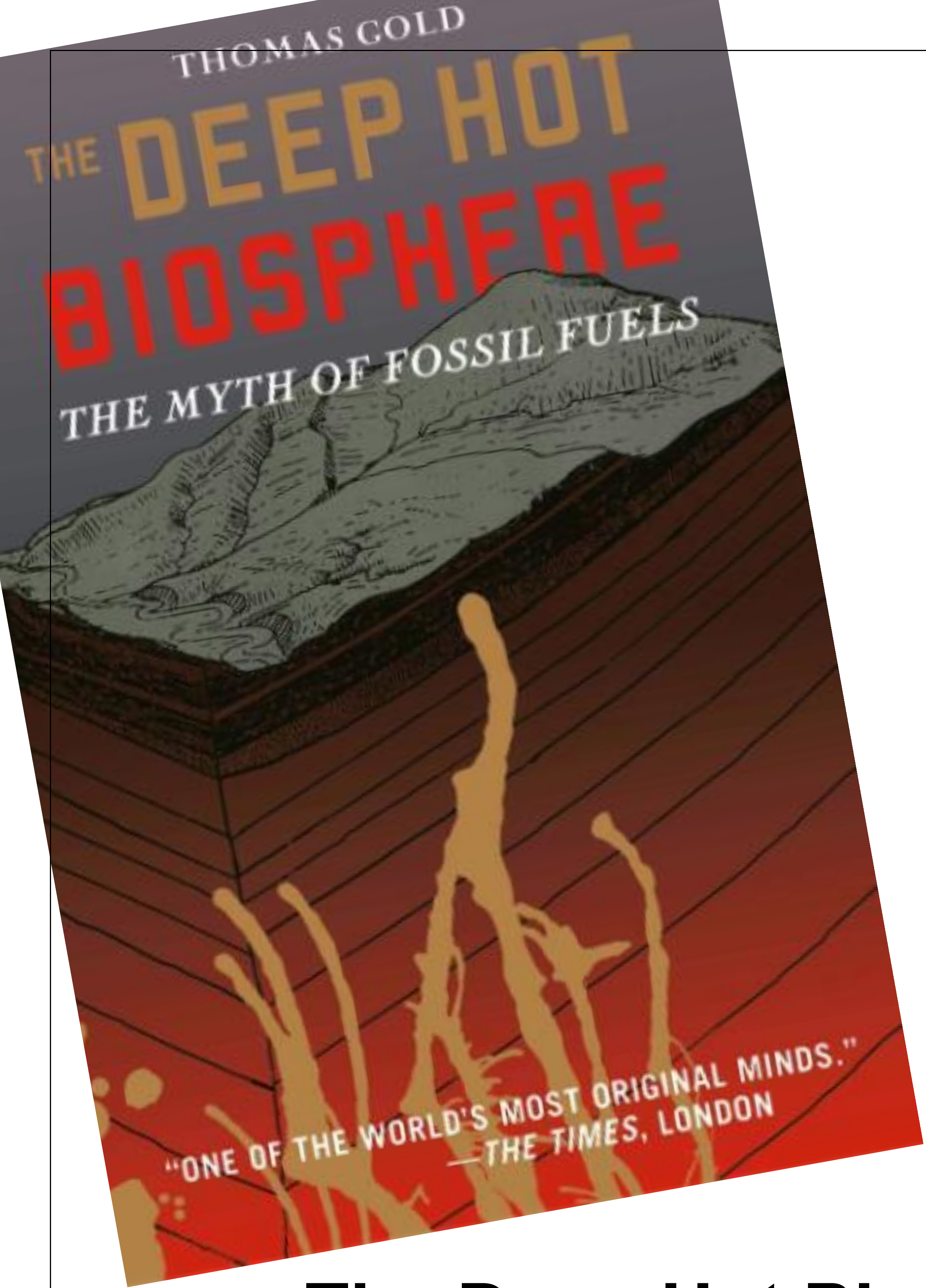

The Deep Hot Biosphere

The Myth of Fossil Fuel

By Thomas Gold

Book Summary by **Lies are Unbekoming**

unbekoming.substack.com

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Contents

Cover letter

Hello there

If you are reading this, then like me you are curious about "Official Stories", and you've probably realised that wherever there is big money and power, there is also likely scientific and narrative distortion. But you are curious and want to find out more...

The reason I produce these summaries, for people like you, is to make the subject matter a bit more accessible by acting as a gateway to important books and ultimately further reading on the subject.

The model I have used to summarize the chapters is:

- Executive Summary
- Key takeaways
- Excerpts

Here is a Preface from the author in the original book:

> 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*

With that, I hope you enjoy this summary, you might want to visit my Substack and/or share this summary with others.

Regards

Lies are Unbekoming

unbekoming.substack.com

July 2023

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.

Chapter 1 – Our Garden of Eden

Executive summary:

The chapter explores the fascinating topic of life's origins and the conditions necessary for its existence. It raises questions about how life began, whether it is unique to Earth, and if life can exist in harsh environments beyond our planet. The author proposes the existence of a deep hot biosphere beneath the Earth's surface, fueled by hydrocarbons, which challenges the traditional belief that hydrocarbons are only remnants of surface life. By understanding the role of chemical energy and the possibility of subsurface life, the chapter calls for a shift in the search for extraterrestrial life.

Key takeaways:

1. Biology remains full of surprises, particularly the origin and existence of life itself, raising questions about how life started and whether it exists elsewhere in the universe.
2. All known life forms share common building blocks, such as amino acids and proteins, suggesting a connection between diverse life forms.
3. Conditions necessary for life include liquid water, limited temperature range, and chemical energy, making Earth's surface an ideal habitat.
4. The universe presents extreme conditions with vast cold spaces and intense heat from stars, making most places unsuitable for life.
5. Hydrocarbons, essential for life's chemical energy, may have a deep-earth origin rather than being solely derived from surface life as traditionally believed.
6. The deep hot biosphere theory proposes the existence of a subsurface biosphere, supported by chemical energy from hydrocarbons and oxygen sources in rocks.
7. The subsurface realm extends down to great depths and likely harbors vast microbial life forms, indicating the possibility of life on other planetary bodies.
8. Surface life is likely descended from an original form of life that began at depth, challenging the assumption of life originating on the surface.
9. The chapter suggests that a subsurface biosphere may exist on many other planetary bodies with similar internal conditions to Earth.
10. Recognition of a thriving subterranean biosphere on Earth is essential to developing techniques for searching for extraterrestrial life on other planets.
11. Observations of hydrocarbons associated with helium, not explainable by a sedimentary origin, provide evidence for subsurface microbial life.
12. The chapter proposes a large-scale drilling project in Sweden to investigate the deep hot biosphere theory and search for deep microbial life.
13. Exploring the borderland regions between surface and subsurface biospheres, such as hydrothermal vents and methane-rich caves, may provide valuable insights into the existence and nature of subsurface life.

Excerpts:

1. "Foremost is the surprise that life exists at all. How could life have started? Did one extraordinary chance occurrence in the universe assemble the first primitive living organism, and did everything else follow from that?"
2. "Life is thus built up from a variety of atoms forged in nuclear furnaces deep inside giant stars. More precisely, life is constructed from molecules, clumpings of atoms that are in close enough contact and cool enough for a weak attractive force to hold them together."
3. "I propose that the original source of energy for earthly life was derived not from photosynthesis but from the oxidation of hydrocarbons that were already present, just as they are also present on many other planetary bodies and in the original materials that formed the solar system."

Chapter 2 – Life at the Borders

Executive summary:

The discovery of life thriving around deep-ocean vents challenges the conventional belief that surface life driven by photosynthesis is the only viable form of life. In 1977, scientists observed a rich and unique community of organisms, including giant tube worms, clams, and mussels, living in the deep-sea ecosystem near hydrothermal vents. These ecosystems are fueled by chemical energy from hydrocarbons like methane, rather than sunlight, which suggests that life might have originated from below the Earth's surface. The deep-ocean vents provide a new habitat for life, dependent on microbes, and these ecosystems are global phenomena.

The chapter discusses the discovery of various borderland ecosystems, including microbial communities in hot pools of Yellowstone National Park, ecosystems associated with hot springs and hydrothermal vents on the ocean floor, and thriving ecosystems in caves based on chemical energy from reduced gases. It also explores the potential for life in Lake Vostok, a vast lake beneath the Antarctic ice, and the abundance of methane hydrates on the ocean floor. The concept of a deep hot biosphere is presented, suggesting that life may exist in the earth's crust, utilizing hydrocarbons as a fuel source. The significance of the Archaea domain of life and the need to explore the deep earth for evidence of life are emphasized.

Key takeaways:

1. These ecosystems represent a new habitat for life, where microbes play a crucial role in providing the energy source for various organisms.
2. The deep-ocean vent ecosystems are global phenomena, existing in various locations in the Pacific, Atlantic, and Indian Oceans.
3. Microbes, including bacteria and archaea, are likely the base of the food chain in these ecosystems, possibly originating from below the Earth's surface.
4. The chemical energy derived from hydrocarbons sustains the entire ecosystem and supports the growth of various organisms.
5. These ecosystems are not directly dependent on surface photosynthesis, as previously assumed.
6. The organisms in these ecosystems are adapted to survive in extreme conditions, including high temperatures and pressure.
7. The presence of abundant oxygen is critical for these deep-ocean vent communities, and oxygen sources like sulfate and ferric iron oxides play a crucial role in microbial processes.
8. The symbiotic relationships between macrofauna and microbes within these ecosystems are essential for energy transfer and survival.
9. Microbes that utilize methane and other hydrocarbons are present in the deep-ocean vent communities.
10. Borderland ecosystems, such as hot springs, hydrothermal vents, oil seeps, and gas-rich caves, have been discovered in the past three decades, revealing diverse and intriguing forms of life.

11. Yellowstone's hot pools harbor thermophilic (heat-loving) microbes with unique metabolic talents, such as the bacterium Thermus aquaticus, which revolutionized DNA replication in molecular biology.
12. Cold petroleum seeps on continental shelves offer marine life a chemical energy source over vast deep expanses, where photosynthesis is not possible.
13. Romanian cave ecosystems exist, thriving on chemical energy derived from reduced gases emanating from below, and supporting a variety of land animals and invertebrates.
14. Lake Vostok, a vast lake beneath Antarctica's ice, presents an exciting opportunity to explore a potential deep biosphere based on chemical energy welling up from below.
15. Hyperthermophiles, microbes thriving at extreme temperatures, are abundant in certain regions and can tolerate high pressure as well.
16. The classification of microbial life has been rethought, with Archaea standing out as a unique domain and potentially representing the most ancient form of life.
17. The deep hot biosphere theory suggests that hydrocarbons, including methane, are not solely derived from biological remains but could be primordial constituents of the solar system debris.
18. Studying the deep hot biosphere requires drilling into rocks to explore and understand its inhabitants, potentially including hyperthermophilic microbes from the Archaea domain.
19. Evidence supports the existence of indigenous microbial communities at significant depths in the Earth's crust, with some microbes thriving at temperatures of up to 110°C.
20. Methane and other hydrocarbons may serve as essential fuel sources and carbon providers for life deep within the Earth's crust, challenging traditional notions of hydrocarbon origins.

Excerpts:

1. "In February and March of 1977, the small deep-sea-diving submarine Alvin descended to a depth of 2.6 kilometers along the East Pacific Rise. This region, northeast of the Galapagos Islands, was known to be a center of sea floor spreading. A research ship had drawn a camera over the area the previous year, confirming the existence of a series of cracks in the ocean floor that appeared to be volcanically active. But the occupants of Alvin saw much more."
2. "Further investigations soon revealed that this strange and isolated community of life was by no means unique. Populations of the same organisms were discovered at other points along that ocean rift, at hydrothermally active vents elsewhere in the Pacific, and in the Atlantic and Indian Oceans too. This was clearly a global phenomenon. These unsuspected oases represent an entirely new habitat for life."
3. "In summary, there are important differences and important similarities between the two biospheres. The surface biosphere runs on solar energy converted into chemical energy; the deep biosphere begins with chemical energy freely supplied from the depths of the earth. Both biospheres rely on unoxidized carbon as the building block of life, but surface life extracts it initially, with the help of sunlight, from carbon dioxide in the atmosphere, whereas deep life extracts it from the same substances used as the energy source: hydrocarbons."

Chapter 3 – The Deep-Earth Gas Theory

Executive summary:

This chapter discusses two conflicting theories on the origin of petroleum: the biogenic theory and the abiogenic theory. The biogenic theory suggests that petroleum is formed from biological debris buried in sediments over millions of years. In contrast, the abiogenic theory proposes that petroleum originates from the initial materials that formed the Earth, located deep within the Earth's crust. The author favors the abiogenic theory and presents evidence to support this view, challenging the widely accepted notion that petroleum is a fossil fuel derived solely from biological sources. The abiogenic theory, in turn, forms the foundation for the concept of the "deep hot biosphere."

The deep-Earth gas theory challenges the traditional belief that hydrocarbons, the building blocks of petroleum, originate solely from organic sources such as decaying plant and animal matter. Instead, it proposes that hydrocarbons are primordial, abundant in the universe, and were present during the Earth's formation. The theory is built on five key assumptions, including the prevalence of hydrocarbons in the universe, the Earth's early accretion from solid materials containing hydrocarbons, the existence of pore spaces within rocks at great depths to accommodate hydrocarbons, the Earth's partial melt, and the thermodynamic stability of hydrocarbons at deep levels. The presence of hydrocarbons deep within the Earth challenges the traditional notion of oil formation and emphasizes the importance of understanding the Earth as a complex system where geological processes interact with deeper cosmic origins.

Key takeaways:

1. Petroleum has been the subject of debate since its discovery, with two main theories: biogenic (derived from biological debris) and abiogenic (originating from deep within the Earth).
2. The biogenic theory, widely accepted in the Western world, faces little room for scientific dissent.
3. The presence of hydrocarbons on other planetary bodies supports the possibility of abiogenic origins.
4. The biogenic theory led to a self-fulfilling prophecy, as oil exploration focused on sedimentary rocks.
5. The Soviet Union was more lenient toward scientific dissent, allowing research on both theories.
6. The abiogenic theory assumes five key factors, including the presence of hydrocarbons in primordial materials and their stability at high pressures and temperatures.
7. Hydrocarbons from deep sources can reach the Earth's surface without encountering magma and may be oxidized into carbon dioxide and water over time.
8. Hydrocarbons are primordial, abundant elements in the universe and present during Earth's formation.
9. Hydrocarbons exist on various planetary bodies and asteroids within the solar system.
10. Spectrographic studies provide clear evidence of the abundance of hydrocarbons throughout the solar system and beyond.

11. Meteorites and carbonaceous chondrites deliver hydrocarbons and other volatile substances to Earth during accretion.
12. The Earth was subjected to partial melting during its early formation, creating a rocky crust and mantle.
13. Traditional views on Earth's early molten state and uniform cooling are challenged, with evidence supporting partial melting.
14. The presence of hydrocarbons deep within the Earth is not an anomaly but a natural occurrence.
15. Hydrocarbons must not have been fully oxidized during Earth's history, suggesting they persist at depth.
16. Hydrocarbons are stable at great depths and can resist dissociation under substantial pressure.
17. The existence of pore spaces within rocks at great depths allows for the storage and movement of hydrocarbons.
18. The notion that high pressure would eliminate all pore spaces in rocks is incorrect.
19. Empirical evidence supports the upwelling of hydrocarbons from great depths, indicating a source still present in the Earth's crust.
20. The abiogenic theory challenges traditional biogenic theories of oil formation and emphasizes the complexity of Earth's geological processes in relation to cosmic origins.

Excerpts:

1. "A critical attitude is clearly required of every seeker of truth. But one must be equally critical of both the old ideas as of the new."
2. "At the present time, most petroleum geologists outside the former Soviet Union would say that the question has been completely answered-that deposits of biological debris, reworked by geological processes, account for all natural petroleum."
3. "The abiogenic theory holds that hydrocarbons were a component of the material that formed the earth, through accretion of solids, some 4.5 billion years ago."
4. "The first assumption underlying the abiogenic view of petroleum formation - that hydrocarbons were a common constituent of the primordial materials out of which the earth accreted - is now common knowledge among astronomers and planetary scientists."
5. "Fundamentally, spectrographic studies have demonstrated that carbon is the fourth most abundant element in the universe and also in our solar system, mostly in compounds with hydrogen - hydrocarbons - found in bodies great and small within our solar system."
6. "The earth is, after all, a planet, and thus geology should be regarded first and foremost as a subset of planetary science, but that view has been slow to take hold."

Chapter 4 – Evidence for Deep-Earth Gas

Executive summary:

The abiogenic theory of petroleum formation posits that significant quantities of hydrocarbons originate in the Earth's upper mantle and lower crust, far deeper than can be directly sampled. To support this theory, empirical evidence is sought in regions accessible by drilling equipment. Seven main types of evidence favoring the abiogenic theory have been identified.

1. First, petroleum reservoirs exhibit long lines or arcs over large geographic areas.
2. Second, hydrocarbon-rich areas persist at all levels, including the crystalline basement, suggesting an upward flow of hydrocarbons.
3. Third, methane is found in locations where a biological explanation is improbable.
4. Fourth, petroleum deposits in a region share common chemical features regardless of geological age.
5. Fifth, some hydrocarbon reservoirs appear to refill themselves after production.
6. Sixth, the distribution of carbonate rock and carbon isotope composition argues against a surface biological origin.
7. Lastly, hydrocarbons are often associated with the chemically inert gas helium, pointing to an ascent from great depths.

The chapter also delves into the carbon cycle on Earth, exploring the mystery of why the planet's surface and subsurface contain an immense amount of carbon compared to what would be expected from rock erosion. The author examines the origin of this carbon, its distribution in oxidized and unoxidized forms, and the theories regarding its accumulation over geological time. Two major theories are presented: one suggesting a massive early atmosphere of carbon dioxide that later transformed into carbonate rocks, and the other proposing a continuous supply of upwelling carbon from deep within the Earth. The chapter emphasizes the significance of carbon isotope data, which can provide crucial insights into the source and history of carbon on our planet.

The chapter then discusses the strong association of helium with hydrocarbons and its implications for understanding the origin of petroleum deposits. Helium, produced through the radioactive decay of uranium and thorium, is found in significant quantities in regions where hydrocarbons are abundant. The author proposes the "deep earth gas theory," suggesting that hydrocarbon fluids serve as carriers of helium from deep within the Earth's crust to the surface. This theory is supported by the close relationship between helium and hydrocarbons in oil and gas fields and the absence of pure helium fields without associated hydrocarbons.

Key takeaways:

1. Abiogenic theory suggests deep-Earth sources of hydrocarbons.
2. Empirical evidence supports abiogenic theory in petroleum formation.
3. Petroleum reservoirs often exhibit linear patterns over large geographic areas.
4. Hydrocarbon-rich areas persist at all levels, including the crystalline basement.
5. Methane is found in locations where biological explanations are unlikely.
6. Petroleum deposits in a region share common chemical features regardless of geological age.
7. Some hydrocarbon reservoirs appear to refill after production.

8. Caprocks cannot hold down upward-flowing fluids with high pressure.
9. The upwelling flow can partly recharge reservoirs, but another process is responsible for faster refilling.
10. The top field can be replenished from deeper reserves without drilling deeper.
11. Reported occurrences of self-refilling petroleum reservoirs provide evidence for the deep-Earth gas theory.
12. Earth's surface and subsurface contain a vast amount of carbon, far exceeding what would be expected from rock erosion.
13. Carbon exists in both oxidized (carbonates) and unoxidized (coal, oil, natural gas) forms, with the latter representing a larger portion.
14. Theories about the origin of this carbon include an early atmosphere of carbon dioxide converted into carbonate rocks and continuous upwelling of carbon from deep within the Earth.
15. Isotopic analysis of carbon provides valuable information about its source and history.
16. Evidence suggests that hydrocarbons (fossil fuels) were likely primordial constituents of the Earth.
17. Carbonates, like limestone, have a relatively constant isotopic composition over geological time, supporting the continuous supply of carbon from deep sources.
18. The biogenic theory (carbon derived from photosynthetic surface life) fails to explain the constant isotopic composition of carbonates, while the abiogenic theory (upwelling hydrocarbons from deep sources) provides a more plausible explanation.
19. Upwelling methane likely undergoes isotopic fractionation before reaching the atmosphere, but this effect is mixed out globally, resulting in a relatively constant atmospheric isotopic ratio.
20. Atmospheric mixing masks the isotopic fractionation of hydrocarbons in individual outflow areas, leading to a consistent average isotopic composition for the entire Earth and over long periods.
21. The evidence supports the view that hydrocarbons are primordial constituents of Earth and continue to upwell into the outer crust, where they oxidize and mix with the atmosphere.
22. Helium is strongly associated with hydrocarbons, particularly in oil and gas fields.
23. The association of helium with hydrocarbons challenges the prevailing biogenic theory of petroleum formation.
24. Helium is primarily produced through the radioactive decay of uranium and thorium in rocks.
25. Helium enrichment in petroleum-bearing regions suggests a pumping action driven
26. The deep earth gas theory proposes that hydrocarbon fluids carry helium from deep within the Earth's crust to the surface.
27. Helium concentration can serve as an indication of the depth from which hydrocarbon gases originated.
28. The absence of pure helium fields without hydrocarbons supports the idea of hydrocarbon fluids as carriers of helium.

29. The origin of hydrocarbons remains a paradox between their presence at great depths and their association with biological molecules.
30. Understanding the interaction between hydrocarbons and biological molecules is the subject of further exploration.

Excerpts:

1. "The abiogenic theory of petroleum formation presumes that an enormous source of primordial hydrocarbons resides in the upper mantle and lower crust - far deeper than can be drilled and sampled directly."
2. "First, reservoirs of petroleum, including methane and ethane, are frequently found in geographical patterns of long lines or arcs extending for hundreds or even thousands of kilometers."
3. "The hydrocarbon deposits of a large area often show common chemical features regardless of the varied composition or the geological ages of the formations in which they are found."
4. "The surface and subsurface sediments on the earth contain approximately one hundred times as much of the element carbon as would have been derived from the grinding up of the basement rocks that contributed to the sediments. The surface is thus enormously enriched in carbon. This enrichment requires an explanation."
5. "One attempt at an explanation of this large excess of carbon at the surface and in the sediments was to suppose that in the early days of planetary accretion, the earth acquired a huge atmosphere of carbon dioxide, which was then turned into carbonate rocks."
6. "The only sound explanation, in my view, is that atmospheric gases have derived mainly from outgassing of volatiles derived at depth from buried solid materials-not from an initial large atmosphere acquired at the earth's formation or by later capture of gases from space."
7. "There is a very strong association of helium with hydrocarbons. Helium sniffing has been found useful in detecting oil and gas fields."
8. "Helium is produced mainly in the radioactive decay of uranium and thorium. The present quantities of helium are far higher than the sediments could have produced from their radioactive components alone."
9. "The deeper the source of hydrocarbons, the greater the total length of pore spaces through which hydrocarbons must flow before reaching the surface. The helium concentration in a gas can be used as an indication of the depth from which this gas has come."

Chapter 5 – Resolving the Petroleum Paradox

Executive summary:

The chapter presents an alternative theory, the "deep hot biosphere," challenging the prevailing biogenic view of petroleum formation. The author proposes that a vast domain of life exists within the Earth's crust, where microbes feed on deep, abiogenic hydrocarbons. This theory resolves the paradox of petroleum formation, explaining the presence of biological molecules in crude oil without relying on fossilized remains of surface life. Additionally, the chapter introduces the upwelling theory, which challenges the traditional biogenic explanation of coal formation from ancient swamps. Instead, coal is suggested to be derived from hydrocarbons upwelling from deep within the Earth, providing a more plausible explanation for coal's composition and distribution.

Key takeaways:

1. The "deep hot biosphere" theory proposes a thriving community of microbes that feeds on deep, abiogenic hydrocarbons, resolving the paradox of petroleum formation.
2. Petroleum's abiogenic origin challenges the prevailing biogenic theory, which attributes it to fossilized biological debris transformed by geological processes.
3. The presence of biological molecules in petroleum samples supports the existence of a deep hot biosphere within the Earth's crust.
4. The deep hot biosphere theory suggests life's presence beyond the Earth's surface, opening possibilities for life in other planetary bodies.
5. The upwelling theory challenges the traditional view of coal formation from ancient swamps, proposing coal is derived from hydrocarbons rising from the Earth's depths.
6. Coal's low mineral content and overlapping distribution with oil deposits support the upwelling theory, offering a new perspective on coal's origin.
7. The upwelling theory provides a more plausible explanation for the formation of black coals, lignite, and peat than the traditional biogenic theory.
8. Methane from upwelling hydrocarbons influences the formation of peat and lignite, affecting their presence in oil and gas-rich regions.
9. The transition from black coals to brown lignite and peat is marked by distinct changes in formation circumstances.
10. The abiogenic theory accounts for spatial and chemical features of hydrocarbon reserves that the biogenic theory cannot explain.
11. Evidence supports ongoing microbial activity in petroleum reservoirs, indicating a thriving deep hot biosphere that feeds on hydrocarbons from the depths.
12. The estimated biomass of the deep hot biosphere could match or exceed the entire living mass of the surface biosphere.
13. The deep hot biosphere theory provides a novel perspective on petroleum and coal formation, challenging traditional views and shedding light on life's potential in Earth's subsurface and beyond.

Excerpts:

1. "To contend, as I do, that complex hydrocarbons were primordial constituents of solar system debris out of which the planets formed... is a radically contrarious view of petroleum formation."
2. "Supporters of the biogenic theory of petroleum formation build their case on four central observations... These molecules could not have been built up in a non-biological process."
3. "With respect to the petroleum paradox, the unrecognized assumption on both sides of the debate was an unquestioned belief that life can exist only at the surface of the earth... the problem had become a paradox only because arguments on both sides contained an unrecognized hidden assumption."

Chapter 6 – The Siljan Experiment

Executive summary:

The chapter recounts the Siljan Experiment, a drilling operation in Sweden's Siljan Ring, aimed at challenging conventional theories of petroleum formation and discovering commercial quantities of hydrocarbons to support the abiogenic theory. When the drill got stuck at a depth of 6 kilometers, fluids from the environment entered the pipe, resulting in the recovery of a black paste emitting a strong odor. Analysis revealed that the paste contained fine-grained magnetite, suggesting the involvement of thermophilic microorganisms and supporting the presence of a deep hot biosphere. The discovery challenges prevailing notions of petroleum origin and highlights the significance of subsurface microbial activity in hydrocarbon formation.

Key takeaways:

1. The Siljan Experiment aimed to challenge conventional theories of petroleum formation and validate the abiogenic theory by discovering hydrocarbons in the Siljan Ring impact structure in Sweden.
2. A drilling operation in Siljan Ring led to the recovery of a black paste containing fine-grained magnetite, indicating the presence of thermophilic microorganisms and supporting the concept of a deep hot biosphere.
3. The discovery challenges the prevailing biogenic theory of petroleum formation, suggesting that hydrocarbons can originate from inorganic processes rather than solely from organic matter.
4. Magnetite's presence and correlation with hydrocarbons may serve as a potential indicator of hydrocarbon-rich areas in petroleum exploration.
5. The Siljan Ring's positive magnetic anomaly and the abundance of magnetite suggest microbial activity in the subsurface of other regions as well.
6. The presence of hydrocarbons deep in the Earth supports the abiogenic theory of petroleum formation and indicates the existence of a deep hot biosphere.
7. The Siljan Experiment did not achieve commercial success due to the abundant magnetite paste blocking cracks and impeding sustained petroleum production.
8. Despite not being economically successful, the scientific findings shed light on deep subsurface microbial activity and its role in hydrocarbon and magnetite formation.
9. The deep hot biosphere theory suggests that subsurface microbiology may be widespread, and the quantity of subsurface life could be comparable to surface life.
10. The discovery calls for a re-evaluation of conventional petroleum geology theories and emphasizes the importance of subsurface life in geological processes.
11. Magnetite's presence and concentration in the Siljan Ring provide insights into potential microbial activity in other similar geological formations.
12. The Siljan Experiment highlights the need for further research on subsurface microbial processes and their influence on hydrocarbon reservoirs.
13. The chapter underscores the importance of the deep hot biosphere theory in understanding petroleum formation and subsurface ecosystems.

Excerpts:

1. "The only black and magnetic material that I knew to occur in nature was magnetite (Fe_3O_4). What I seemed to have detected, therefore, was unusually fine-grained magnetite, yet in a size range large enough to be ferromagnetic."
2. "The investigation was carried out by Paul Philp, a specialist in the investigation of biological molecules in petroleum, and he analyzed the oil in the black sludge for such molecules. First, he concluded that the oil was not any form of contaminant introduced by the drilling process or from any of the additives. It was a natural material."
3. "The most remarkable recent analysis of the Siljan sludge revealed the probable origin of all the magnetite, which would also account for its concentration and for the stench of the sludge. The answer: Life was responsible."

Chapter 7 – Extending the Theory

Executive Summary:

This chapter explores two extensions of the deep-earth gas theory, shedding light on geological mysteries and challenging conventional beliefs. The first extension delves into the genesis of diamonds at great depths within the Earth's mantle, unexpected on the surface due to the immense pressure required for their formation. The presence of diamonds at the surface is linked to gas blowouts from the depths, revealing fascinating insights into their preservation as supercooled solids. The second extension presents a fresh perspective on the formation of concentrated metal deposits found in clusters worldwide. The author suggests that hydrocarbon fluids originating from deep within the Earth play a pivotal role in leaching, transporting, and depositing metals, challenging traditional hydrothermal theories.

Key Takeaways:

1. Hydrocarbon sources from the Earth's mantle contribute to various geological phenomena, offering new insights into natural processes.
2. Extreme pressure at great depths alters chemistry, leading to unknown molecules and crystallographic forms not observed on the surface.
3. Geological processes concentrate materials in well-defined locations within the Earth's crust, driven by internal energy like gravity.
4. The presence of diamonds at the Earth's surface challenges conventional beliefs, as they require immense pressure to form deep in the mantle.
5. Diamond formations are associated with gas blowouts from great depths, explaining their presence on the surface and as supercooled solids.
6. Rarity of diamonds on the surface may result from infrequent deep blowouts, rather than scarcity at depth.
7. Diamonds often contain inclusions of high-pressure carbon-bearing fluids, with nitrogen playing a role in the formation process.
8. Hydrocarbons spontaneously form at high pressures in the Earth's upper mantle and deep crust, shedding hydrogen as they rise to lower pressures.
9. The abiogenic theory of petroleum formation provides a more comprehensive explanation for diamond origin, challenging conventional geological beliefs.
10. Understanding diamond formation may shed light on other important resources, such as metal deposits.
11. Concentrated metal deposits in clusters require a fluid capable of leaching and transporting metals through rocks, challenging traditional hydrothermal theories.
12. Hydrocarbon fluids from deep within the Earth are better suited for leaching and transporting metals due to their solubility and pumping power.
13. Limited exploration and experimentation on hydrocarbons at high pressures have hindered understanding of metal deposit genesis, inspiring further research.

Excerpts:

1. "Chemistry at great depth is likely to be quite different from the low-pressure chemistry with which we are familiar."
2. "One such source of energy is the gravitational field, which would tend to make heavy substances sink and light substances rise."
3. "The discovery on and near the earth's surface of crystals of pure carbon-diamonds-was wholly unexpected."
4. "Several general conditions must be satisfied for metal concentrations to form. First, as already discussed, there must be a fluid that can flow through pore spaces and fissures in a source rock where the metal is only sparsely distributed. This fluid must be able to gather up-that is, to leach-the metal from the rock and carry it along with the flow."
5. "Better candidate fluids for the leaching and transport of metals are hydrocarbons. Hydrocarbon fluids surpass water in both the capacity to hold metals in solution and the pumping power required for the energy-intensive leaching process."
6. "Regardless of whether the booty of interest to mining companies is the work of deep-earth hydrocarbons alone or in collaboration with microbial efforts in the deep hot biosphere, I believe that hydrocarbons are indeed the fluids responsible for leaching, binding, and transporting many of the metals."

Chapter 8 – Rethinking Earthquakes

Executive summary:

This chapter presents the deep-earth gas theory as a comprehensive explanation for earthquakes, challenging existing theories. According to this theory, the Earth continuously expels fluids, including volatile gases, from great depths, contributing to volcanic eruptions, mud volcanoes, and earthquakes. Upwelling fluids from deep within the Earth create fractures, change stress patterns, and weaken rocks, leading to seismic events. The chapter discusses eyewitness accounts of earthquakes throughout history and how they provide evidence for the theory that gases play a significant role in seismic events. Additionally, it explores earthquake spots, regions with consistent low-level earthquake activity, proposing the upwelling-gas theory to explain these phenomena.

Key Takeaways:

1. The deep-earth gas theory offers a new perspective on the causes and mechanisms behind earthquakes, linking them to fluid emissions from deep within the Earth.
2. Mud volcanoes, pockmarks on ocean floors, and other gas-related phenomena indicate the release of gases from the Earth's interior, associated with earthquakes.
3. Upwelling fluids from deep within the Earth create fractures and change stress patterns, contributing to the occurrence of earthquakes.
4. Gas emissions weaken rocks, expand fault lines, and contribute to the sudden influx of energy that triggers earthquakes.
5. Precursor phenomena like changes in temperature, fog, and animal behavior have been observed before earthquakes, providing potential warning signs.
6. Historical accounts by Aristotle, Seneca, and other scholars reveal ancient beliefs about earthquakes and their association with gas phenomena.
7. Observations of methane emanation from earth mounds in Charlevoix and Enola support the upwelling-gas theory.
8. The Western scientific view of earthquakes focuses on tectonic stresses, while regions like Japan and China consider gas phenomena.
9. Integrating observations of subsurface gases into early-warning systems can improve earthquake prediction and preparedness.
10. The upwelling-gas theory has implications for mineral deposit formation and the study of life within the Earth.
11. Combining the upwelling-gas theory with tectonic block movements may lead to a better understanding of earthquakes.
12. Monitoring gas leakage, changes in groundwater, and seismic velocities could provide evidence of impending earthquakes.
13. The deep-earth gas theory may alter scientific views on the origin of Earth life and the potential for life elsewhere in the solar system.

Excerpts:

1. "According to the deep-earth gas theory, the earth is continuously expelling fluids from great depths, including juvenile volatiles issuing from the mantle."
2. "Earthquake spots can in no way be explained in the usual fashion; they are clearly not born of plates shearing against one another."
3. "I believe that earthquake spots are best explained-indeed, can only be explained-by the upwelling-gas theory."

Chapter 9 – The Origin of Life

Executive summary:

The chapter delves into the concept of "punctuated equilibrium," challenging the traditional view of gradual evolution proposed by Charles Darwin. According to this theory, species undergo rapid adaptations during short periods in response to environmental changes, followed by longer periods of stasis. The chapter emphasizes the significant differences between microbial and macrobiological evolution, with microorganisms showing faster and more diverse evolutionary rates. Major metabolic innovations are primarily achieved by microorganisms, while macrofauna focus on reproduction and rearrangement. The concept of gene splicing is introduced as a potential mechanism for major evolutionary innovations, allowing for the transfer of genetic material between different organisms and potentially explaining the absence of intermediate forms in the fossil record. Additionally, the chapter discusses the importance of molecular chirality in life's diversity and evolution.

Key takeaways:

1. The "punctuated equilibrium" theory challenges the idea of gradual evolution and proposes rapid adaptations followed by periods of stasis.
2. Microbial evolution occurs at a faster pace compared to macrobiological evolution, leading to greater metabolic variety among microorganisms.
3. Major metabolic innovations are achieved primarily by microorganisms, while macrofauna focus on reproduction and structural adaptations.
4. Gene splicing and endosymbiosis are mechanisms that facilitate the transfer of evolutionary innovations across different lineages.
5. The fossil record does not always show intermediate forms, possibly due to gene splicing and other mechanisms that lead to rapid transitions.
6. Modern biotechnology utilizes deliberate selection and gene splicing for agriculture and pharmaceutical purposes.
7. Evolutionary processes are interconnected across terrestrial biology, with microorganisms likely playing a crucial role in early life's innovations.
8. Molecular chirality, the characteristic of molecules to be either left-handed or right-handed, plays a role in the uniformity of certain biological molecules across all life forms.
9. DNA and certain amino acids exhibit consistent chirality throughout all known terrestrial life forms.
10. The choice of chirality in the first living organism might have been arbitrary, and subsequent evolution maintained this pattern.
11. Gene splicing could explain why certain lineages have not shifted to the opposite chirality, preventing their isolation and extinction.
12. The chapter proposes a combined evolution of terrestrial biology, highlighting the significance of microorganisms in early life's innovations.
13. The deep hot biosphere, potentially nurturing the first living systems, might have been the site of essential evolutionary events.

Excerpts:

1. "The gradual evolution implied by occasional random errors in the genetic blueprints should leave evidence for many intermediate forms in the evolution of a species, but that is not what the fossil record shows."
2. "Microbes excel in metabolic variety, whereas eukaryotes are the pioneers of form."
3. "Could naturally occurring methods of gene splicing have been a major driving force for evolution, and could they have resulted in much more rapid transitions and fewer intermediate steps than individual chance mutations would have required?"

Chapter 10 – What Next?

Executive summary:

This chapter delves into two interconnected theories, the deep-earth gas theory, and the deep hot biosphere theory, which challenge the conventional understanding of hydrocarbon formation. The deep-earth gas theory suggests that hydrocarbons originate from great depths within the Earth and then upwell to shallower depths, supporting a distinct microbiology. On the other hand, the deep hot biosphere theory proposes the existence of a vast realm of life beneath the Earth's surface, fueled by subsurface hydrocarbons. The chapter stresses the need for further investigation and evidence to confirm these theories and their implications for our understanding of the origin of life and the limits of life on Earth.

Key takeaways:

1. The deep-earth gas theory proposes that hydrocarbons originate from great depths within the Earth and then upwell to shallower depths, supporting microbial life.
2. The Siljan Ring drilling experiment in Sweden confirmed the presence of hydrocarbons at great depth, providing support for the deep-earth gas theory.
3. Observations of gas seepages and rates in existing gas fields may challenge the conventional biogenic theory of hydrocarbon formation.
4. Calculations based on rock permeability suggest that gas fields could exhaust themselves much faster than the conventional age estimates.
5. Investigative methods, such as tracer gas experiments and tent-based measurements, can provide valuable data on hydrocarbon flow from depth.
6. The deep hot biosphere theory proposes a vast realm of life beneath the Earth's surface, which could be fueled by subsurface hydrocarbons.
7. Studying microbial life in extreme conditions and different ecosystems is challenging, requiring proper culturing techniques and consideration of temperature and pressure conditions.
8. Methanotrophs, microbes that derive energy and carbon from methane, play a significant role in deep-ocean vent ecosystems.
9. Culturing deep-earth microbes requires equipment and conditions mimicking the extreme depths from where the samples are taken.
10. Research on deep life may reveal new insights into Earth's ecosystems and challenge existing understandings of hydrocarbon origins.
11. The source and role of methane in deep-ocean vent ecosystems require further investigation.
12. Innovative culturing techniques hold the potential to reveal the entire ecology of deep life and uncover new discoveries about life beneath the Earth's surface.
13. The theories presented challenge the prevailing view of hydrocarbon origins and the limits of life on Earth.

Excerpts:

1. "The deep-earth gas theory has already been confirmed in the drilling experiment described in Chapter 6. The Siljan Ring geological structure in Sweden was chosen as the site for this experiment because it is a purely granitic province, so any gas

discovered at depth there could not be explained by the biogenic theory of the formation of hydrocarbons."

2. "Accurate measurements of the rates of gas seepages, particularly over regions where natural gas is produced commercially, might yield data that would be difficult to explain by the biogenic theory of hydrocarbon formation."
3. "Photosynthesizers at the base of the surface food web convert the energy of sunlight into chemical energy, from which they fuel their metabolisms and build their bodies. Proceeding up the scale of consumption, whatever energy is left over in the bodies or metabolic products of one group is tackled by the next group in the sequence."

Afterward to the Paperback Edition

Executive summary:

In this afterword, Thomas Gold challenges the widely accepted view that petroleum and black coal are fossil residues derived from buried biological debris. Instead, he proposes an alternative theory that Earth's hydrocarbon reserves are abiogenic, originating from the primordial "soup" from which the planet was created and still existing in abundance deep within the Earth's crust. Gold presents evidence supporting the deep origin of petroleum, including its presence in locations untouched by surface biological remains and the discovery of massive deep biospheres thriving on hydrocarbons. He argues that the quantities of hydrocarbons far exceed what could be explained by biogenic origins, and petroleum fields often show refilling, suggesting continuous upwelling from deep sources.

Key takeaways:

1. Thomas Gold disputes the traditional view of fossil fuels' biogenic origin, proposing instead that Earth's hydrocarbons are abiogenic and come from deep within the planet's crust.
2. The vast quantities of hydrocarbons, the presence of petroleum in locations with no access to surface biological remains, and the refilling of oil fields support Gold's theory.
3. Evidence points to the existence of a massive deep biosphere, separate from surface life, that thrives on hydrocarbons in Earth's crust.
4. The deep biosphere likely contains vast amounts of microbial life, possibly surpassing the mass of the surface biosphere.
5. Hydrocarbons seeping upward from the deep biosphere are a source of nourishment for microbial life, and oxygen supplied by oxidized sulfur and iron supports this life.
6. Deep-source petroleum and gas have different trace elements, such as helium, suggesting a distinct origin from surface hydrocarbons.
7. Observations from the petroleum industry and drilling in basement rock indicate a large underground reservoir of hydrocarbons.
8. Methane hydrate on the ocean floor, the outgassing of methane, and explosive gas eruptions provide further evidence of deep hydrocarbon sources.
9. Gold argues that life likely originated in the deep biosphere due to stable environmental conditions, abundant food supply, and the probability of autocatalytic molecule formation.
10. He suggests that life's initial stages occurred in warm or hot surroundings, favoring the deep biosphere's constant conditions.
11. The deep biosphere may hold the key to understanding the origin of life and the abundance of hydrocarbons in the universe.
12. The genetic connection between the deep biosphere and surface life implies a common origin, but the question of which came first remains unanswered.
13. Gold encourages continued exploration of the deep hot biosphere and systematic research into the origin of petroleum and underground life.

Excerpts:

1. "I have only become more convinced that petroleum and black coal are not fossil residues that have worked their way down from the surface of Earth into their subterranean resting places."
2. "Petroleum and methane have been found and continue to be found in locations on Earth to which surface biological remains have never had access; the presence of oil and gas at these sites simply cannot be explained by the biogenic theory."
3. "Today, however, there is clear evidence for the existence of a massive deep biosphere. It represents not just a small perturbation in the scheme of geochemistry, if it is to account for all the biological substances that hydrocarbons are bringing up and have brought up over long periods of geologic time. It is instead vast. Space for all this living material is not a problem, provided it is microbial life, thriving in the pores of rocks."