

Praise for Thomas Gold. . .

“Gold is one of America’s most iconoclastic scientists.”

—Stephen Jay Gould

“Thomas Gold is one of the world’s most original minds.”

—*The Times*, London

“Thomas Gold might have grown tired of tilting at windmills long ago had he not destroyed so many.”

—*USA Today*

“What if someone told you that [the oil crisis] was all wrong and that the hydrocarbons that make up petroleum are constantly refilling reservoirs. Interested? Well, you should read this book. . . . Gold presents his evidence skillfully. You may not agree with him, but you have to appreciate his fresh and comprehensive approach to these major areas of Earth science. . . . [This book] demonstrates that scientific debate is alive and well. Science is hypothesis-led and thrives on controversy—and few people are more controversial than Thomas Gold.”

—*Nature*

“. . . Thomas Gold, a respected astronomer and professor emeritus at Cornell University in Ithaca, N.Y., has held for years that oil is actually a renewable, primordial syrup continually manufactured by the Earth under ultrahot conditions and pressures.”

—*The Wall Street Journal*

“Most scientists think the oil we drill for comes from decomposed prehistoric plants. Gold believes it has been there since the Earth’s formation, that it supports its own ecosystem far underground and that life there preceded life on the Earth’s surface. . . . If Gold is right, the planet’s oil reserves are far larger than policymakers expect, and earthquake prediction procedures require a shakeup; moreover, astronomers hoping for extraterrestrial contacts might want to stop seeking life *on* other planets and inquire about life *in* them.”

—*Publishers Weekly*

“Gold’s theories are always original, always important, and usually right. It is my belief, based on fifty years of observation of Gold as a friend and colleague, that *The Deep Hot Biosphere* is all of the above: original, important, controversial, and right.”

—Freeman Dyson

“Whatever the status of the upwelling gas theory, many of Gold’s ideas deserve to be taken seriously. . . . The existence of [a deep hot biosphere] could prove to be one of the monumental discoveries of our age. This book serves to set the record straight.”

—*Physics World*

“My knowledge and experience of natural gas, gained from drilling and operating many of the world’s deepest and highest pressure natural gas wells, lends more credence to your ideas than the conventional theories of the biological/thermogenic origin of natural gas. Your theory explains best what we actually encountered in deep drilling operations.”

—Robert A. Hefner III, The GHK Companies, Oklahoma City, Oklahoma;
From a letter to the author

“Within the scientific community, Gold has a reputation as a brilliantly clever renegade, having put forward radical theories in fields ranging from cosmology to physiology.”

—*The Sunday Telegraph*, London

“In *The Deep Hot Biosphere*, [Gold] reveals evidence supporting a subterranean biosphere and speculates on how energy may be produced in a region void of photosynthesis. He speculates on the ramifications his concepts could have in predicting earthquakes, deciphering Earth’s origins, and finding extraterrestrial life.”

—*Science News*

“Gold’s theory, as explained in *The Deep Hot Biosphere*, offers new and radical ideas to our incomplete notions of what causes earthquakes and where we would look for life in outer space: not on planets, but in them.”

—*Ithaca Times*

“[*The Deep Hot Biosphere*] now seems to be supported by a growing body of evidence.”

—*Journal of Petroleum Technology*

“Gold knows experts are pooh-pooing his belief. It happens to Gold consistently. He has developed a reputation as someone who takes on a long-held assumption, advances a new idea and gets rewarded when time—a decade or two—proves him right.”

—*The Juneau Empire*

“Thomas Gold has questioned the very foundations of the entrenched conventional models. . . . [*The Deep Hot Biosphere*] is evidently one of the most controversial of all books published in recent history. It is bound to cause much debate, and, if found correct, is likely to revolutionize the face of science.”

—*Current Science*

“[Thomas Gold] is one of the few who, despite the attacks of mediocrities, is courageous enough to think in a scientifically unconventional way. . . . [His] courage and original ideas are rays of hope on the horizon of science.”

—Prof. Dr. Alfred Barth, The European Academy of Sciences and Arts, Paris

The Deep Hot Biosphere

The Myth of Fossil Fuels

Thomas Gold

With a Foreword by Freeman Dyson



SPRINGER-SCIENCE+BUSINESS MEDIA, LLC

First softcover printing, 2001

© 1999 Springer Science+Business Media New York

Originally published by Springer-Verlag New York, Inc. in 1999

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of the publisher.

Library of Congress Cataloging-in-Publication Data
Gold, Thomas.

The deep hot biosphere: the myth of fossil fuels / Thomas Gold ; foreword
by Freeman Dyson.

p. cm.

Includes bibliographical references and index.

ISBN 978-0-387-95253-6 ISBN 978-1-4612-1400-7 (eBook)

DOI 10.1007/978-1-4612-1400-7

1. Deep-earth gas theory. 2. Petroleum—Geology.

3. Hydrocarbons. 4. Life—Origin. 5. Extreme environment
microbiology. I. Title.

TN870.5.G66 1998

576.8'3—dc21

98-42598

Printed on acid-free paper.

9 8 7 6 5 4 3 2 1

ISBN 978-0-387-95253-6 SPIN 10795990

Foreword

by Freeman Dyson

The first time I met Tommy Gold was in 1946, when I served as a guinea pig in an experiment that he was doing on the capabilities of the human ear. Humans have a remarkable ability to discriminate the pitch of musical sounds. We can easily tell the difference when the frequency of a pure tone wobbles by as little as 1 percent. How do we do it? This was the question that Gold was determined to answer. There were two possible answers. Either the inner ear contains a set of finely tuned resonators that vibrate in response to incident sounds, or the ear does not resonate but merely translates the incident sounds directly into neural signals that are then analyzed into pure tones by some unknown neural process inside our brains. In 1946, experts in the anatomy and physiology of the ear believed that the second answer must be correct: that the discrimination of pitch happens in our brains, not in our ears. They rejected the first answer because they knew that the inner ear is a small cavity filled with flabby flesh and water. They could not imagine the flabby little membranes in the ear resonating like the strings of a harp or a piano.

Gold designed his experiment to prove the experts wrong. The experiment was simple, elegant, and original. During World War II he had been working for the Royal Navy on radio communications and radar. He built his apparatus out of war surplus Navy electronics and headphones. He fed into the headphones a signal consisting of short

pulses of a pure tone, separated by intervals of silence. The silent intervals were at least ten times longer than the period of the pure tone. The pulses were all the same shape, but they had phases that could be reversed independently. To reverse the phase of a pulse means to reverse the movement of the speaker in the headphone. The speaker in a reversed pulse is pushing the air outward when the speaker in an unreversed pulse is pulling the air inward. Sometimes Gold gave all the pulses the same phase, and sometimes he alternated the phases so that the even pulses had one phase and the odd pulses had the opposite phase. All I had to do was sit with the headphones on my ears and listen while Gold fed in signals with either constant or alternating phases. Then I had to tell him, from the sound, whether the phase was constant or alternating.

When the silent interval between pulses was ten times the period of the pure tone, it was easy to tell the difference. I heard a noise like a mosquito, a hum and a buzz sounding together, and the quality of the hum changed noticeably when the phases were changed from constant to alternating. We repeated the trials with longer silent intervals. I could still detect the difference, even when the silent interval was as long as thirty periods. I was not the only guinea pig. Several other friends of Gold listened to the signals and reported similar results. The experiment showed that the human ear can remember the phase of a signal, after the signal stops, for thirty times the period of the signal. To be able to remember phase, the ear must contain finely tuned resonators that continue to vibrate during the intervals of silence. The result of the experiment proved that pitch discrimination is done mainly in the ear, not in the brain.

Besides having experimental proof that the ear can resonate, Gold also had a theory to explain how a finely tuned resonator can be built out of flabby and dissipative materials. His theory was that the inner ear contains an electrical feedback system. The mechanical resonators are coupled to electrically powered sensors and drivers, so that the combined electromechanical system works like a finely tuned amplifier. The positive feedback provided by the electrical components counteracts the damping produced by the flabbiness of the mechanical

components. Gold's experience as an electrical engineer made this theory seem plausible to him, although he could not identify the anatomical structures in the ear that functioned as sensors and drivers. In 1948 he published two papers, one reporting the results of the experiment and the other describing the theory.

Having myself participated in the experiment and having listened to Gold explaining the theory, I never had any doubt that he was right. But the professional auditory physiologists were equally sure that he was wrong. They found the theory implausible and the experiment unconvincing. They regarded Gold as an ignorant outsider intruding into a field where he had no training and no credentials. For years his work on hearing was ignored, and he moved on to other things.

Thirty years later, a new generation of auditory physiologists began to explore the ear with far more sophisticated tools. They discovered that everything Gold had said in 1948 was true. The electrical sensors and drivers in the inner ear were identified. They are two different kinds of hair cells, and they function in the way Gold said they should. The community of physiologists finally recognized the importance of his work, forty years after it was published.

Gold's study of the mechanism of hearing is typical of the way he has worked throughout his life. About once every five years, he invades a new field of research and proposes an outrageous theory that arouses intense opposition from the professional experts in the field. He then works very hard to prove the experts wrong. He does not always succeed. Sometimes it turns out that the experts are right and he is wrong. He is not afraid of being wrong. He was famously wrong (or so it is widely believed) when he promoted the theory of a steady-state universe in which matter is continuously created to keep the density constant as the universe expands. He may have been wrong when he cautioned that the moon may present a dangerous surface, being covered by a fine, loose dust. It proved indeed to be so covered, but fortunately no hazards were encountered by the astronauts. When he is proved wrong, he concedes with good humor. Science is no fun, he says, if you are never wrong. His wrong ideas are insignificant compared with his far more important right ideas. Among his important right ideas was

the theory that pulsars, the regularly pulsing celestial radio-sources discovered by radio-astronomers in 1967, are rotating neutron stars. Unlike most of his right ideas, his theory of pulsars was accepted almost immediately by the experts.

Another of Gold's right ideas was rejected by the experts even longer than his theory of hearing. This was his theory of the 90-degree flip of the axis of rotation of the earth. In 1955, he published a revolutionary paper entitled "Instability of the Earth's Axis of Rotation." He proposed that the earth's axis might occasionally flip over through an angle of 90 degrees within a time on the order of a million years, so that the old north and south poles would move to the equator, and two points of the old equator would move to the poles. The flip would be triggered by movements of mass that would cause the old axis of rotation to become unstable and the new axis of rotation to become stable. For example, a large accumulation of ice at the old north and south poles might cause such an exchange of stability. Gold's paper was ignored by the experts for forty years. The experts at that time were focusing their attention narrowly on the phenomenon of continental drift and the theory of plate tectonics. Gold's theory had nothing to do with continental drift or plate tectonics, so it was of no interest to them. The flip predicted by Gold would occur much more rapidly than continental drift, and it would not change the positions of continents relative to one another. The flip would change the positions of continents only relative to the axis of rotation.

In 1997, Joseph Kirschvink, an expert on rock magnetism at the California Institute of Technology, published a paper presenting evidence that a 90-degree flip of the rotation axis actually occurred during a geologically short time in the early Cambrian era. This discovery is of great importance for the history of life, because the time of the flip appears to coincide with the time of the "Cambrian Explosion," the brief period when all the major varieties of higher organisms suddenly appear in the fossil record. It is possible that the flip of the rotation axis caused profound environmental changes in the oceans and triggered the rapid evolution of new life forms. Kirschvink gives Gold credit for suggesting the theory that makes sense of his observations. If the theory

had not been ignored for forty years, the evidence that confirms it might have been collected sooner.

Gold's most controversial idea is the non-biological origin of natural gas and oil. He maintains that natural gas and oil come from reservoirs deep in the earth and are relics of the material out of which the earth condensed. The biological molecules found in oil show that the oil is contaminated by living creatures, not that the oil was produced by living creatures. This theory, like his theories of hearing and of polar flip, contradicts the entrenched dogma of the experts. Once again, Gold is regarded as an intruder ignorant of the field he is invading. In fact, Gold *is* an intruder, but he is not ignorant. He knows the details of the geology and chemistry of natural gas and oil. His arguments supporting his theory are based on a wealth of factual information. Perhaps it will once again take us forty years to decide whether the theory is right. Whether the theory of non-biological origin is ultimately found to be right or wrong, collecting evidence to test it will add greatly to our knowledge of the earth and its history.

Finally, the most recent of Gold's revolutionary proposals, the theory of the deep hot biosphere, is the subject of this book. The theory says that the entire crust of the earth, down to a depth of several miles, is populated with living creatures. The creatures that we see living on the surface are only a small part of the biosphere. The greater and more ancient part of the biosphere is deep and hot. The theory is supported by a considerable mass of evidence. I do not need to summarize this evidence here, because it is clearly presented in the pages that follow. I prefer to let Gold speak for himself. The purpose of my remarks is only to explain how the theory of the deep hot biosphere fits into the general pattern of Gold's life and work.

Gold's theories are always original, always important, usually controversial—and usually right. It is my belief, based on fifty years of observation of Gold as a friend and colleague, that the deep hot biosphere is all of the above: original, important, controversial—and right.

Preface

In June 1997 I was asked by NASA to give the annual lecture at the Goddard Space Flight Center in Maryland. My contribution to the deep hot biosphere theory and its implications for extraterrestrial life had won me the invitation. I was flattered, of course, but at the same time chagrined by the topic I was asked to address: life in extreme environments. I had little interest in talking about the surface biosphere on earth, and yet, if I were to take the topic literally, this is precisely what I was being asked to do. The life in extreme environments is our own surface life.

If there is one idea that I hope you will retain long after you finish reading this book, it is this: It is we who live in the extreme environments. And if there is one desire I hope to stimulate in you, it is a curiosity to learn more about the first and most truly *terrestrial* beings—all of whom live far beneath our feet, in what I have come to call the deep hot biosphere.

Alas, I can only begin to satisfy this curiosity here, for at this moment in our biological and cosmic understanding, there are still more questions than answers. But that is exactly what makes investigating the deep hot biosphere so exciting.

Thomas Gold
Ithaca, New York
December 1998

Contents

	Foreword	v
	<i>Freeman Dyson</i>	
	Preface	xi
Chapter 1	Our Garden of Eden	1
	The Narrow Window for Surface Life	2
	Chemical Energy for Subsurface Life	4
	A Preview of This Book	7
Chapter 2	Life at the Borders	11
	Energy Deep in the Earth	13
	The Ecology of Deep-Ocean Vent Life	19
	Other Borderland Ecologies	23
	Deep Is Desirable	27
	Beneath the Borderlands	30
Chapter 3	The Deep-Earth Gas Theory	37
	The Origin of Petroleum: Two Conflicting Theories	38
	Five Assumptions Underlying the Deep-Earth Gas Theory	43
Chapter 4	Evidence for Deep-Earth Gas	57
	Petroleum Reservoirs That Refill	59
	Clues in the Carbonate Record	61
	The Association of Helium with Hydrocarbons	72

Chapter 5	Resolving the Petroleum Paradox	79
	The Deep Hot Biosphere Solution	80
	Biological Molecules in Non-Biological Petroleum	82
	The Upwelling Theory of Coal Formation	86
	Evidence for the Upwelling Theory	94
	An Exemption for Peat	100
Chapter 6	The Siljan Experiment	105
	Drilling in Swedish Granite	107
	Magnetite and Microbial Geology	114
Chapter 7	Extending the Theory	125
	The Origin of Diamonds	127
	A New Explanation for Concentrated Metal Deposits	131
Chapter 8	Rethinking Earthquakes	141
	Mud Volcanoes	142
	A Challenge to Earthquake Theory	143
	Eyewitness Accounts	145
	Earthquake Spots and Earth Mounds	156
	Upwelling Deep Gas as the Cause of Earthquakes	159
Chapter 9	The Origin of Life	165
	The Habitability of Surface and Subsurface Realms	166
	The Enhanced Probability for Life's Origin	170
	Darwin's Dilemma	176
Chapter 10	What Next?	185
	Microbial Investigations	188
	Prospects for Extraterrestrial Surface Life	193
	Deepening the Search for Extraterrestrial Life	201
	Independent Beginnings or Panspermia?	205
	Afterword to the Paperback Edition	209
	Notes	217
	Acknowledgments	235
	Index	237