that "each new meaning of the gene created an additional dimension along which life could be imagined to vary and unfold" (p. 4).

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Origins

THE TANGLED TREE: A Radical New History of Life by David Quammen. New York: Simon & Schuster, 2018. 461 pages. Hardcover; $30.00. ISBN: 9781476776620.

Many ASA members have spent years and spilled metaphorical blood over this or that detail of the story of evolution and the origin of life, which we all agree is God's marvelous creation. Well, wouldn't it be good to have a book that highlights the debates not among onlookers to the field of biology, but among those actually working and publishing in the field? We now have such a book. *The Tangled Tree* covers humanity's place in the created order of cellular life forms, stretching from the premolecular days of Ernst Haeckel to modern times, when we can quite literally read the instruction book of any and every kind of cell. David Quammen's book is of interest to ASA members as it tackles one of the very biggest questions in biology: "What is the shape of the tree of life?" Such trees have been produced over the years, but the central character of this book, Carl Woese, claimed that he had discovered a more correct, truer tree than had been ever produced before, to the surprise of many in the field. Many believe that Woese deserved a Nobel Prize for his discovery, and yet, most people have never heard of him.

Quammen's skill comes in bringing together key players and voices in the topic at hand and extracting revealing and key quotes in his clear paragraphs and short chapters. We are permitted to go behind the scenes with Quammen as he recollects his own learning experience. The fact that Quammen trained as a writer and not in science helps him render these insights in ways that not only are comprehensible to nonscientists, but are also helpful to biologists (such as me) who have significant background knowledge.

I recall teaching on the relationship between bacteria, archaea, and our own types of nucleated cells, and referencing Carl Woese (pronounced "woes") and his colleague Norm Pace, who first identified the third branch of life now known as archaea, previously assumed to be bacteria based on appearance. It is no surprise within the life science field to be teaching material that was totally unknown during one's own training, and this book serves to highlight the pace of change. The 1970s seem like ancient history, and in a sense they are. However, it is still possible to interview primary players in the field, and so Quammen does a great service in stirring up these waters. As far back as I can remember, I have always emphasized to my students that the group that textbooks call "prokaryotes" is really not a "true" group, being made up of bacteria and archaea; that the archaea are in many key ways more closely related to humans than to bacteria. And so, using "prokaryote" is directly analogous to grouping butterflies, birds, and bats into a single group. Sure, it might at times be useful to have a group called "flyers," but that name tells nothing of their true relationships, which is what biologists and scientists should strive to ascertain. Further, it creates new problems. Where do penguins fit? What about flying squirrels? Another topic of great interest to my undergraduate students is the concept of endosymbiosis: mitochondria once existed free-living in the bacterial branch of life's tree; and at a time in the impossibly distant past they became symbiotically, irreversibly associated with another cell. As many biologists know, Lynn Margulis is credited with this big hypothesis, which was quite controversial at the time and was not readily accepted by the mainstream of scientists who favored other explanations.

So, what a pleasure it has been for me to peek behind the curtain and learn that it was not Lynn Margulis who originally had the idea of endosymbiosis, and to learn much more about the central character of the book, Carl Woese, who doggedly pursued the big questions of biology without getting lost in the minute details. Quammen spends the first third of the book setting the stage for Woese's entry by a concise retelling of the discovery of the gene by Watson and Crick, and of Crick's prescience in speculating that the sequences of long molecules (DNA, RNA, protein) might provide insights into ancestral relationships among living organisms. Yes, from the earliest days of obtaining sequence information, some forward-thinking scientists realized that the order of subunits within our long molecules, since they are inherited, provide a window on the past—a remarkable insight.

And so Quammen's book is actually a book about molecular phylogenetics. It is a book about a field which provides, many would argue, a truer picture of how living species are connected to each other, based on inherited sequence information. It relates the story of how Woese and colleagues selected one particular molecule to focus on, and based on that choice, produced what Woese argued was the true tree of life with three ascending branches: bacteria, archaea, eukarya. And yet, this is a scientific

hypothesis, the truth of which will be decided on the evidence. And the evidence is, in some respects, confusing.

There is no doubt that the big tree with three branches is what you get using the large ribosomal RNA (the long molecule Woese selected), but in fact each gene has its own history, and trees do not work with the microbial world very well (that is the confusing part). I do not want to give away too much in this review, but Quammen's discussion of gene sharing among organisms is remarkably well done. Along the way he explores the truly "Lamarckian" aspect of the CRISPR system of bacteria and archaea, wherein they purposefully store part of their environment within their genome as part of a highly advanced (not at all primitive) microbial immune system. The final third of the book focuses on this phenomenon of horizontal gene transfer (HGT). It is hard to deny that such processes have contributed a tremendous amount to the human nuclear genomes we adore so much. But does this diminish our humanness? What does it mean to be human? What is a species? These questions are addressed only from a biological perspective in this book, and while some Christian readers may find this a limitation, Quammen appropriately focuses on scientific questions, not theological ones. The final section of the book is "E. Pluribus Human," which readers should realize is speaking simply of our biological origins, not our spiritual natures as described by scripture.

It is noteworthy that Carl Woese apparently believed in the existence of a personal deity at some level, even kidding his long-time atheist assistant that she might be blessed by "the God you don't believe in." As a working biologist, I am continually amazed at the amount of antievolution material produced by the Christian community. I realize that, for many, the term "evolution" equates with atheism, and I have been asked if I am a "Darwinist" multiple times, whereupon a lengthy discussion usually ensues. But much like the term "prokaryote," we really ought to use more precise language to avoid misunderstanding. Can we start to call this natural process what it is: biological evolution? It is science, neither a worldview nor a philosophy. It is genetic change over time. It is complicated, and we can now read the information as never before. The fact that our very cells record a history of how God has used the atoms and molecules (whose very existence we believe he upholds) to accomplish his ultimate ends, somehow with an openness and freedom, is a truly breathtaking realization.

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Science and Religion

CHRIST AND THE CREATED ORDER, Vol. 2 of Perspectives from Theology, Philosophy, and Science by Andrew B. Torrance and Thomas H. McCall, eds. Grand Rapids, MI: Zondervan, 2018. 304 pages. Paperback; $36.99. ISBN: 9780310536086.

Christ and the Created Order is the second volume of "perspectives from theology, philosophy, and science." (The first volume was reviewed in the June 2019 issue of this journal.) As the title indicates, this collection of essays brings together distinctively Christian insights on the subjects of creation and science.

The selection was slightly more wide ranging than the first volume, and the quality and relevance of articles oscillated. Three or four seemed overspecialized and out of place for a broader interdisciplinary theological conversation, while others more directly addressed pertinent issues relating to Christology and the doctrine of creation.

Some of the narrow subtopics addressed, however, effectively enlighten readers to reconsider our understanding of "science," the "natural" world, and the nature of religion in general. For example, Murray Rae discusses one of Chopin's symphonies as a case study for the interpretation of real, meaningful phenomena, even though the "utility" of all the details that gave rise to the piece "cannot be proven" (p. 28). Various fields of knowledge, whether religion or otherwise, are providing an interpretation of a slice of our experience. We can debate meaning, but we cannot debate that there is more going on than we may be able to put to words. What we are "hearing" in the symphony of creation is *something* indeed.

> The sciences contribute their expertise to examine and explain how the world is ordered; poets and visual artists and musicians help us see in a different light the complex interdependence of things; economists, political theorists, and social scientists give insight into the working of human culture and society, while historians provide a further means of contemplating the realms of human action and discerning the consequences of what we do. All these disciplines and more contribute to our understanding of the world. (p. 28)

Part of the distinctively Christian view of the world is that God in Christ is behind it all. All the above disciplines "go about their business under the assumption, repeatedly confirmed by experience, that the world does have an order and a coherence that is intelligible, at least in part, even if its ultimate basis in Christ