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Another Scientific Revolution: Now Yielding a ‘Cosmic Biology’ Consistent with Natural Theology

Theodore Walker Jr.

[This paper is an April 2018 revision of the first part of a two-part paper—“Advancing and Challenging Classical Theism with Biology and Bioethics”—presented on 10 August 2017 at the Templeton Foundation funded international conference on “Analytic Theology and the Nature of God: Advancing and Challenging Classical Theism” (7-12 August 2017) at Hochschule für Philosophie München [Munich School of Philosophy] at Fürstenried Palace, Exerzitenhaus Schloss Fürstenried, in Munich, DE - Germany. Conference speakers: John Bishop, University of Auckland, New Zealand; Joseph Bracken SJ, Xavier University Cincinnati; Godehard Brüntrup SJ, Munich School of Philosophy; Anna Case-Winters, McCormick Theological Seminary; Philip Clayton, Claremont School of Theology; Benedikt Göcke, Ruhr University Bochum; Johnathan D. Jacobs, St. Louis University; John Leslie, University of Guelph; Gesche Linde, University of Rostock; Klaus Müller, University of Münster; Ken Perszyk, University of Waikato; Andrew Pinsent, Oxford University; Thomas Schärfl-Trendel, University of Regensburg; Johannes Stoffers SJ, Munich School of Philosophy; Giovanni Ventimiglia, University of Lucerne; Theodore Walker Jr., Perkins School of Theology, Southern Methodist University; coordinated by Prof. Dr. Godehard Brüntrup SJ and Dr. Tobias Müller; with Dr. Ludwig Jaskolla, Niklas Ernst, Fredrich Sieben, and others.]

Abstract -

Beyond the Copernican revolution, another scientific revolution is now in process. Inspired by Sir Fred Hoyle and others, this contemporary extension of the Copernican revolution is replacing biology conceived as exclusively Earth science with biology conceived as including study of stellar evolution and cosmic evolution. Furthermore, astrobiology, panspermia, and cosmic biology (Hoyle and Wickramasinghe) are advancing in ways consistent with natural theology, especially with panentheism. Some of this was anticipated and advocated by Alfred North Whitehead, Charles Hartshorne, and other philosophers of nature.

Key words: panspermia, astrobiology, stellar evolution, cosmic biology, cosmic evolution, panentheism

ANOTHER SCIENTIFIC REVOLUTION

Consider the idea of two scientific revolutions: a Copernican revolution followed by a Darwinian revolution. This idea is addressed by biologist Francisco J. Ayala in “From Paley to Darwin: Design to Natural Selection” (2008) in *Back to Darwin: A Richer Account of Evolution*, edited by John B. Cobb Jr. In a chapter section—titled “Darwin’s Revolution”—Ayala argues persuasively that a “priggish version” of this idea is true, yet inadequate.

I have proposed that this version of the two revolutions is inadequate: what it says is true, but it misses what is most important about these two intellectual revolutions, namely, that they ushered in the beginning of science in the modern sense of the

word. These two revolutions may jointly be seen as the one scientific revolution, with two stages, the Copernican and the Darwinian. ... *Origin of Species* is important because it completed the Copernican revolution, initiated three centuries earlier, and thereby radically changed our conception of the universe and the place of mankind in it.
(Ayala 2008: 68).

Ayala holds that Copernicus and Darwin achieved “one scientific revolution with two stages” (2008: 68).

Stage one of this scientific revolution [Copernicus] “consisted in *displacing the earth* from its previously accepted locus as the center of the universe, moving it to a subordinate place as one more planet revolving around the sun” (Ayala 2008: 67, italics added).

Stage two of this same scientific revolution [Darwin] “consisted in *displacing humans* from their position as the center of life on Earth, with all other species created for the purpose of humankind, and placing humans instead as one species among many in the living world, so that humans are related to chimpanzees, gorillas, and other species by shared common ancestry” (Ayala 2008: 67-68, italics added). The Darwinian second stage “... completed the Copernican revolution ...” (Ayala 2008: 68, 69).

Accordingly, scientific revolution stage one (in astronomy) was *displacing the Earth* from the spatial center of the universe, and placing the Earth in revolution around a star. Then, stage two (in biology) was *displacing humans* from un-relatedness to other evolving life on Earth. And now, another scientific revolution (in astrobiology and cosmic biology) is *displacing the Earth* again. Now Earth is no longer conceived to be the biological center of the universe.

[With regard to displacing humans from the biological center; in *Beyond Humanism: Essays in the Philosophy of Nature* (1975 [c1937]) Charles Hartshorne says, “the notion that man is the center of the universe” is “not yet completely shattered by astronomy, since we still do not know that we are *not* the highest of the creatures; but it certainly has no positive support from reason—to say the least,” and Hartshorne conceives of the possibility of creatures “more intelligent or more richly sensitive than we” (1975 [c1937]: 88), and of “intermediate individualities” possibly “interposed between” the universal individual (God) and human individuals (1975 [c1937]: 310). In other words: individuals less inclusive than God, and more inclusive than humans.]

The idea that all life originated in some “warm little pond” (Darwin to Joseph Hooker 1871) on planet Earth is being replaced with the idea of a vastly larger pond: our Milky Way galaxy (with our solar system embedded in a spiral arm revolving around a galactic center). Moreover, the Milky Way is one among many billions of galactic ponds. Contrary to the astronomically improbable belief that microbial life originated exclusively in our *little* pond; Fred Hoyle advanced the vastly more probable idea that microbial life as such “did not begin on the Earth” (1980: 21), that “life is not confined to a particular galaxy,” and that “Life can spread itself through the Universe” (1980: 23). Rather than being restricted to Earth, life is “a cosmic phenomenon” (Hoyle and Wickramasinghe 7 August 1986).

B²FH

Historically, the revolutionary practice of connecting evolutionary biology to astronomy and cosmology was greatly advanced when Fred Hoyle and others produced evidence indicating the heavy elements (elements heavier than hydrogen and helium, including especially carbon) were synthesized from hydrogen in stars (Hoyle 1946; Hoyle 1947; *B²FH* 1957).

[See “The Synthesis of the Elements from Hydrogen” (1946) and “On the Formation of Heavy Elements in Stars” (1947) by Fred Hoyle; and “Synthesis of the Elements in Stars” (1957) by E. Margaret Burbidge, Geoffrey R. Burbidge, William A. Fowler, and Fred Hoyle /*B²FH*.]

B²FH is “known to all astronomers” (Martin Rees 1997: 16) as referring to the initials of the four authors of “Synthesis of the Elements in Stars” (1957): E. Margaret Burbidge, Geoffrey R. Burbidge, William A. Fowler, and Fred Hoyle. The work signified by *B²FH* is so widely known because it was “a turning point in our knowledge of how the universe works” (Neil de Grasse Tyson and Donald Goldsmith 2004: 165).

This revolutionary turning point connected biology to stellar evolution. We are made of heavy elements synthesized in stars. We are evolved stardust.

[Concerning evolved stardust: Though Hoyle and others did science and mathematics showing that we are evolved stardust (Hoyle 1946, Hoyle 1947: *B²FH* 1957); many of us first learned to conceive of ourselves as stardust from musician-poets Crosby, Stills, Nash & Young singing: “We are stardust. We are golden. We are ten billion year old carbon. And we got to get ourselves back to the garden.” (1969 at Woodstock)]

Since then (Hoyle 1946; Hoyle 1947; *B²FH* 1957; Woodstock 1969), evolutionary astrobiology (along with advancing theories of “cosmic evolution” and “cosmic biology”) has been displacing the idea that biology is exclusively Earth science.

[Concerning “cosmic evolution” and “cosmic biology,” see: *Origins: Fourteen Billion Years of Cosmic Evolution* (2004) by Neil de Grasse Tyson and Donald Goldsmith; “Imperatives of Cosmic Biology” (2 March 2010) by Chandra Wickramasinghe and Carl H. Gibson; *Cosmic Biology: How Life Could Evolve on Other Worlds* (c2011) by Louis N. Irwin and Dirk Schulze-Makuch; and *Vindication of Cosmic Biology: Tribute to Sir Fred Hoyle (1915-2001)* (2015) edited by Chandra Wickramasinghe. Concerning relations between astronomy and biology: In 1936-37 in *Beyond Humanism: Essays in the Philosophy of Nature* (1975 [c1937]) Charles Hartshorne was saying “astronomy is not as yet of much help in determining the prevalence in space-time of conditions favoring animal organism” (58). Since then, especially since *B²FH* (1957), astronomers have learned to be of much help to biology; and in so doing, they created the new convergent disciplines of astrobiology and cosmic biology. Also, concerning converging disciplines and interdisciplinarity more generally, see *Undisciplining Knowledge: Interdisciplinarity in the Twentieth Century* (2015) by Harvey J. Graff, and see “Biology, social science, and history: interdisciplinarity in three directions” (2016) by Chris Renwick.]

ASTROBIOLOGY AND COSMIC BIOLOGY

Turning—from Earth-only biology to astrobiology and cosmic biology—was indicated in Fred Hoyle’s *The Relation of Biology to Astronomy* (1980). Here, drawing upon work with Chandra Wickramasinghe, Hoyle argued that interstellar clouds include granular particles of bacteria. And he predicted that the idea of interstellar and cosmic microbiological processes will become obvious to future generations. Hoyle said:

I suspect that the cosmic quality of microbiology will seem as obvious to future generations as the Sun being the centre of our solar system seems obvious to the present generation.
(Hoyle 1980: 24-25)

Hoyle's 1980 prediction is coming true. The cosmic quality of microbiology is becoming more and more obvious. And the "maverick science of astrobiology" (Darling 2001) is now becoming less and less maverick.

[In *Life Everywhere: The Maverick Science of Astrobiology* (2001) David Darling says, with regard to panspermia theories advanced by Hoyle and Wickramasinghe, "Today ... panspermia is at least tolerated" and "the idea of microbes being able to hop from world to world has very much entered the scientific mainstream" (47). Also, see *The Living Universe: NASA and the Development of Astrobiology* (2005 [c2004]) by Steven J. Dick (chief NASA historian) and James E. Strick. Also see: (Hoyle and Wickramasinghe 30 March 1979), (Hoyle and Wickramasinghe 6 November 1979), and (Hoyle and Wickramasinghe 1981; 1982; September 1983; December 1983; 1984).]

The previous scientific revolution (in astronomy and biology) displaced Earth from the spatial center of the universe (Copernicus 1543) and displaced humans from un-relatedness to other evolving life on Earth (Darwin 1859).

The current scientific revolution (in astrobiology and cosmic biology) is displacing Earth from the biological center of the universe, and theory of evolution on Earth is displaced from un-relatedness to stellar, galactic, and cosmic evolution (B²FH 1957). Furthermore, this Copernicus-like revolution is producing a cosmic biology consistent with natural theology (Hoyle and Wickramasinghe 1981; 1982; 7 August 1986; 1988).

CONSTSTENT WITH NATURAL THEOLOGY

Hoyle and Wickramasinghe argue that precisely tuned life-favoring cosmic circumstances are required to make life possible. The "coupling constants" of physics must be chosen with enormous precision (Hoyle and Wickramasinghe 1981: 141-43; also Hoyle 1984 [c1983]: 218-19). Creating and sustaining such enormously precise cosmic circumstances (today called cosmic fine tuning) requires deliberate acts of a "super intelligence," an interacting and "all-embracing intelligence" (Hoyle 1984 [c1983]: 215). The numerical calculations put the need for cosmic intelligence—exercising cosmic influences—beyond question.

A commonsense interpretation of the facts suggests that a superintellect has monkeyed with physics, as well as with chemistry and biology, and that there are no blind forces worth speaking about in nature.
(Hoyle 1981: 12)

The numbers one calculates from the facts seem to me to be so overwhelming as to put this conclusion beyond question.
(Hoyle 1981:12)

And given the extreme complexity of even the smallest living microbe, mathematical calculations witness against the still prevailing theory of life emerging from non-life by random/chance assembly.

The chance that life forms might have emerged in this way [by way of random assembly] is comparable with the chance that a tornado sweeping through a junk-yard might assemble a Boeing 747 from material therein.

(Hoyle 12 November 1981: 105)

A commonsense interpretation of the facts forced Hoyle to conclude (against his previous atheism) that a cosmic intelligence must be exerting cosmic influences favoring the evolution of life. This implicitly pro-theological conclusion is rendered explicit in chapter 9—“Convergence to God”—of *Evolution from Space: A Theory of Cosmic Creationism* (1981) by Fred Hoyle and N. Chandra Wickramasinghe.

[Also, concerning God, evolution, creation, and cosmic creationism, see “Hoyle on Evolution” (12 November 1981) by Fred Hoyle in *Nature*; chapter 1—“Chance and the Universe”—in *The Intelligent Universe: A New View of Creation and Evolution* (1984 [c1983]) by Fred Hoyle; and chapter 10—“The Concept of a Creator”—in *Cosmic Life-Force* (1990) by Fred Hoyle and N. Chandra Wickramasinghe. And, from among theologians at Perkins School of Theology, see *Sisters of Dust, Sisters of Spirit: Womanist Wordings on God and Creation* (1998) by Karen Baker-Fletcher, and *The Big Bang and God: An Astro-Theology ...* (2015) by Theodore Walker Jr. and Chandra Wickramasinghe [where “Astro-Theology” indicates a constructive postmodern revision of early modern *Astro-Theology: Or, A Demonstration of the Being and Attributes of God, from a Survey of the Heavens* (1715) by William Derham]; and note that in a chapter titled “It’s Only Natural” Craig C. Hill [a New Testament scholar attentive to biology] says, “... perhaps our biology is meant to drive us to God” (Hill 2016: 21).]

This revolutionary practice—of connecting evolutionary biology to creationist cosmology and natural theology—was anticipated and advanced by natural philosophers thinking deeply about science and biology. For instance, in *Science and the Modern World* (1925) Alfred North Whitehead conceived that science was becoming “the study of organisms” (103), with physicists studying the smaller organisms, and biologists studying the larger organisms. And, with emphasis upon universal creativity, Whitehead connected his biology-oriented “philosophy of organism” to cosmology and theology in *Process and Reality: An Essay in Cosmology* (1927-28). Similarly, biology was connected to ontology, evolutionary cosmology, and natural theology in *Beyond Humanism: Essays in the Philosophy of Nature* (1975 [c1937]) by Charles Hartshorne. Here Hartshorne held that “the structure of reality” is “one of organisms within organisms” (91), that “the philosophical argument for *cosmic evolutionism* stands on its own feet” (140; italics added), and we are “cells in the body of God” (197).

BIOLOGY AND PANENTHEISM

In the Preface to the 1975 reprint of his 1937 book, Hartshorne offers two important “retractions” from his 1937 terminology. He retracts labeling his “neoclassical” metaphysics and theology with the classical term “pantheism” in favor of labeling it “*my panentheism*” (italics added); and he retracts labeling it “naturalism” (which implies contingent existence and contingent actuality, instead of necessary existence and contingent actuality) in favor of labeling it “supernaturalism” (1975 [c1937]: viii-ix). As indicated in this Preface, after 1937,

Hartshorne's consistent typological label—for his (and Whitehead's) organic cosmology and theology—became “panentheism.” *According to Hartshornean panentheism*, <pan-en-theos –ism> means <all that is real is - included in - God –ism>; and God (the all-inclusive individual) includes and transcends (is greater than, better than, more creative than) the sum of all parts of reality.

[In accordance with Godehard Brüntrup's account of various types of panentheism, Hartshornean panentheism (being dipolar, and featuring dual transcendence) would be a “strong modal bi-direction panentheism” (Brüntrup 9 August 2017).]

Revolutionary advances in astrobiology and cosmic biology are catching up to philosophical anticipations, and connecting agreeably with “a quiet revolution” in theology identified in M. W. Brierley's “Naming a Quiet Revolution: The Panentheistic Turn in Modern Theology” (2004). At “the panentheistic turn,” theology converges with biology.

[Also, concerning panentheism and evolution, see: *A Natural Theology for Our Time* (1967) by Charles Hartshorne; *Analytic Theism, Hartshorne, and the Concept of God* (1996) and *Whitehead's Religious Thought: From Mechanism to Organism, from Force to Persuasion* (January 2017) by Daniel A. Dombrowski; “Panentheism: A Field-Oriented Approach” (2004) by Joseph Bracken; “Evolution and Process Thought” (2008) by Ian G. Barbour; “Organisms as Agents in Evolution” (2008) by John B. Cobb Jr.; “Whitehead's Naturalism and a Non-Darwinian View of Evolution” (2008) by David Ray Griffin; “A Process Cosmology” (September 2012) by Lewis S. Ford; “polyamorous panentheism” (pp. 77-81; 207) in *Intercarnations: Exercises in Theological Possibility* (2017) by Catherine Keller; and *Entangled Worlds: Religion, Science, and New Materialisms* (2017) edited by Catherine Keller and Mary-Jane Rubenstein.]

PANENTHEISM AND MORAL THEORY

The panentheist turn also converges with moral theory (theory of ethics). Panentheism helps with discerning that the biblical imperatives (Matthew 5:43-48; 22:34-40)—to love our neighbors and our enemies as we love ourselves—are founded upon realism, not mere idealism. Every experience confirms what no experience can deny: we really are (f-actually are) partly inclusive parts among variously inclusive parts of reality. And logical/mereological analysis shows that all parts of reality are parts of the whole of reality, parts of “the one all-inclusive [divine] whole of reality” (Ogden 1984: 21; also Hartshorne 1973 [1967]). Hence, conformity to reality (living righteously, not missing the mark [not sinning]) requires valuing neighbors, enemies, and selves as they/we really are: as parts of the divine whole. This is ethical realism.

References

- Ayala, Francisco J. (2008). "From Paley to Darwin: Design to Natural Selection" (50-75) in *Back to Darwin: A Richer Account of Evolution*, edited by John B. Cobb Jr. Grand Rapids, Michigan: William B. Eerdmans.
- Baker-Fletcher, Karen. (1998). *Sisters of Dust, Sisters of Spirit: Womanist Wordings on God and Creation*. Minneapolis: Fortress Press.
- Barbour, Ian G. (2008). "Evolution and Process Thought" (196-214) in *Back to Darwin: A Richer Account of Evolution*, edited by John B. Cobb Jr. Grand Rapids: Eerdmans.
- Birch, Charles and John B. Cobb Jr. (1981). *Liberation of Life: From the Cell to the Community*. Cambridge University Press.
- Bracken, Joseph. (2004). "Panentheism: A Field-Oriented Approach" in *In Whom We Live and Move and Have Our Being: Panentheistic Reflections on God's Presence in a Scientific World*. Grand Rapids: Eerdmans, edited by Philip Clayton and Arthur Peacocke.
- Brierley, M. W. (2004). "Naming a Quiet Revolution: The Panentheistic Turn in Modern Theology" in *In Whom We Live and Move and Have Our Being: Panentheistic Reflections on God's Presence in a Scientific World*. Grand Rapids: Eerdmans, edited by Philip Clayton and Arthur Peacocke.
- Brüntrup, Godehard. (9 August 2017). "Why Panentheism Might Not Be a Meaningful Concept," delivered at a Templeton Foundation funded international conference on "Analytic Theology and the Nature of God: Advancing and Challenging Classical Theism" at Hochschule für Philosophie München [Munich School of Philosophy] at Fürstenried Palace, Exerzitenhaus Schloss Fürstenried, in Munich, DE - Germany.
- Burbidge, E. Margaret with Geoffrey R. Burbidge, William A. Fowler and Fred Hoyle [B²FH]. (October 1957). "Synthesis of the Elements in Stars" in *Review of Modern Physics*, vol. 29, issue 4, 547-650 [doi:10.1103/RevModPhys.29.547].
- Clayton, Philip and Jeffrey Schloss, editors. (c2004). *Evolution and Ethics: Human Morality in Biological and Religious Perspectives*. Grand Rapids: Eerdmans.
- Clayton, Philip and Arthur Peacocke, editors. (2004). *In Whom We Live and Move and Have Our Being: Panentheistic Reflections on God's Presence in a Scientific World*. Grand Rapids: Eerdmans.
- Cobb, John B., Jr. (2008). "Organisms as Agents in Evolution" is chapter 14 (pp. 215-242) in *Back to Darwin: A Richer Account of Evolution*, edited by John B. Cobb Jr. Grand Rapids: Eerdmans.
- Copernicus, Nicolaus. (1543). *De revolutionibus orbium coelestium*, libri VI. Budapest: Tancsics Konyvkiado, 1973.
- Darling, David (2001). *Life Everywhere: The Maverick Science of Astrobiology*. New York: Basic.
- Darling, David (2001). *Life Everywhere: The Maverick Science of Astrobiology*. New York: Basic.
- Darwin, Charles. (1859). *On the Origin of Species By Means of Natural Selection, Or the Preservation of Favoured Races in the Struggle for Life*. London: John Murray.

- Derham, William. (1715). *Astro-Theology: Or, A Demonstration of the Being and Attributes of God, from a Survey of the Heavens*. London: William Innys.
- Dick, Steven J. [chief NASA historian] and James E. Strick. (2005 [c2004]). *The Living Universe: NASA and the Development of Astrobiology*. Rutgers University Press.
- Dombrowski, Daniel A. (1996). *Analytic Theism, Hartshorne, and the Concept of God*. Albany, New York: State University of New York Press.
- Dombrowski, Daniel A. (January 2017). *Whitehead's Religious Thought: From Mechanism to Organism, from Force to Persuasion*. Albany: SUNY Press.
- Ford, Lewis S. (September 2012). "A Process Cosmology" in *Journal of Cosmology*, volume 20, pp. 8645-8647, online at <journalofcosmology.com>.
- Graff, Harvey J. (2015). *Undisciplining Knowledge: Interdisciplinarity in the Twentieth Century*. Baltimore: John Hopkins University Press.
- Griffin, David Ray. (2008). "Whitehead's Naturalism and a Non-Darwinian View of Evolution" is chapter 22 (364-390) in *Back to Darwin: A Richer Account of Evolution*, edited by John B. Cobb Jr. Grand Rapids: Eerdmans.
- Hartshorne, Charles. (c1937, 1975). *Beyond Humanism: Essays in the Philosophy of Nature*. Gloucester, Mass.: Peter Smith.
- Hartshorne, Charles. (1967, 1973). *A Natural Theology for Our Time*. La Salle: Open Court.
- Hartshorne, Charles and William L. Reese. (1953). *Philosophers Speak of God*. Chicago: University of Chicago Press; Midway, 1976; Humanity, 2000.
- Hill, Craig C. (2016). "It's Only Natural" is chapter 2 in *Servant of All: Status, Ambition, and the Way of Jesus*. Grand Rapids: Eerdmans.
- Hoyle, Fred. (2 December 1946 [April 6]). "The Synthesis of the Elements from Hydrogen" in *Monthly Notices of the Royal Astronomical Society*, volume 106, issue 5, 343-83.
- Hoyle, Fred. (1947). "On the Formation of Heavy Elements in Stars" in *Proceedings of the Physical Society*, volume 59, issue 6, 972-78.
- Hoyle, Fred. (15 April 1980). *The Relation of Biology to Astronomy*. University College Cardiff Press. Cardiff, Wales.
- Hoyle, Fred. (12 November 1981). "Hoyle on Evolution" in *Nature*, vol. 294, issue 5837, 104-05 [doi:10.1038/294104b0]. Here is Hoyle's famous "chance that a tornado sweeping through a junk-yard might assemble a Boeing 747" analogy for evolution by chance assembly.
- Hoyle, Fred and Chandra Wickramasinghe. (1979 [30 March 1979]). "On the Nature of Interstellar Grains" in *Astrophysics and Space Science*, volume 66, issue 1, 77-90.

Hoyle, Fred and N. C. Wickramasinghe. (May 1980 [6 November 1979]). “Organic Grains in Space” in *Astrophysics and Space Science*, volume 69, issue 2, 511-13.

Hoyle, Fred and N. Chandra Wickramasinghe. (1981 [1980]). “Comets—a Vehicle for Panspermia” in *Comets and the Origin of Life: Proceedings of the Fifth College Park Colloquium on Chemical Evolution, October 29-31, University of Maryland*, edited by Cyril Ponnampereuma. Boston: Kluwer. [Wickramasinghe describes this essay as the first “explicit exposition of our cometary panspermia theory” in the September-October 2011 volume 16 *Journal of Cosmology* reprint online at <journalofcosmology.com>.]

Hoyle, Fred and N. Chandra Wickramasinghe. (1981). “Convergence to God” is chapter 9 in *Evolution from Space: A Theory of Cosmic Creationism*. New York: Simon and Schuster, 129-45.

Hoyle, Fred and N. Chandra Wickramasinghe. (1982). “Comets” is section C (23-35) in *Proofs that Life is Cosmic: Memoirs of the Institute of Fundamental Studies*. Sri Lanka: Government Press.

Hoyle, Fred and N. Chandra Wickramasinghe. (8 September 1983). “Organic Grains in Taurus Interstellar Clouds” in *Nature*, volume 305, issue 5930, 161 [doi:10.1038/305261a0].

Hoyle, Fred and N. Chandra Wickramasinghe. (1 December 1983). “Bacterial Life in Space” in *Nature*, volume 306, issue 5942, 420 [doi:10.1038/306420a0].

Hoyle, Fred and N. Chandra Wickramasinghe. (1984). *From Grains to Bacteria*. Cardiff: University College Cardiff Press.

Hoyle, Fred and Chandra Wickramasinghe. (7 August 1986). “The Case for Life as a Cosmic Phenomenon” in *Nature*, vol. 32, issue 6079, 509-11 [doi:10.1038/322509a0].

Hoyle, Fred and N. Chandra Wickramasinghe. (1988). “The Concept of a Creator” is chapter 10 in *Cosmic Life-Force*. London: J. M. Dent; New York: Paragon, 1990, 132-44.

Irwin, Louis N. and Dirk Schulze-Makuch. (c2011). *Cosmic Biology: How Life Could Evolve on Other Worlds*. New York; London: Springer.

Keller, Catherine. (2017). *Intercarnations: Exercises in Theological Possibility*. New York: Fordham University Press.

Keller, Catherine and Mary-Jane Rubenstein, editors. (2017). *Entangled Worlds: Religion, Science, and New Materialisms*. New York: Fordham University Press.

Ogden, Schubert M. (Spring 1984). “Process Theology and the Wesleyan Witness” in *Perkins School of Theology Journal*, vol. 37, issue 3, 18-33 [reprinted in *Thy Nature and Thy Name Is Love: Wesleyan and Process Theologies in Dialogue* (2001), edited by Bryan P. Stone and Thomas Jay Oord].

Rees, Martin. (1997). *Before the Beginning: Our Universe and Others*, foreword by Stephen Hawking. Cambridge: Helix Books.

Renwick, Chris. (2016). “Biology, social science, and history: interdisciplinarity in three directions.” *Palgrave Communications*, 2:16001 doi:10.1057/palcomms.2016.1.

Stone, Bryan P. and Thomas Jay Oord, editors. (2001). *Thy Nature and Thy Name Is Love: Wesleyan and Process Theologies in Dialogue*. Nashville: Abingdon.

Tyson, Neil de Grasse and Donald Goldsmith. (2004). *Origins: Fourteen Billion Years of Cosmic Evolution*. New York: Norton.

Walker, Theodore, Jr. and Chandra Wickramasinghe [editing by Alexander Vishio]. (2015). *The Big Bang and God: An Astro-Theology wherein an astronomer and a theologian offer a study of interdisciplinary convergences with natural theology both in the scientific researches of Sir Fred Hoyle and in the philosophical researches of Charles Hartshorne and Alfred North Whitehead, thereby illustrating a constructive postmodern trend*. New York: Palgrave Macmillan.

Whitehead, Alfred North. (1925). *Science and the Modern World* (Lowell Lectures, 1925). New York: Macmillan; Free Press, 1967.

Whitehead, Alfred North. (1927-28). *Process and Reality: An Essay in Cosmology* (Gifford Lectures), Corrected Edition, edited by David Ray Griffin and Donald W. Sherburne. New York: Free Press, 1978.

Whitehead, Alfred North. (c1934). *Nature and Life*. Chicago: University of Chicago Press.

Wickramasinghe, Chandra, editor. (2015). *Vindication of Cosmic Biology: Tribute to Sir Fred Hoyle (1915-2001)*. Hackensack, NJ: World Scientific.

Wickramasinghe, Chandra and Carl H. Gibson. (2 March 2010 [27 February]). “Imperatives of Cosmic Biology” in *Inspire: High Energy Physics Information System*, subject: Cosmology and Nongalactic Astrophysics (astro-ph.CO); Astrophysics of Galaxies (astro-ph.GA), 17 pages [arXiv:1003.0091].

Wickramasinghe, Chandra and Gensuke Tokoro. (January 2014). “Life as a Cosmic Phenomenon: 2. The Panspermia Trajectory of *Homo sapiens*” in *Astrobiology and Outreach*, vol. 2, issue 2, 115 [doi:10.4172/2332-2519.1000115].

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