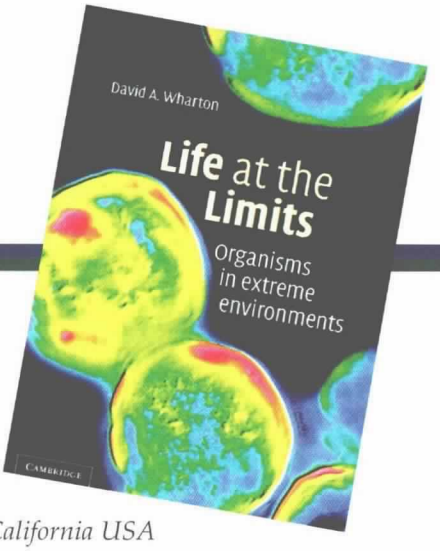
Book Reviews



Life at the Limits: Organisms in Extreme Environments

by David A. Wharton
Cambridge University Press, 320 pages, ISBN 0521782120

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Wharton is a zoologist who began his career with studies of parasitic nematodes. The free-living stages of parasitic nematodes possess "extraordinary abilities" (p. ix) to tolerate freezing, desiccation and other treatments usually lethal for most organisms. These properties of parasitic nematodes and Wharton's field trips to Antarctica are the sources of his interests in extreme environments and, presumably, of the inspiration for his book of eight chapters. His discussions of the adaptations of organisms to desiccation and to low temperatures are, as we might expect, among the highlights of the book and give more detail than the discussions of adaptations to other extreme environments. In the Preface Wharton states "the book is written to be understandable by a non-expert...with little background in biology or science." I review this book with Wharton's goal in mind.

The significance of Wharton's purpose of communicating with non-experts became evident even at the beginning of modern science when Galileo wrote (de Santillana, 1955, p. 2) to a friend:

> *"I have many and most admirable plans and devices; but they could only be put to work by princes, because it is they who are able to carry on war, build and defend fortresses, and for their regal sport make most splendid expenditure, and not I or any private gentleman."*

The "most splendid expenditure" for basic science is possible today primarily through the collection of taxes by governments. Taxpaying citizens are the modern day equivalent of princes and have, in my experience, an unbridled curiosity about scientific discovery and new developments in science. Scientists such as T. H. Huxley, John Tyndall, Michael Faraday, Jared Diamond, Carl Sagan, Stephen Jay Gould, among others, have written essays and books to convey, in general terms, the excitement and meaning of scientific discoveries that otherwise would be shared by only a few. This task is not easy and perhaps requires a special and uncommon talent. Communicating science to taxpayers, as Wharton does, is crucial to earn their continued support for our scientific endeavors.

He begins his tale of extreme organisms, as he calls them, with an overview chapter entitled "Introduction: extreme life". Therein he briefly discusses the physical, chemical, and biological interactions that form boundaries defining what he calls the "life box". Wharton uses the visually expressive idea of a "life box" to define two classes of extreme organism. The first class consists of organisms able to function at conditions that are harmful to most organisms in the biosphere. This is the type of extremophile that perhaps most of us imagine and is found at limiting conditions of, for example, high temperature, high salt concentration, high pressure, low temperature, and high radiation background. A second type of organism is not quite so obviously an extremophile. It functions under "life box" conditions where most organisms live. But, when confronted with extreme conditions, it displays special survival tactics. The most remarkable of these tactics is the creation of resting or dormant states from which the organism emerges when "life box" conditions are again available. The inclusion of dormant states of organisms as examples of extreme life is appropriate and one of the highlights of the book. Wharton gives several examples of bacterial dormancy in the first chapter. After noting reports of bacterial dormancy for periods of 30 to 250 million years, he cautiously states "if the evidence for these sorts of claims holds up, then there is no reason not to believe that bacterial spores can be immortal." I applaud Wharton for qualifying the conclusion because the fascinating work suggesting bacterial survival for millions of years is, indeed, controversial.

The longest chapter of the book is entitled "Be it ever so humble...". It is both a survey of extreme

environments and a selection of examples of the adaptations enabling life in these environments. Among the extreme environments in the survey are deserts, polar regions, deep-sea habitats, and subterranean places. Wharton provides nice descriptions of several fascinating adaptations. My favorite is that of the African lungfish, which burrows into the riverbed of a drying river, forms a cocoon, and awaits the return of water.

A book of broad scope like Wharton's cannot attribute all of the discoveries to particular individuals because it would become overburdened with citations of little interest to his intended lay audience. If, however, attribution is specific and inaccurate, then some might claim an injustice is done. On page 84, Wharton erroneously attributes the first use of DNA probes to identify microorganisms in natural settings to the Subsurface Science Program (SSP) (a very successful and influential program) of the U.S. Department of Energy. I did not read the book with the purpose of finding errors such as this one and do not feel that this type of error detracts from the book's appeal to a lay audience.

The next three chapters cover how organisms respond to desiccation or dehydration, to living in very hot places, and to an existence in very cold environments, respectively. Wharton has a writing style that is comfortable, casual, and informative. I particularly enjoyed Chapter 3, "Life without water", and Chapter 5, "Cold Lazarus". In Chapter 3 Wharton reviews the remarkable property of some organisms to suffer nearly complete removal of water and then regain normal function after the re-introduction of water. Readers of this review will have to go to Wharton's book to find out exactly why Chapter 5 on life in cold places is entitled "Cold Lazarus". He introduces the subject of adaptation to low temperatures with a short summary of the cryopreservation movement which was recently in the news because of a family dispute over whether or not to preserve by freezing the body of a deceased famous relative. Wharton's presentation here and elsewhere in the book shows a knack of relating the science of adaptation to extreme environments to everyday experience.

The twenty-one pages of chapter six offer a brief survey of adaptations to the deep-sea, hypersaline conditions, high and low pH environments, and high ultraviolet light intensities. The coverage of adaptations to the deep sea is of uneven quality and too brief to do justice to the stunning adaptations of many of its inhabitants.

In the last chapter, Wharton states that "such a wide variety of organisms have solved the problems of living in the deep sea that we cannot now consider it to be extreme." If we were to adopt such a criterion for the polar regions of Earth, we would trivialize the astounding adaptations of organisms such as the polar bear, walrus and ice fish. Thus, I fault his claim that the deep sea is not an extreme environment on several grounds, the chief of which is that the deep sea is not a single environment if only from the standpoint of the pressure gradient. The deep trenches of the oceans are, quite distinctly and demonstrably, extreme environments because of the high pressure in them. Hydrothermal vents are empowered as extreme habitats not only by the high temperature but also by the pressure of the deep sea that prevents water from boiling and moderates other high temperature induced changes in water properties and in molecular properties of organisms. Deep-sea hyper saline basins and cold seeps rival any other environment on Earth as extreme habitats. Adaptations to buoyant forces are possibly as remarkable for deep-sea organisms as flight is for birds, bats and insects. I think Wharton has inadvertently departed from his "life box" imagery in arriving to the view that the deep-sea is not an extreme environment. Quite possibly, we are erring in trying to classify organisms as extremophiles. After all, many of the examples, such as the desert camel, in Wharton's book are those studied by comparative physiologists and biochemists over much of the 20th century. These classic comparative approaches along with the newer comparative molecular biology and genomics are today all seeking the mechanisms by which organisms evolve to manage their remarkable tricks of endurance and survival.

In summary, Wharton shares with both non-scientists and scientists working in other disciplines his view of and excitement for research on life in extreme conditions. His writing style is distinctly non-formal and at times quite engaging. Although Wharton's fields of study are cryptobiosis and polar biology, his coverage of topics goes well beyond his specialties. A specialist in any of the several fields he covers may be disappointed when reading this book because the coverage of the various subjects is not complete. Wharton, however, did not intend to offer either a comprehensive coverage or a research bibliography of the various specialties and should not suffer criticism for giving a short bibliography. As a specialist in one aspect of life in extreme environments, I must say that I truly enjoyed this book showing the multitude of ways in which organisms make possible a life that is otherwise tough.

Reference

de Santillana, G., 1955: *The Crime of Galileo*. University of Chicago Press, Chicago.