have originated independently in several lineages), secondary growth, arborescence, and heterospory (also independently evolved in a few lineages). Some minor quirks of the chapter include the statement that in ferns most of the mineral uptake occurs through the surface of the plant (a reference would have been useful); and use of "isosporous" instead of the more widely circulated "homosporous", which is consistently used throughout the rest of the volume. Nevertheless, the pteridophyte-dominated landscapes depicted in the nine postcards are vivid and demonstrate the diversity and importance of these plants throughout the history of Earth's biomes. *In situ* and parautochthonous assemblages are clearly most appropriate for this type of vegetation reconstructions and many such assemblages that include ferns are scattered throughout the world and the Phanerozoic rock record. While an exhaustive review of all these assemblages falls far beyond the scope of a single volume chapter, a future update could include additional maps and diagrams summarizing the geographic and stratigraphic positions of more of these assemblages.

Chapters 12 and 13 offer a two-parted treatment of vegetation during the climatic oscillations of the Carboniferous (Mississippian and Pennsylvanian) and Permian. The two chapters, written by the same group of authors, cover plant taxonomic diversity, and floristics and vegetation, respectively, as they relate to the alternation of icehouse-hothouse conditions associated with the Late Paleozoic Ice Age (LPIA). The emphasis is on tropical forests and the non-analogous character of the vegetation, *i.e.*, the prevalent plant lineages that were different from those characteristic of this vegetation type in the modern biota—specifically, the dominance of seed-free plants and the fact that most of the groups that were prevalent at that time are now extinct. The few redundancies between the two chapters and between them and Chapter 11 may have been unavoidable given the organization of the book.

Structured differently from most other chapters, Chapter 12 is primarily a review of the main groups of plants that formed the Carboniferous–Permian tropical forests. Included are also brief discussions of the factors determining the climatic changes of the LPIA; of the global effects of these changes in terms of sea level oscillations, sequence stratigraphy and sedimentology; and of the effects of all these changes on vegetation types, especially tropical forests. These provide a useful foundation for understanding global-scale vegetation patterns. Chapter 13 returns to the typical format of the volume, with "postcards" from different localities around the world, but going up in time, from the Mississippian to the Permian. The central topic is the history of the tropical peat swamp forests, which are re-

ferred to as the coal farms of the Paleozoic. Particularly impressive are the reconstructions of forest structure at several of the localities visited, which provide detailed information on both the spatial distribution of plant diversity and forest stratification. These reconstructions rank among the most impressive bodies of data to demonstrate the impact that studies of fossil plants have in broadening our knowledge of nature during the past hundreds of million-years. Considering this, a box explaining in some detail the process by which such reconstructions of forest structure are produced would add value to an update of this chapter. For now, the chapter also includes a useful synopsis of Mississippian to Permian biome-level turnover in different parts of the globe, which paints a telling story of the scale of global changes that occur over geologic time.

Chapter 14, evocatively titled "Diving with Trilobites," explores Silurian and Devonian marine life. The best-preserved marine habitats of this period—continental shelf, reef, and lagoon environments—are explored in the context of early Paleozoic paleogeography and climate. The abiotic environmental information is helpful at the start of this chapter, particularly for readers that may lack a geology background, and the explanation of past continents sets the stage for each fossil locality. We especially appreciated the box on algal floras of the Silurian, an often-overlooked aspect of these early marine environments. The chapter is organized from shallow to deep settings, starting with a lagoon or tidal flat, then progressing into reefs, then the open continental shelf (which is further divided by animal phylum), and finally the pelagic zone (where phytoplankton, graptolites, and arthropods are also discussed). The closing section covers both minor and major extinction events, comparing and contrasting their effects on different groups of organisms. Interestingly, the authors of this chapter follow the line of Chapter 7—fishes are unaffected by most extinction events, but not without noting that the Hangenberg Event at the end of the Devonian is likely a "major exception" to that rule.

The last chapter, Chapter 15, goes "back to the beginnings", looking at the early stages of plant evolution, in the Silurian and Devonian. Many of the postcards come from North American localities, with a few stops in Europe. They depict the Late and Middle Devonian progymnosperm and cladoxylopsid forests, then transition to the plant communities of increasingly lower stature descending into the Early Devonian and the Silurian, all the way to diminutive bryophyte-grade and cryptospore-producing plants. This comprehensive review has many strengths and only misses one significant locality, that of the Posongchong flora of China. A postcard from this locality would have rounded up nicely the picture of Early Devonian landscapes. The section on the history of the classification of early polysporangiophytes and tracheophytes is helpful for understanding these plants that have no living morphological equivalent. The diagram summarizing phylogenetic relationships of the major groups is also useful, although some of the stratigraphic ranges depicted need to be revised (*e.g.*, for hornworts, mosses, sphenophytes). Another strength of the chapter is that descriptions of the different types of vegetation are accompanied by a welcome complement of evolutionary considerations, such as are not emphasized in some of the other chapters. However, the information presented is contradictory or confusing in a few places. Such is the case of *Cooksonia barrandei*, designated at one point as the earliest vascular plant, although it has not been shown to possess xylem and the genus as a whole has yet to be demonstrated as including exclusively *bona fide* tracheophytes (a fact that is acknowledged elsewhere in the chapter). In which case, *Cooksonia* is a polysporangiophyte, but not the oldest, as older reliable polysporangiophyte have been reported from the uppermost Ordovician of Poland, an occurrence that should be noted. In another instance, the term "polysporangiate" is confusingly explained as "plants in which more than one type of sporangia developed", although in that context it is meant to refer to plants that produce multiple sporangia per sporophyte (polysporangiophytes). Such minor shortcomings notwithstanding, the discussion insightfully addresses the evolution of roots and leaves, secondary (woody) growth, and conducting cells of the xylem. Future updates of the chapter could include more information on root and leaf evolution, given their impact on terrestrial landscapes. Likewise, inclusion of a few images will convey more effectively the arcane details of tracheid cell wall thickenings discussed in a text box; and recently developed data and hypotheses on the early (earlier than traditionally thought) advent of secondary growth will enrich evolutionary discussions. Finally, more could have been made, here or possibly in Chapter 12, of the Devonian rise of

seed plants, whose descendants currently dominate the vegetation of terrestrial biomes.

The volume ends abruptly at the final of Chapter 15, where we are left looking down into the chasm of even deeper time (Ordovician, Cambrian and beyond), from where a few story threads cast toward the end of this chapter, beckon. Clearly, in the editors' view, nature refers to the biosphere. Given the long (>3 billion-years) history of life on Earth and the at least one billion-year history of life on land, it would be fitting, given the scope of the volume, if an additional one-two chapters would provide even summary accounts of nature in pre-Silurian times.

Since we have reached here the point of general considerations and hoping that the editors and publisher will consider future updates of this volume, here are a few more suggestions for additions that we consider useful. First, and perhaps most important (also from a pedagogical standpoint), a final chapter could summarize all the information and understanding acquired after working through the entire book, to provide a synthetic upward outlook at nature through time and an overarching vision of the major changes in landscapes and biomes throughout the history of nature. Other helpful additions that come to mind include: a chapter reviewing global paleogeography throughout the Phanerozoic and its influences on the distribution of major climate and vegetation zones; a chapter summarizing modes of fossil preservation for plants and animals, the way they influence what we can know about those organisms, the way whole-plant reconstructions are pieced together and why they are important for understanding past plants and vegetation; and maybe a chapter on "amber forests" and the diversity of organisms preserved in amber, along with discussions of the stratigraphic record of amber and of when and how amber deposits form.

As stated explicitly in the preface, the editors wanted to "avoid a 'factory' approach to each chapter", so that the chapters don't "follow a single, constant, and predictable formula". Indeed, different chapters follow different organizational schemes. Nevertheless, the volume would benefit from more consistency, among the chapters, in the way the geographic positions of the localities or regions visited are illustrated, both on today's globe and in the paleogeographic configurations of their respective ages. Likewise, more consistent organization of the chapters around major unifying themes that are followed throughout the history of life would strengthen the sense of unity of the volume, as a whole.

In its depictions of nature through different geologic intervals, the volume has a strong paleoecological focus. The emphasis is primarily on floristics and paleobiogeography, and their relationship with climate. Less emphasis is placed on evolutionary topics, which are brought up mostly indirectly, or phylogeny, which is rarely discussed. This is understandable, given the very broad taxonomic and stratigraphic scope of the volume, and the editors are careful to explain from the beginning that the volume is not a complete guide to the natural systems and their transformation through time. However, given our evolutionary biologists bias, we think that a chapter reviewing in a "forward" (or upward) outlook through time the major evolutionary events in the history of life and the phylogenetic patterns that reflect them, would be a valuable addition to a future update of the volume, providing, in one place, the necessary evolutionary context for many of the discussions. For instance, the fossil record of several major plant lineages (*e.g.*, mosses, ferns, conifers) shows a sharp transition between the Triassic representatives, most of which cannot be assigned to extant families, and Cretaceous (and to some extent Jurassic) fossils, most of which can be placed in living families. This has further implications for the degree of certainty with which we can infer the ecology of the extinct plants of different ages.

Another pledge made at the beginning of the volume, in view of its pedagogic strategy, is to keep specialized details to a minimum and avoid technical language as much as possible. This is true for most chapters, but we also encountered parts of the text where we slogged through dry descriptions of the sedimentology of successive rock units at different localities. These technical details do not contribute much, in a direct way, in terms of useful information, especially since the inferential step that leads from sedimentology to interpretations of depositional environments is not explained. In such cases, descriptions limited only to the environments implied by sedimentology at those localities would have been informative enough and much more relatable to a broader audience.

The English of the volume is quirky at times, which can be endearing with funny turns of phrase in some places or

can introduce confusion in a few spots where it is hard to know exactly what the authors meant; some additional copy-editing would benefit a future edition. Another round of text editing would also eliminate the rare typos (*Astromylon*, spenophytes, fly ash instead of flysch) and incongruences (nematodes included among arthropods).

The above comments and suggestions notwithstanding, the editors and authors of "Nature through time" deserve recognition for embarking on such a daring project and succeeding at it. The volume holds much value, both as a reference and as a teaching resource, and has excellent potential for further development. In terms of value, it will be a very useful reference for anyone interested in, or working on, the Phanerozoic history of (mostly terrestrial and autotrophic) life, because of its dense coverage of the fossil record in both space and time, its up-to-date information, and the useful reference lists at the end of each chapter. The volume also fulfills its planned pedagogical function—given its content, it is easy to imagine a lower division college course in geology, botany, or biology based on it. Aside from the rich illustration—further enriched by the supplemental slide sets that accompany each chapter—and the text boxes that detail more arcane concepts, each chapter is complemented by review questions or lists of references "for deeper learning". The volume also includes a glossary of terms (which are marked with asterisks throughout the text), an extensive (46 pages) index of all the taxa that appear in the volume, cross-referenced for slides and text boxes, and a general index of terms. All these tools make "Nature through time" a valuable resource for teachers and a good model for similar publications. Future potential additions that would benefit the volume's pedagogical mission could include a box in each chapter that hierarchically names the taxonomic groups discussed in that chapter, so that readers unfamiliar with, for example, the orders or families of mammals, can understand who the chapter is talking about and how these groups fit into the broader scheme of animal systematics. Alternately, the taxonomic index at the end of the volume could serve this purpose, if it was cross-referenced with the chapters and, ideally, also provided online as a searchable Excel file.

From its current state as a solid foundational survey of the history of Phanerozoic life, the volume has tremendous potential to grow—along the lines we suggest above, and not only—and we hope that the publisher and editors will plan to release an updated and expanded edition, in due time. After all, the fossil record will keep revealing new species, which will require continued documentation and re-synthesis of the data to update our understanding of the history of life on Earth.

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