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## DEEP MICROBES

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Gold, Thomas. 1999. **The deep hot biosphere**. Copernicus/Springer-Verlag, New York. 225 pp. \$27.00, ISBN: 0-387-98546-8 (alk. paper).

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Thomas Gold presents interesting and controversial theories concerning the origins of petroleum hydrocarbons and the abundance of deep-subsurface microbial life in his book, *The deep hot biosphere*. Essentially, the book expounds upon ideas that Gold originally presented in a *PNAS* paper in 1992 (*Proceedings of the National Academy of Sciences* **89**:6045–6049). Gold's book encompasses two general theses: 1) that the majority of Earth's hydrocarbons were entrapped during the coalescence of pre-planetary materials (not the metamorphic remains of past biomass), and 2) that these hydrocarbons provide the food source for a vast underground biosphere consisting of hyperthermophilic, hyperbarophilic microorganisms.

The first two chapters of the book provide an overview of the mainstream dogma of primordial evolution and the origin of subterranean microorganisms, which holds that subsurface life evolved after surface-based life. According to Gold (and others), life evolved not in surface oceans or ponds, but deep within the Earth's crust where it was protected from harsh ultraviolet radiation. Gold also argues that the deep subsurface provided food in the form of hydrocarbons for the first evolving cells. In the next several chapters, Gold presents and defends his theory that the world's petroleum resources come from relic, pre-planetary sources.

The prevailing theory of petroleum production states that "fossil fuels" are the result of the actions of extreme heat and pressure on buried biomass. Presumably, the biomass originated as plant and animal matter from millions of years ago that was buried in the sediments of lakes and oceans. Thus, petroleum reserves should be found in sedimentary formations. Gold cites numerous examples where petroleum deposits are found not in sedimentary formations, but in deep igneous formations, where according to mainstream Western thought, petroleum should not have formed. Gold reminds the reader that hydrocarbons abound in the solar system—the giant gas planets have enormous stores of methane and other light hydrocarbons, and many satellites of the outer planets appear to contain hydrocarbon ices. These hydrocarbons would have been dispersed throughout the cloud of debris that eventually accreted to form the solar system. If the outer planets kept their primordial hydrocarbons, might Earth have kept its hydrocarbons also? Gold thinks that it did, and that primordial hydrocarbons are largely responsible for present-day petroleum reserves. Gold also puts forth the idea that many, if not most, of the microorganisms found in petroleum samples are not contaminants, but natives of the subsurface. Gold notes that while his theory has been met with considerable skepticism in the Western Hemisphere, Eastern scientists have considered similar ideas for quite some time. During his research for the book, Gold found that he was not

the first to propose the idea of a deep, hot biosphere. Russian (or ex-Soviet) scientists have pursued the idea for about one hundred years.

In later chapters, Gold suggests that movement of primordial hydrocarbons also may be responsible for earthquakes that occur away from fault lines, and that release of methane and other light hydrocarbons is a prelude to an earthquake. He cites mainly anecdotal historical evidence to support his hypothesis. He also recommends systematic monitoring of hydrocarbon outgassing as a means to predict earthquakes. Finally, in the last two chapters, Gold discusses how his "deep-earth gas theory" relates to the evolution of life on Earth and on Mars. If Earth retained primordial hydrocarbons and supports a deep-subterranean biosphere, might Mars have a similar subsurface biosphere? Gold presents a fairly detailed discussion of how subsurface life might have evolved on Mars. He also briefly states that the same could be true of other planets and planetary satellites.

On the whole, I found Gold's ideas very interesting. I admit that I am skeptical about Gold's deep-earth gas theory of petroleum origin, but I think that I am also a product of the mainstream Western dogma. He argues his points well and supports them with research published in well-respected journals (*Science*, *Nature*, *PNAS*, etc.). It is certainly reasonable to expect that if "chunks" of hydrocarbons were floating around in space with the rest of the pre-planetary debris, Earth may have a considerable store of subsurface hydrocarbons. Regardless of the source of hydrocarbons, the notion of extremophilic subsurface microorganisms is generally well accepted. The question then is whether subsurface microorganisms are a rare curiosity, or as Gold indicates, a part of a large and thriving biome. Only additional research will answer that question. The question of life on Mars and other planetary bodies is also still very much open to question. Although his discussion of possible Martian life was adequate, I would have liked to see more discussion about how his hypotheses relate to subsurface life on other planets.

While I found the intellectual content of *The deep hot biosphere* to be most satisfying, the book itself could use better editing. Gold's style of writing seemed to oscillate between that of a popular science book and a technical monograph. Thus, the educated lay person may have difficulty following some parts of the book while the scientist may yearn for more detail. I found this imbalance to be especially true of Gold's explanations of anaerobic metabolism and alternate electron acceptors in the subsurface environment. One glaring mistake that caught my attention was where Gold stated that methane was an atom. I'm certain that this was simply a slip of the keyboard, so to speak, but a knowledgeable editor should have caught it. Also, much of the book was highly repetitive. Although I can understand Gold's use of repetition to reinforce some of his more controversial points, it was overdone and I found it distracting.

Even though I didn't like the style and editing, I believe that *The deep hot biosphere* is a potentially important book.

I recommend it to anyone who is interested in planetary science, petroleum geology, microbiology, early evolution, or astrobiology—if for no other reason than because it prods us into examining the shortcomings of current theories of the origins of both petroleum and life.

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#### WETLAND RESTORATION: STILL MORE CHANCE THAN SCIENCE?

Middleton, Beth. 1999. **Wetland restoration, flood pulsing, and disturbance dynamics.** Wiley and Sons, New York. xi + 388 p. \$64.95, ISBN: 0-471-29263-X (alk. paper).

Restoration ecologists have long argued that restoration efforts represent the penultimate test of our ecological understanding. Because comprehensive understanding of an ecosystem, particularly one that has been substantially altered, is often lacking, restorationists often acknowledge, albeit sometimes reluctantly, an element of luck (and art) in their efforts. When tens of thousands of wetlands world-wide are in need of restoration and massive monetary expenditures are at stake, one would certainly hope that wetland restoration efforts are more likely to succeed because of their greater dependence on good science than on a roll of the dice (or artistic merit).

Despite the recent proliferation of relevant scientific articles, most of the texts dealing with wetland restoration that have heretofore been available vary considerably in quality. Books range from overly simplistic cookbook “engineered” approaches (at worst) to more ecologically based approaches that are, nevertheless, disconnected from modern ecological theory and real-world practice (at best). In *Wetland restoration, flood pulsing, and disturbance dynamics*, Beth Middleton takes considerable strides in redressing these shortcomings.

As one might infer from the title, a principal objective of the book is to build a case for incorporating flood pulsing and disturbance dynamics into the planning and execution of wetland restoration projects. Given this goal, the book is a remarkable success and a pleasure to read. Part I, which also equates to Chapter 1, initially introduces the suite of disturbances that can affect wetland dynamics. Flood pulsing and relevant theory account for almost half the discussion, but other important physical (fire, wind), biotic (beaver, cattle), and anthropogenic disturbances are discussed to varying degrees. Part II contains two chapters that cover a smorgasbord of topics. Chapter 2, entitled “Restoration theory,” reviews self-design versus design, succession, and invasion theories as they relate to restoration. The chapter concludes with a section on river theory that includes discussion of the flood pulse concept and the intermediate disturbance hypothesis, material that seems better suited for the preceding chapter. Chapter 3 presents a comprehensive and invaluable overview of plant life history requirements and their relevance to res-

toration and disturbance. In addition, numerous well-researched tables relate survivorship of herbaceous species and tree seedlings and saplings to water depth (i.e., flood tolerance).

Not until (the final) Part III do we actually encounter three chapters that focus entirely on wetland restoration. Chapter 4 covers “traditional” restoration topics such as site selection, passive and active restoration, engineering options, and rewatering wetlands. Chapter 5 documents revegetation alternatives and discusses site preparation and direct seeding, seed banks, reincorporating fire, and controlling exotics and animals. The final chapter ostensibly presents four case histories of wetland restoration. The first example deals with the restoration of the Kissimmee River in Florida, a very high visibility and important restoration project in the United States where we have already learned a great deal from initial efforts to restore wetland structure and function. The second example describes efforts to restore or create wetland habitats in an area that was significantly altered in response to the construction of the Panshet Dam near Pune, India. The relevance of the last two case histories, one which details the need for restoration in the Murray-Darling River in Australia and a second which primarily documents water quality problems in Germany’s Rhine River, is less apparent. Some case histories of restoring small, isolated wetlands or streamside habitat would likely have provided a broader perspective to this chapter and better exemplified the material presented in earlier chapters.

By emphasizing the importance of flood pulsing and disturbance dynamics, Middleton injects a healthy dose of much-needed realism into wetland restoration. Inarguably, this book advances the scientific basis for successful restoration planning and implementation. However, there are some important omissions. Most notably, the book’s excellent treatment of, but almost singular focus on, revegetation (i.e., wetland structure) is done at the expense of wetland functional considerations (e.g., nutrient cycling, decomposition) and other biota (e.g., birds, fish, invertebrates). In addition, I expected to see more detailed discussion of strategies for monitoring and evaluating the success of wetland restoration projects. Such evaluation is critical for further enhancing the science of wetland restoration.

Overall, this book was extremely well organized, with early chapters focusing on disturbance- and restoration-related concepts and theory, middle chapters on implementation, and a final chapter on case histories. I particularly liked this logical