یادداشت‌ها و منابع کتاب معمای پیدایش حیات

پیش درآمد: نسخه‌ی اصلی طراحی‌هوشمندانه

1. Mary Shelley, Frankenstein [1818] (New York: Barnes & Noble Classics, 2003), 8.

2. Charles Darwin, quoted in Lucas Brouwers, “Did life evolve in a ‘warm little pond’?” Scientific American, February 16, 2012, https://blogs.scientificamerican.com/thoughtomics/did-life-evolve-in-awarm- little-pond/.

3. Charles B. Thaxton, Walter L. Bradley, and Roger L. Olsen, The Mystery of Life’s Origin: Reassessing Current Theories [1984], 2nd printing (Dallas, TX: Lewis and Stanley, 1992), 193, 210.

4. Thaxton, The Mystery of Life’s Origin, 211.

5. Thaxton, The Mystery of Life’s Origin, 193.

6. Thaxton, The Mystery of Life’s Origin, 206.

7. Thaxton, The Mystery of Life’s Origin, 209.

8. Thaxton, The Mystery of Life’s Origin, 211.

9. Thaxton, The Mystery of Life’s Origin, 211.

10. Thaxton, The Mystery of Life’s Origin, 202–203, 205.

11. Stephen Meyer, Signature in the Cell: DNA and the Evidence for Intelligent Design (New York: HarperOne, 2009), 29.

12. Allan Bloom, The Republic of Plato, 2nd ed. (New York: Basic Books, 1991), 73.

۱۳- تمام نقل قول‌های والتر بردلی از مصاحبه‌ی ضبط‌شده‌ای است که جان وست در ۵ مارس ۲۰۱۹ انجام داده است، مگر این‌که غیر از این ذکر شده باشد.

14.Thaxton, The Mystery of Life’s Origin, 213

15. Unless otherwise noted, all quotes from Charles Thaxton are from a recorded interview conducted by John West on March 15, 2019.

16. Ronald L. Numbers, The Creationists: From Scientific Creationism to Intelligent Design [1996], expanded ed. (Cambridge, MA: Harvard University Press, 2006), 373–4.

17. Thaxton, The Mystery of Life’s Origin, v, viii.

18. All correspondence with Cornell University Press was supplied to me by Charles Thaxton.

19. Abraham Loeb, "When Lab Experiments Carry Theological Implications," Scientific American, April 22, 2019, https://blogs.scientificamerican.com/observations/when-lab-experimentscarry- theological-implications/.

20. Correspondence with Grahame J. C. Smith was supplied to me by Charles Thaxton.

21. See http://www.philosophicallibrary.com/philosophical-library-authors/.

22. See David Klinghoffer, "Wikipedia Co-Founder Blasts 'Appallingly Biased' Wikipedia Entry on Intelligent Design," Evolution News & Science Today, Dec. 12, 2017, https://evolutionnews.org/2017/12/wikipedia-co-founder-calls-wikipediaentry- on-intelligent-design-appallingly-biased/.

23. Sidney W. Fox, "Beyond the Power of Science?", The Quarterly Review of Biology, 60:2 (June 1985), 193–195.

24. James F. Jekel, The Yale Journal of Biology and Medicine, 58:4 (July- August 1985), 407– 408.

25. Harold Morowitz, Robert Hazen, and James Trefil, "Intelligent Design Has No Place in the Science Curriculum," The Chronicle of Higher Education, Sept. 2, 2005, https://www.chronicle.com/article/Intelligent- Design-Has-No/31763.

26. Sam Roberts, "Harold Morowitz, 88, Biophysicist, Dies; Tackled Enigmas Big and Small," New York Times, April 1, 2016, https://www.nytimes.com/2016/04/02/science/harold-morowitzbiophysicist- who-tackled-enigmas-big-and-small-dies-at-88.html.

27. Correspondence with Harold J. Morowitz was supplied to me by Charles Thaxton.

28.See"HaroldMorowitzDies, https://ncse.com/news/2016/04/haroldmorowitz- dies-0016998.

29. Quotations in this paragraph are from correspondence provided to me by Charles Thaxton.

30. Richard M. Lemmon, "Life's Origin and the Supernatural," Chemical & Engineering News, July 1, 1985.

31. Michael A. Beilstein, "More on life's origin," Chemical & Engineering News, August 26, 1985.

32. Eugene C. McKannan, "More on life's origin," Chemical & Engineering News, August 26, 1985.

33. Henry F. Schaeffer III, “Mystery of life’s origin,” Chemical & Engineering News, August 12, 1985.

34. See https://en.wikipedia.org/wiki/Henry_F._Schaefer_III.

35.Seehttps://www.discovery.org/m/2019/02/A-Scientific-Dissent-from- Darwinism-List-020419.pdf (last visited Sept. 17, 2019).

36. Correspondence with Charles Thaxton provided to me by John West.

37. “Confidential Report on Trip to Princeton University,” by Jon Buell, provided to me by Pam Bailey, Discovery Institute, Dallas.

38. Correspondence with Thomas Woodward.

39. Meyer, Signature in the Cell, 25.

40. Meyer, Signature in the Cell, 26.

41. Meyer, Signature in the Cell, 28.

42. Correspondence with William Dembski.

43. Correspondence with Michael Behe.

44. Correspondence with Brian Miller.

45. Stephen Meyer,“A Scientific History and Philosophical Defense of the Theory of Intelligent Design,” Religion—Staat—Gesellschaft: Journal for the Study of Beliefs and Worldviews, vol. 7 (Münster, Germany: LIT Verlag, 2008), 10; see https://www.discovery.org/a/7471/ (last visited on Sept. 17, 2019).

46. Thomas Nagel, “Books of the Year,” Times Literary Supplement, November 27, 2009, https://www.the-tls.co.uk/articles/public/thomasnagel- and-stephen-c-meyers-signature-in-the-cell/.

47. David Gelernter, “Giving Up Darwin,” Claremont Review of Books, 19:2 (Spring 2019), 104–109.

48. Steve Connor, “Found: the origin of life,” The Independent, May 14,2009, https://www.independent.co.uk/news/science/found-the-origin-oflife-1684584.html.

49. Mike Wehner, “Amazing discovery may hold key to the origins of life,” New York Post, November 7, 2017, https://nypost.com/2017/11/07/amazing-discovery-may-hold-key-tolearning- how-life-on-earth-began/.

بخش نخست

فصل نخست: بحران در شیمی منشا حیات

1. J. D. Watson and F. H. Crick, “Molecular Structure of Nucleic Acids: A Structure for Deoxyribose Nucleic Acid,” Nature 171 (April 25, 1953): 737–738, doi: https://doi.org/10.1038/171737a0.

2. Stanley L. Miller, “A Production of Amino Acids Under Possible Primitive Earth Conditions,” Science 117 (May 15, 1953): 528–529, doi: 10.1126/science.117.3046.528.

3. Anonymous, Nature 265 (February 24, 1977): 685; F. Sanger et al.,“Nucleotide Sequence of Bacteriophage φX174 DNA,” Nature 265 (February 24, 1977): 687–695, doi: https://doi.org/10.1038/265687a0.

4.P. S. Moorhead and M. M. Kaplan, eds., Mathematical Challenges to the Neo-Darwinian Interpretation of Evolution (Philadelphia: Wistar Institute, 1967).

5. Murray Eden, in “Heresy in the Halls of Biology: Mathematicians Question Darwinism,” Scientific Research (November 1967), 59.

6. V. F. Weisskopf, in “Summary Discussion,” Mathematical Challenges, 100.

7. Murray Eden, “Inadequacies of Neo-Darwinian Evolution as a Scientific Theory,” Mathematical Challenges, 109.

8. Peter Medawar, “Remarks by the Chairman,” Mathematical Challenges, xi.

9. Marcel P. Schützenberger, “Algorithms and the Neo-Darwinian Theory of Evolution,” Mathematical Challenges, 73.

10. C. H. Waddington, in “Discussion [of] Paper by Dr. Schützenberger,” Mathematical Challenges, 75–80.

11. Ilya Prigogine, Gregoire Nicolis, and Agnes Babloyantz,“Thermodynamics of Evolution,” Physics Today 25, no. 11 (November 1972): 23, doi: 10.1063/1.3071090.

12. Michael Polanyi, “Life’s Irreducible Structure,” Science 160, no. 3834 (June 21, 1968): 1308, http://www.jstor.org/stable/1724152.

13. S. L. Miller, in The Heritage of Copernicus, ed. Jerzy Neyman (Cambridge, MA: The MIT Press, 1974), 228.

14. Harold Klein, “Space Cut is Feared If Viking Doesn’t Discover Life on Mars,” The New York Times, July 6, 1976, 15, https://www.nytimes.com/1976/07/06/archives/space-cut-is-feared-ifviking- doesnt-discover-life-on-mars.html?searchResultPosition=1.

15. K. Biemann, J. Oro, P. Toulmin III, L. E. Orgel, A. O. Nier, D. M. Anderson, P. G. Simmonds, D. Flory, A. V. Diaz, D. R. Rushneck, J. E. Biller, and A. L. Lafleur, “The Search for Organic Substances and Inorganic Volatile Compounds in the Surface of Mars,” Journal of Geophysical Research 82, no. 28 (September 30, 1977): 4641–4658, https://doi.org/10.1029/JS082i028p04641.

16. D. Goldsmith and T. Owen, The Search for Life in the Universe (Menlo Park, CA: Benjamin/Cummings, 1980), 106.

17. David C. Catling and James F. Kasting, Atmospheric Evolution on Inhabited and Lifeless Worlds (Cambridge University Press, 2017), Kindle edition, Table 14.4, p. 405.

18. H. R. Post, The Listener 197, Feb. 10, 1966.

19. George Gaylord Simpson, “The Nonprevalence of Humanoids,” Science 143, no. 3608 (1964): 769, doi: 10.1126/science.143.3608.769.

20. Anonymous, “What Future for Biogenesis?,” Nature 216 (November 18, 1967): 635, https://doi.org/10.1038/216635a0.

21. D. H. Kenyon and G. Steinman, Biochemical Predestination (New York: McGraw-Hill, 1969), 30.

22. Karl Popper, Conjectures and Refutations (New York: Harper Torchbooks, 1963).

فصل دوم: نظریه‌ی تکامل بیوشیمیایی

1. For additional discussion of the history of the idea of spontaneous generation, see John Farley, “The Spontaneous Generation Controversy (1859–1880): British and German Reactions to the Problem of Abiogenesis,” Journal of the History of Biology 5, no. 2 (1972): 285–319, from which this discussion has drawn substantially.

2. R. Vallery-Radot, The Life of Pasteur, translated from the French by Mrs. R. L. Devonshire (New York: Doubleday, 1920), 109.

3. Quoted in Francis Darwin, The Life and Letters of Charles Darwin, vol. 3 (London: John Murray, 1887), 18. The passage was written in 1871. See the original text of the Life and Letters (along with all Darwin’s other writings) athttp://darwin-online.org.uk/content/frameset? keywords=little%20pond%20warm&pageseq=30&itemID=F1452.3&vi wtype=text

4. London Times, Sept. 19, 1870.

5. A. I. Oparin, Proiskhozhdenie Zhizni (Moscow: Izd. Moskovski Rabochii,

1924), translated as Origin of Life by S. Morgulis (New York: Macmillan, 1938), 6.

6. J. B. S. Haldane, "Origin of Life," Rationalist Annual 148 (1929): 3 10.

7. Y. D. Bernal, "The Physical Basis of Life," paper presented before British Physical Society in 1949, found in The Physical Basis of Life (London: Routledge, 1951).

8. H. C. Urey, The Planets: Their Origin and Development (New Haven: Yale University Press, 1952).

9. Cyril Ponnamperuma, "Chemical Evolution and the Origin of Life," Nature 201 (January 25, 1964): 337, doi: https://doi.org/10.1038/201337a0

فصل سوم: شبیه‌سازی سنتز مونومر پیش‌زیستی

1. Howard H. Pattee, "On the Origin of Macromolecular Sequences," Biophysical Journal 1, no. 8 (1961): 683–710, https://doi.org/10.1016/S0006-3495(61)86917-8; A. Rich, in Origins of Life [Proceedings of the 1st Interdisciplinary Communications Program Conference on the Origins of Life, May 21–24, 1967, Princeton, NJ], ed. Lynn Margulis (New York, Gordon and Breach, 1970); Dean H. Kenyon and Gary Steinman, Biochemical Predestination (New York: McGraw- Hill, 1969), 36.

2. Kenyon and Steinman, Biochemical Predestination, 284.

3. Richard M. Lemmon, "Chemical Evolution," Chemical Reviews 70, no. 1 (1970): 95–100, https://doi.org/10.1021/cr60263a003; C. Ponnamperuma, "Primordial Organic Chemistry and the Origin of Life " Quarterly Review of Biophysics 4, no. 2–3 (1971): 77–106, https://doi.org/10.1017/S0033583500000603; E.Stephen-Sherwood and J. Oro, Space Life Sciences 4, no. 1 (1973): 5–31; N. H. Horowitz and J.S. Hubbard, "The Origin of Life, Annual Review of Genetics 8 (December 1974): https://doi.org/10.1146/annurev.ge.08.120174.002141; M. A. Bodin, "The Origin of Life," Journal of the British Interplanetary Society 31 (1978):140–146; M. Calvin, Chemical Evolution (New York: Oxford U. Press, 1969); Kenyon and Steinman, Biochemical Predestination; S. W. Fox and K. Dose, Molecular Evolution and the Origin of Life (San Francisco: W. H. Freeman, 1972); J. Brooks and G. Shaw, Origin and Development of Living Systems (New York: Academic Press, 1973); S. L. Miller and L. E. Orgel, The Origins of Life on the Earth (Englewood Cliffs, New Jersey: Prentice-Hall, 1974); The Origin of Life and Evolutionary Biochemistry, eds. K. Dose, S. W. Fox, G. A. Deborin, and T. E. Pavlovskaya (New York: Plenum Press, 1974); Lawrence S. Dillon, The Genetic Mechanism and the Origin of Life (New York: Plenum Press, 1978). Stanley L. Miller, "A Production of Amino Acids Under Possible

4. Primitive Earth Conditions," Science 117 (May 15, 1953): 528–529, doi:10.1126/science.117.3046.528.

5. Stanley L. Miller, in The Heritage of Copernicus, ed. J. Neyman (Cambridge: MIT Press, 1974), 228.

6. Miller, The Heritage of Copernicus, 235.

7. Miller, The Heritage of Copernicus, 235, 236.

8. Miller and Orgel, The Origins of Life on the Earth, 85. See also: D. Ring, Y. Wolman, N. Friedmann, and S. Miller, "Prebiotic Synthesis of Hydrophobic and Protein Amino Acids," PNAS 69, no. 3 (1972): 765– 768, https://www.pnas.org/content/pnas/69/3/765.full.pdf; Y. Wolman, W. J. Haverland, and S. L. Miller, "Nonprotein Amino Acids from Spark Discharges and Their Comparison with the Murchison Meteorite Amino Acids," PNAS 69, no. 4 (1972): 809–811, https://doi.org/10.1073/pnas.69.4.809; S. Miller,"Production of Some Organic Compounds under Possible Primitive Earth Conditions," Journal of the American Chemical Society 77, no. 9 (May 1, 1955): 2351 2361, https://doi.org/10.1021/ja01614a001.

9. J. Oro, "Synthesis of Organic Compounds by Electric Discharges," Nature 197 (March 2, 1963): 862–867, https://doi.org/10.1038/197862a0.

10. T. E. Pavlovskaya and A. G. Pasynskii, in The Origin of Life on the Earth, eds. A. I. Oparin et al. (London: Pergamon, 1959), 151.

11. C. Ponnamperuma and J. Flores. Amer. Chem. Soc. Abstracts, 1966.

12. Miller, The Heritage of Copernicus, 239.

13. C. Ponnamperuma, R. M. Lemmon, R. Mariner and M. Calvin, "Formation of Adenine by Electron Irradiation of Methane, Ammonia and Water," PNAS 49, no. 5 (May 1, 1963): 737–740, https://doi.org/10.1073/pnas.49.5.737; C. Ponnamperuma, Abiological Synthesis of Some Nucleic Acid Constituents," The Origins of Prebiological Systems and of Their Molecular Matrices, ed. S. W. Pox (New York: Academic Press, 1965), 221.

14. Reported at the 186th National Meeting of the American Chemical Society, August 29, 1983, held in Washington, D.C. See "ACS National Meeting: Meteorite, Agent Orange, Polymers," Chemical & Engineering News 61, no. 36 (September 5, 1983): 4, https://pubs.acs.org/doi/pdf/10.1021/cen-v061n036.p004.

15. S. L. Miller and H. C. Urey, "Organic Compound Synthes on the Primitive Earth," Science 130, no. 3370 (1959): 245–251, doi:10.1126/science.130.3370.245.

16. Ponnamperuma, "Abiological Synthesis of Some Nucleic Acid Constituents," 221.

17. Fox and Dose, Molecular Evolution and the Origin of Life, 84.

18. K. Harada and S. W. Fox, "Thermal Synthesis of Natural Amino-Acids from a Postulated Primitive Terrestrial Atmosphere," Nature 201 (1964): 335; see also K. Harada and S. W. Fox, "The Thermal Synthesis of Amino Acids from a Hypothetically Primitive Terrestrial Atmosphere," The Origins of Prebiological Systems and of Their Molecular Matrices, 187.

19. Harada and Fox, "The Thermal Synthesis of Amino Acids from a Hypothetically Primitive Terrestrial Atmosphere," 192.

20. J. G. Lawless and C. D. Boynton, "Thermal Synthesis of Amino Acids from a Simulated Primitive Atmosphere," Nature 243 (1973): 405–407, https://www.nature.com/articles/243405a0.

21. S. W. Fox, "Response to Comments on Thermal Polypeptides," Journal of Molecular Evolution 8, no. 3 (1976): 301–304, https://link.springer.com/article/10.1007/BF01731004.

22. D. Yoshino, R. Haratsu, and E. Anders, "Origin of Organic Matter in Early Solar System—III. Amino Acids: Catalytic Synthesis," Geochimica et Cosmochimica Acta 35, no. 9 (September 1971): 927–28, https://doi.org/10.1016/0016-7037(71)90006-8; R. Hayatsu, M. H. Studier, and R. Anders, "Origin of Organic Matter in Early Solar System —IV. Amino Acids: Confirmation of Catalytic Synthesis by Mass Spectrometry," Geochimica et Cosmochimica Acta 35, no. 9 (September 1971): 939–51, https://doi.org/10.1016/0016-7037(71)90007-X E. Anders, R. Hayatsu, and M. H. Studier, "Organic Compounds in Meteorites: They May Have Formed in the Solar Nebula, by Catalytic Reactions of Carbon Monoxide, Hydrogen, and Ammonia," Science 182, no 4114 (1973): 781–790, doi:10.1126/science.182.4114.781.

۲۳- هیچ معیار کلی قابل قبولی برای قضاوت در مورد این اصطلاح تاییدشده وجود ندارد و این امر به‌ویژه برای قضاوت در مورد توضیحات منتشرشده‌ی قبل، از حدود سال ۱۹۷۰ یک مشکل است. در دوره‌ی قبل اغلب تکنیک تحلیلی واحدی، برای مثال، کروماتوگرافی کاغذی، برای «شناسایی» یک ترکیب خاص استفاده می‌شد. با تکنیک‌های بهبودیافته که عمدتا به لطف پیشرفت‌های عصر فضا در اختیار ما قرار گرفته، به‌طور گسترده‌ای اثبات شده که روش مناسب و قابل اعتماد برای شناسایی اسیدهای آمینه، آنالیز با ترکیب کروماتوگرافی گازی با طیف‌سنجی جرمی است.

24. S. Miller, H. Urey, and J. Oro, "Origin of Organic Compounds on the Primitive Earth and in Meteorites," Journal of Molecular Evolution 9 (1976): 69.

25. N. H. Horowitz, F. D. Drake, S. E. Miller, L. E. Orgel, and C. Sagan, in Biology and the Future of Man, ed. P. Handler (New York Oxford U. Press, 1970), 163.

26. Experiments summarized in Table 3-6: W. Groth and H. von Weyssenhoff, "Photochemische Bildung von Aminosäuren aus Mischungen einfacher Gase," Naturwissenschaften 44, no. 19 (January 1957): 510–11, and "Photochemical Formation of Organic Compounds from Mixtures of Simple Gases," Planetary and Space Science 2, no. 2 3 (April 1960): 79–85, https://doi.org/10.1016/0032-0633(60)90001-5; A. N. Terenin, in The Origin of Life on the Earth, 136; N. Dodonova and A. L. Sidorova, "Photosynthesis of Amino Acids from a Mixture of Simple Gases under the Influence of Ultraviolet Rays in Vacuum," Biophysics 6 (1961): 149–58.

27. Ponnamperuma, in The Origins of Prebiological Systems and of Their Molecular Matrices, 22.

28. Experiments summarized in Table 3-7: W. Groth and H. von Weyssenhoff, "Photochemical Formation of Organic Compounds from Mixtures of Simple Gases," Planetary and Space Science 2, no. 2-3 (April 1960): 79-85, https://doi.org/10.1016/0032-0633(60)90001-5; C. agan and B. N. Khare, "Long-Wavelength Ultraviolet Photoproduction of Amino Acids on the Primitive Earth," Science 173, no. 3995 (1971): 417-20, doi: 10.1126/science.173.3995.417; B. N. Khare and C. Sagan, "Synthesis of Cystine in Simulated Primitive Conditions," Nature 232 (1971): 577-79, https://www.nature.com/articles/232577a0; B. N. Khare and C. Sagan, "Experimental Interstellar Organic Chemistry: Preliminary Findings," Molecules in the Galactic Environment, eds. M. A. Gordon and L. E. Snyder (New York: John Wiley, 1973), 399; K. Hong, J. Hong, and R. Becker, "Hot Hydrogen Atoms: Initiators of Reactions of Interest in Interstellar Chemistry and Evolution," Science 184, no. 4140 (1974): 984-87, doi:10.1126/science.184.4140.984.

29. A. Bar-Nun, N. Bar-Nun, S. H. Bauer, and C. Sagan, "Shock Synthesis of Amino Acids in Simulated Primitive Environments," Science 168, no. 3930 (1970), 470–72, doi:10.1126/ science.168.3930.470; Sagan and Khare, "Long-Wavelength Ultraviolet Photoproduction of Amino Acids on the Primitive Earth," Science 173, no. 3995 (1971), 417–20, doi:10.1126/science.173.3995.417.

30. A. Bar-Nun and M. E. Teuber, "'Thunder': Shock Waves in Prebiological Organic Synthesis," Space Life Sciences https://link.springer.com/article/10.1007/BF00928170; A. Bar- Nun and A. Shaviv, "Dynamics of the Chemical Evolution of Earth's Primitive Atmosphere," Icarus 24, no. 2 (February 1975): 197–210, https://doi.org/10.1016/0019-1035(75)90099-8.

31. Miller and Orgel, The Origins of Life on the Earth, 83–117.

32. Experiments summarized in Table 3-8: J. Oro and S. S. Kamat, "Aminoacid Synthesis from Hydrogen Cyanide under Possible Primitive Earth Conditions," Nature 190 (April 1961): 442–43, https://www.nature.com/articles/190442a0; C. U. Lowe, M. W. Rees, and R. Markham, "Synthesis of Complex Organic Compounds from Simple Precursors: Formation of Amino-Acids, Amino-Acid Polymers, Fatty Acids and Purines from Ammonium Cyanide," Nature 199 (July 1963):219–22,https://www.nature.com/articles/199219a0; Friedmann, W. J. Haverland, and Stanley Miller, in Chemical Evolution and the Origin of Life, eds. R. Buvet and C. Ponnamperuma (Amsterdam: North-Holland, 1971), 123; N. Friedmann, W. J. Haverland, and Stanley Miller, in Chemical Evolution and the Origin of Life, eds. R. Buvet and C. Ponnamperuma (Amsterdam: North-Holland, 1971), 123; P. H. Abelson, "Chemical Events on the Primitive Earth," PNAS 55, no. 6 (June 1966): 1365–1372, https://doi.org/10.1073/pnas.55.6.1365; C. N. Matthews and R. E. Moser, "Peptide Synthesis from Hydrogen Cyanide and Water," Nature 215 (September 1967): 1230–34, https://www.nature.com/articles/2151230a0; Pavlovskaya and Pasynskii, in The Origin of Life on the Earth, 151; J. E. Van Trump and S. L. Miller, "Prebiotic Synthesis of Methionine," Science 178, no. 4063 (November 1972): 859–60, doi:10.1126/science.178.4063.859; R. A. Sanchez, J. P. Ferris, and L. E. Orgel, "Cyanoacetylene in Prebiotic Synthesis," Science 154, no. 3750 (November 1966): 784–85, doi:10.1126/science.154.3750.784; S. W. Fox and C. R. Windsor, "Synthesis of Amino Acids by the Heating of Formaldehyde and Ammonia," Science 170, no. 3691 (November 1970): 984–86, doi: 10.1126/science.170.3961.984; H. R. Hulett, Y. Wolman, S. L. Miller, J. Ibanez, J. Oro, S. W. Fox, and Charles R. Windsor, "Formaldehyde and Ammonia as Precursors to Prebiotic Amino Acids," Science 174, no. 4013 (December 1971): 1038–41, doi 10.1126/science.174.4013.1038.

33. J. Oro and A. P. Kimball, "Synthesis of Purines under Possible Primitive Earth Conditions. I. Adenine from Hydrogen Cyanide," Archives of Biochemistry and. Biophysics 94 (August 1961): 217–27, doi: 10.1016/0003-9861(61)90033-9; Lowe, Rees, and Markham, "Synthesis of Complex Organic Compounds," Nature 199 (July 1963): 219–22.

34. Ponnamperuma, "Abiological Synthesis of Some Nucleic Acid Constituents," 221.

35. Sanchez, Ferris, and Orgel, "Cyanoacetylene in Prebiotic Synthesis " 784.

36. S. W. Fox and R. Harada, "Synthesis of Uracil under Conditions of a Thermal Model of Prebiological Chemistry," Science 133, no. 3468 (June 1961): 1923–24, doi:10.1126/science.133.3468.1923.

37. J. Oro, “Stages and Mechanisms of Prebiological Organic Synthesis ” The Origins of Pre-biological Systems and of Their Molecular Matrices, 137.

38. E. Stephen-Sherwood, J. Oro, and A. P. Kimball, “Possible Prebiotic Condensation of Mononucleotides by Cyanamide,” Science 173, no. 3995 (July 1971): 444–46, doi 10.1126/ science.173.3995.444.

39. A. Butlerov, “Bildung einer zuckerartigen Substanz durch Synthes ” (Formation of a sugar-like substance by synthesis), Annalen der Chemie 120 (1861): 295–298.

40. Kenyon and Steinman, Biochemical Predestination, 146.

41. J. Oro and A. C. Cox, “Non-Enzymic Synthesis of 2-deoxyribose,” Federation Proceedings 21, no. 2 (1962): 80; J. Oro, “Stages and Mechanisms of Prebiological Organic Synthesis,” 137.

42. N. W. Gabel and C. Ponnamperuma, “Model for Origin of Monosaccharides,” Nature 216 (November 1967): 453–55, https://www.nature.com/articles/216453a0.

43. John Keosian, The Origin of Life (New York: Reinhold Publishing Co.,1964), 88.

44. Lemmon, “Chemical Evolution,” Chemical Reviews 70, no. 1 (1970): 95

فصل چهارم: افسانه‌ی سوپ پیش‌زیستی

1. P. H. Abelson, “Chemical Events on the Primitive Earth,” PNAS 55, no. 6 (June 1966): 1365-1372, https://doi.org/10.1073/pnas.55.6.1365; P. E. Cloud, “Atmospheric and Hydrospheric Evolution on the Primitive Earth,” Science 160, no. 3829 (May 1968): 729-736, doi: 10.1126/science.160.3829.729.

2. A. C. Lasaga, H. D. Holland, and M. J. Dwyer, “Primordial Oil Slick,” Science 174, no. 4004 (October 1971): 53-55, doi: 10.1126/science.174.4004.53.

3. J. P. Pinto, G. R. Gladstone, and Y. L. Yung, “Photochemical Production of Formalde-hyde in Earth’s Primitive Atmosphere” Science 210, no. 4466 (October 1980):183-85, doi:10.1126/science.210.4466.183; C. Ellis and A. A. Wells, The Chemical Action of Ultra-violet Rays, revised and enlarged edition by F. F. Heyroth (New York: Reinhold, 1941), 417; Abelson, “Chemical Events on the Primitive Earth,” 1365; H. R. Hulett, “Limitations on Prebiological Synthesis,” Journal of Theoretical Biology 24, no. 1 (July 1969): 56-72, https://doi.org/10.1016/S0022- 5193(69)80006-8; H. R. Hulett, in Proceedings of the Fourth Conference on Origins of Life: Chemistry and Radioastronomy, ed. Lynn Margulis (New York: Springer-Verlag, 1973), 80.

4. N. H. Horowitz, F. D. Drake, S. L. Miller, L. E. Orgel, and C. Sagan, "The Origins of Life," in Biology and the Future of Man, ed. P. Handler (New York: Oxford U. Press, 1970), 163.

5. Abelson, "Chemical Events on the Primitive Earth," 1365; J. P. Ferris and D. E. Nicodem, "Ammonia Photolysis and the Role of Ammonia in Chemical Revolution," Nature 238 (August 1972): 268-69, https://doi.org/10.1038/238268a0; J. P. Ferris and D. E. Nicodem, "Ammonia: Did It Have a Role in Chemical Evolution?," The Origin of Life and Evolutionary Biochemistry, eds. K. Dose, S. W. Fox, G. A. Deborin, and T. E. Pavlovskaya (New York: Plenum Press, 1974), 107; W. R. Kuhn and S. K. Atreya, "Ammonia Photolysis and the Greenhouse Effect in the Primordial Atmosphere of the Earth," Icarus 37 (1979): 207- 213, https://doi.org/10.1016/0019-1035(79)90126-X; J. S. Levine, "The Photochemistry of the Paleoatmosphere," Journal of Molecular Evolution https://doi.org/10.1007/BF01733042.

6. This estimate of 105–l06 years is based on the equilibrium of NH4+ and NH3 dissolved in the ocean. See J. P. Ferris and D. E. Nicodem, "Ammonia: Did It Have a Role in Chemical Evolution?," 107. For an earlier estimate of 30,000 years, see Abelson, "Chemical Events on the Primitive Earth," 1365.

7. C. Sagan, "Reducing Greenhouses and the Temperature History of Earth and Mars," Nature 269 (September 1977): 224-26, https://www.nature.com/articles/269224a0.

8. Kuhn and Atreya, "Ammonia Photolysis and the Greenhouse Effect " 207.

9. Ferris and Nicodem, "Ammonia Photolysis," 268; Ferris and Nicodem, "Ammonia: Did It Have a Role in Chemical Evolution?," 107; S. Miller, H. Urey, and J. Oro, "Origin of Organic Compounds on the Primitive Earth and in Meteorites," Journal of Molecular Evolution 9, no. 1 (December 1976): 59-72, doi: 10.1007/bf01796123.

10. Ferris and Nicodem, "Ammonia: Did It Have a Role in Chemical Evolution?," 107.

11. C. F. Davidson, "Geochemical Aspects of Atmostpheric Evolution," PNAS https://doi.org/10.1073/pnas.53.6.1194; R. T. Brinkman, "Dissociation of Water Vapor and Evolution of Oxygen in the Terrestrial Atmosphere," Journal of Geophysical Research 74, no. 23 (October 1969): 5355-68, https://doi.org/10.1029/JC074i023p05355; E. Dimroth and M. Kimberly, "Precambrian Atmospheric Oxygen: Evidence in the Sedimentary Distributions of Carbon, Sulfur, Uranium, and Iron," Canadian Journal of Earth Sciences 13, no. 9 (1976): 1161-85, https://doi.org/10.1139/e76- 119; John C. Walton, "The Chemical Composition of the Earth's Original Atmosphere," Origins 3, no. 2 (1976): 66-84, https://grisda.org/origins- 03066; J. H. Carver, "Prebiotic Atmospheric Oxygen Lev-

els," Nature 292 (July 1981): 136-38, https://doi.org/10.1038/292136a0; J. S. Levine, "The Photochemistry of the Paleoatmosphere," 161.

12. News Release No. 30-72-7, Naval Research Laboratory, Washington, D.C.; G. R. Carruthers and Thornton Page, Apollo 16 Far-Ultraviolet Camera/Spectrograph: Earth Observations," Science 177, no. 4051 (September 1973): 788-791, doi: 10.1126/science.177.4051.788.

13. G. R. Carruthers, personal communication, Sept. 28, 1981.

14. Michael I. Ratner and James C. G. Walker, "Atmospheric Ozone and the History of Life," Journal of the Atmospheric Sciences 29, no. 5 (July 1972): 803, https://journals.ametsoc.org/doi/pdf/10.1175/1520 Blake and J. H. Carver, "The Evolutionary Role of Atmospheric Ozone," Journal of the Atmospheric Sciences 34, no. 5 (May 1977): 720-28, https://journals.ametsoc.org/doi/pdf/10.1175/1520-Prebiotic Atmospheric Oxygen Levels," 136.

15.L. E. Orgel, The Origins of Life (New York: Wiley, 1973), 129; Horowitz et al., in Biology and the Future of Man, 171.

16. Hulett, "Limitations on Prebiological Synthesis," 60.

17. D. E. Hull, "Thermodynamics and Kinetics of Spontaneous Generation, https://doi.org/10.1038/186693a0.

18. Miller, Urey, and Oro, "Origin of Organic Compounds on the Primitive Earth," 59.

19. Hull, "Thermodynamics and Kinetics of Spontaneous Generation," 693.

20. L. V. Berkner and L. C. Marshall, "On the Origin and Rise of Oxygen Concentration in the Earth's Atmosphere," Journal of the Atmospheric Sciences 22, no. 3 (May 1965): 225-61, https://doi.org/10.1175/1520-

21. J. W. S. Pringle, "The Evolution of Living Matter," New Biology 16 (1954), 54-67.

22. S. L. Miller and L. E. Orgel, The Origins of Life on the Earth (Englewood Cliffs, New Jersey: Prentice-Hall, 1974), 127.

23. Horowitz et al., Biology and the Future of Man, 174.

24. Horowitz et al., Biology and the Future of Man, 174.

25. J. Brooks and G. Shaw, Origin and Development of Living Systems (London and New York: Academic Press, 1973), 78.

26. Hulett, in Proceedings, 93.

27. A. Bar-Nun, N. Bar-Nun, S. H. Bauer, and C. Sagan, "Shock Synthesis of

Amino Acids in Simulated Primitive Environments," Science 168, no. 3930 (1970), 470-72, doi:10.1126/ science.168.3930.470.

28. A. Bar-Nun et al., "Shock Synthesis of Amino Acids," 472.

29. C. Ponnamperuma, "Our Most Remote Ancestors," Chemistry 51 (1978): 6-12.

30. Hulett, "Limitations on Prebiological Synthesis," 61.

31. N. H. Horowitz and J. S. Hubbard, "The Origin of Life," Annual Review of Genetics 8 (December 1974): 393-410, https://doi.org/10.1146/annurev.ge.08.120174.002141.

32. R. Sanchez, J. Ferris, and L. E. Orgel, "Conditions for Purine Synthesis: Did Prebiotic Synthesis Occur at Low Temperatures?," Science 153, no. 3731 (July 1966): 72-73, doi: 10.1126/science.153.3731.72.

33. Hulett, "Limitations on Prebiological Synthesis," 61.

34. Josée Hulshof and Cyril Ponnamperuma, "Prebiotic Condensation Reactions in an Aqueous Medium: A Review of Condensing Agents," Origins of Life 7, no. 3 (August 1976): 197-224, https://link.springer.com/article/10.1007/BF00926938.

35. A. Nissenbaum, "Scavenging of Soluble Organic Matter from the Prebiotic Oceans," Origins of Life 7, no. 4 (December 1976): 413-416, https://link.springer.com/article/10.1007/BF00927936.

36. Abelson, "Chemical Events on the Primitive Earth," 1365.

۳۷- جالب است بدانید در شرایط غیر عادی و خاصی مانند دیابت، گروه کربونیل گلوکز با گروه آمینه‌ی پروتیین‌های سلولی پیوندهای شیمیایی ایجاد می‌کند، این فرآیندی به نام گلیکوزیلاسیون (glycosylation) است.
See Abner L. Notkins, "The Causes of Diabetes," Scientific American 241, no. 5 (November 1979): 62-73, https://www.jstor.org/stable/24965336.

38. J. F. Walker, Formaldehyde, ACS Monograph 159, 3rd ed. (New York: Reinhold, 1964), 399ff.

39. Walker, Formaldehyde, 404.

40. Walker, Formaldehyde, 399.

41. Walker, Formaldehyde, 398.

42. K. Dose, "Peptides and Amino Acids in the Primordial Hydrosphere," The Origin of Life and Evolutionary Biochemistry, 69.

43. "Amino Acids," Encyclopedia of Science and Technology, vol. 1 (New York: McGraw-Hill, 1982), 411–424.

44. Stanley L. Miller and Michael Parris, “Synthesis of Pyrophosphate Under Primitive Earth Conditions,” Nature 204, no. 4965 (1964): 1248, https://doi.org/10.1038/2041248a0; D. H. Kenyon and G. Steinman, Biochemical Predestination (New York: McGraw-Hill, 1969), 175ff and 218.

45. Abelson, “Chemical Events on the Primitive Earth,”1365.

46. Hulett, “Limitations on Prebiological Synthesis,” 62.

47. E. J. Griffith, Cyril Ponnamperuma, and Norman W. Gabel, “Phosphorus, a Key to Life on the Primitive Earth,” Origins of Life 8, no. 2 (1977): 71- 85, https://doi.org/10.1007/BF00927976

48. Abelson, “Chemical Events on the Primitive Earth,” 1365.

49. Lasaga, Holland, and Dwyer, “Primordial Oil Slick,” 53.

50. Abelson, “Chemical Events on the Primitive Earth,” 1365; P. E. Cloud, “Atmospheric and Hydrospheric Evolution on the Primitive Earth,” 729.

51. Nissenbaum, “Scavenging of Soluble Organic Matter from the Prebiotic Oceans,” 415.

52. Brooks and Shaw, Origin and Development of Living Systems, 359.

53. H. Urey, The Planets (New Haven, Conn.: Yale Univ. Press, 1952), 152.

54. Carl Sagan, “On the Origin and Planetary Distribution of Life,” Radiation-Research 15, no. 2 (1961): 174-192, https://doi.org/10.2307/3571249.

55. Y. Wolman, W. J. Haverland, and S. L. Miller, “Nonprotein Amino Acids from Spark Discharges and Their Comparison with the Murchison Meteorite Amino Acids,” PNAS 69, no. 4 (1972): 809-811, https://doi.org/10.1073/pnas.69.4.809.

56. Sagan, “On the Origin and Planetary Distribution of Life,” 176.

57. Wolman et al., “Nonprotein Amino Acids from Spark Discharges,” 811.

58. Dose, “Peptides and Amino Acids in the Primordial Hydrosphere,” 69.

59. Roger Pocklington, “Physical Sciences: Free Amino-acids Dissolved in North Atlantic Ocean Waters,” Nature 230 (April 1971): 374-75, https://doi.org/10.1038/230374a0.

60. Nissenbaum, “Scavenging of Soluble Organic Matter from the Prebiotic Oceans,” 413.

61.Nissenbaum, “Scavenging of Soluble Organic Matter from the Prebiotic Oceans,” 413.

62. Arie Nissenbaum, Dean H. Kenyon, and Joan Oró, “On the Possible Role of Organic Melanoidin Polymers as Matrices for Prebiotic Activity,” Journal of Molecular Evolution 6, no. 4 (1975): 253-270, https://link.springer.com/article/10.1007/BF01794634.

63. Hull, “Thermodynamics and Kinetics of Spontaneous Generation,” 693.

64. Dose, “Peptides and Amino Acids in the Primordial Hydrosphere,” 74.

65. Nissenbaum et al., “On the Possible Role of Organic Melanoidin Polymers,” 259.

66. J. D. Bernal, “Thermodynamics and Kinetics of Spontaneous Generation,” Nature 186, no. 4726 (May 1960): 694, https://doi.org/10.1038/186694a0.

67. Griffith, Ponnamperuma, and Gabel, “Phosphorus, a Key to Life on the Primitive Earth,” 71-85.

68. Miller and Orgel, The Origins of Life on the Earth, 129ff.

69. Hulett, “Limitations on Prebiological Synthesis,” 61.

70. R. A. Sanchez, J. P. Ferris, and L. E. Orgel, “Studies in Prebiotic Synthesis: II. Synthesis of Purine Precursors and Amino Acids from Aqueous Hydrogen Cyanide,” Journal of Molecular Biology 30, no. 2 (1967): 252:

بنابراین مقداری از نیتروژن آلی معادل یک محلول مولری سیانید می‌تواند هر $۱۰^{۶}$ سال در یک منطقه‌ی محلی جمع شود. ذخایر عظیمی از این نوع مواد می‌توانستند ایجاد شوند و محلی برای مراحل بعدی تکامل حیات را فراهم آورند.

71. Dose, “Peptides and Amino Acids in the Primordial Hydrosphere,” 75.

72. Clair Edwin Folsome, The Origin of Life: A Warm Little Pond (San Francisco: W. H. Freeman and Co., 1979), 84; Clair Edward Folsome, ed., Life: Origin and Evolution. Readings from Scientific American (San Francisco: W.H. Freeman and Co., 1979), 3.

73. Folsome, The Origin of Life, 57, 59.

74. C. N. Matthews and R. E. Moser, “Peptide Synthesis from Hydrogen Cyanide and Water,” Nature 215 (September 1967): 1230-34, https://www.nature.com/articles/2151230a0.

75. Clifford N. Matthews, “The Origin of Proteins: Heteropolypeptides from Hydrogen Cyanide and Water,” Origins of Life 6 (1975): 155-162, https://link.springer.com/article/10.1007/BF01372400; Matthew, John Nelson, Pratibha Varma, and Robert Minard, “Deuterolysis of Amino Acid Precursors: Evidence for Hydrogen Cyanide Polymers as Protein Ancestors,” Science 198, no. 4317 (1977): 622-625, doi: 10.1126/science.21452._

فصل پنجم: زمین اولیه و اتمسفر آن

1. Richard E. Dickerson, "Chemical Evolution and the Origin of Life," Scientific American 239, no. 3 (1978): 70–87, https://www.jstor.org/stable/24955800.

2. "How Did Life Begin?" Newsweek, August 6, 1979, 77.

3. Dickerson, "Chemical Evolution and the Origin of Life," 70.

4. G. Tilton and R. Steiger, "Lead Isotopes and the Age of the Earth," Science 150, no. 3705 (1965): 1805–1808, doi: 10.1126/science.150.3705.1805; Robert H. Dott, Jr., Roger L Batten, and Randall D. Sale, Evolution of the Earth, 3rd ed. (New York: McGraw- Hill, 1981), 157.

5. S. Fox and K. Dose, Molecular Evolution and the Origin of Life (San Francisco: W. H. Freeman & Co., 1972), 286.

6. Fox and Dose, Molecular Evolution and the Origin of Life, 289.

7. This is tricky business, however, as sometimes inorganic materials can be mistaken for microfossils. See E. L. Merek, "Imaging and Life Detection," Bioscience 23, no. 3 (1973): 153–159, https://doi.org/10.2307/1296458 Nigel Henbest, "'Oldest Cells' are Only Weathered Crystals," New Scientist 92, no. 1275 (1981): 164.

8. J. W. Schopf and E. S. Barghoorn, "Alga-like Fossils from the Early Precambrian of South Africa," Science 156, no. 3774 (1967): 508–512, doi: 10.1126/science.156.3774.508.

9. H. Knoll and E. S. Barghoorn, "Archean Microfossils Showing Cell Division from the Swaziland System of South Africa," Science 198, no. 4315 (1977): 396–398, doi: 10.1126/ science.198.4315.396.

10. H. D. Pflug and H. Jaeschke-Boyer, "Combined Structural and Chemical Analysis of 3,800-Myr-old Microfossils," Nature 280, no. 5722 (1979): 483, https://doi.org/10.1038/280483a0; C. Ponnamperuma, quoted in "Looking for Signs of Life," Time, Sept. 24, 1979, http://content.time.com/time/magazine/article/0,9171,947410,00.html;. Ponnamperuma at the American Chemical Society Meeting, Washington, D.C., Sept. 10, 1979.

11. J. W. Schopf, Newsweek, June 30, 1980, 61; Joseph Frankl, "Stunning Fossil Discovery Proves Life on Earth Began at Least 3.5 Billion Years Ago," Newsweek, December 18, 2017, https://www.newsweek.com/stunning-fossil-discovery-proves-life-earthbegan- least-35-billion-years-ago-751904.

12. D. R. Lowe, "Stromatolites 3,400-myr Old from the Archean of Western Australia," Nature 284, no. 5755 (1980): 441, https://doi.org/10.1038/284441a0; M. R. Walter, R. Buick, and J. S. R. Dunlop, "Stromatolites 3,400–3,500 Myr Old

from the North Pole Area, Western Australia," Nature 284, no. 5755 (1980): 443, https://doi.org/10.1038/284443a0.

13. D. Bridgewater, J. H. Allaart, J. W. Schopf, C. Klein, M. R. Walter, E. S. Barghoorn, P. Strother, A. H. Knoll, and B. E. Gorman, "Microfossil-like Objects from the Archaean of Greenland: a Cautionary Note," Nature 289, no. 5793 (1981): 51, https://doi.org/10.1038/289051a0; Henbest, "'Oldest Cells' Are Only Weathered Crystals," 164.

14. J. Brooks and G. Shaw, Origin and Development of Living Systems (London and New York: Academic Press, 1973), 73.

15. Recently a zircon from the Australian Shield area has been dated at 4.2 billion years old. See "Oldest Known Rocks Found in Australia," Science News 123, no. 25 (June 18, 1983): 389, https://www.sciencenews.org/archive/oldest-known-rocks-foundaustralia.

16. Brooks and Shaw, Origin and Development of Living Systems, 78.

17. Brooks and Shaw, Origin and Development of Living Systems, 78.

18. S. L. Miller, in Mineral Deposits and the Evolution of the Biosphere, eds. H. Holland and M. Schidlowski (New York: Springer-Verlag, 1982), 157.

19. S. Awramik, P. Cloud, C. Curtis, R. Folinsbee, H. Holland, H. Jenkyne, J. Langridge, A. Lerman, S. Miller, A. Nissenbaum, and J. Veizer, in Mineral Deposits and the Evolution of the Biosphere, 311.

20. Mitch Waldrop, "Portrait of Venus Emerges from Pioneer Data," Chemical and Engineering News, Feb. 19, 1979, 26, https://doi.org/10.1021/cen-v057n008.p026;J. B. Pollock and D. C. Black, Science 205 (1979), 56.

21. Philip H. Abelson, "Education for the 21st Century," Science 205, no. 4411 (1979): 1087, doi: 10.1126/science.205.4411.1087.

22. D. M. Butler, M. J. Newran, and R. T. Tolbert Jr., "Interstellar Cloud Material: Contribution to Planetary Atmospheres," Science 201, no. 4355 (August 1978): 522, doi: 10.1126/ science.201.4355.522.

23. Linda Garmon, "As It Was in the Beginning," Science News 119, no. 5 (1981): 72–74.

24. J. Oro, in Proceedings of the Second Conference on Origins of Life, ed. L. Margulis (Washington, D.C.: The Interdisciplinary Communication Assoc., Inc., 1971), 7.

25. Fox and Dose, Molecular Evolution and the Origin of Life, 40.

26. Roger Revelle, "On the History of the Oceans," Journal of Marine Research 14, no. 4 (December 31, 1955), 446–661.

27. P. H. Abelson, "Chemical Events on the Primitive Earth," PNAS 55, no. 6 (June 1966): 1365-1372, https://doi.org/10.1073/pnas.55.6.1365.

28. Brooks and Shaw, Origin and Development of Living Systems, 77.

29. A. I. Oparin, The Origin of Life, trans. S. Morgulis (New York: Macmillan, 1938).

30. H. C. Urey, The Planets (New Haven: Yale University Press, 1952).

31. S. L. Miller and H. C. Urey, "Organic Compound Synthes on the Primitive Earth," Science 130, no. 3370 (1959): 245–251, doi:10.1126/science.130.3370.245.

32. Fox and Dose, Molecular Evolution and the Origin of Life, 43.

33. H. D. Holland, in Petrologic Studies, eds. A. E. J. Engel, H. L. James, and B. F. Leonard (Geological Society of America, 1962), 447.

34. J. C. G. Walker, Evolution of the Atmosphere (New York: Macmillan, 1977), 210, 246.

35. J. C. G. Walker, "Oxygen and Hydrogen in the Primitive Atmosphere," Pure and Applied Geophysics 116, no. 2–3 (1978): 222–231, https://doi.org/10.1007/BF01636879.

36. J. S. Levine, "The Photochemistry of the Paleoatmosphere," Journal of Molecular Evolution 18, no. 3 (1982): 161–72, https://doi.org/10.1007/BF01733042.

37. H. D. Holland (Harvard University, Dept. of Geological Sciences), personal communication, June 24, 1983.

38. Garmon, "As It Was in the Beginning," 72.

39. Richard A. Kerr, "Origin of Life: New Ingredients Suggested," Science 210, no. 4465 (1980): 42–43, doi: 10.1126/science.210.4465.42.

40. R. C. Cowen, Technology Review, April, 1981, 8.

41.Waldrop, Chemical and Engineering News, Feb. 19, 1979, 26; James Pollock and David Black, "Implications of the Gas Compositional Measurements of Pioneer Venus for the Origin of Planetary Atmospheres," Science 205, no. 4401 (July 1979): 56–59, doi: 10.1126/ science.205.4401.56.

42. Joseph Pinto, G. Randall Gladstone, and Yuk Ling Yung, "Photochemical Production of Formaldehyde in Earth's Primitive Atmosphere," Science 210, no. 4466 (1980): 183–185, doi: 10.1126/science.210.4466.183.

43. Keizo Kawamoto and Mitsuhiko Akabosh, "Study on the Chemical Evolu-

tion of Low Molecular Weight Compounds in a Highly Oxidized Atmosphere Using Electric Discharges," Origins of Life 12, no. 2 (1982): 133–141, https://doi.org/10.1007/BF00927140; Clair Folsome, Andrew Brittain, and Michael Zelko, "Photochemical Synthesis of Bio-molecules under Anoxic Conditions," Origins of Life 13, no. 1 (1983): 49–55, https://doi.org/10.1007/BF00928763.

44. W. M. Garrison, D. C. Morrison, J. G. Hamilton, A. A. Benson, and M. Calvin, "Reduction of Carbon Dioxide in Aqueous Solutions by Ionizing Radiation," Science 114, no. 2964 (October 1951): 416, doi: 10.1126/science.114.2964.416.

45. I. S. Shklovskii and C. Sagan, Intelligent Life in the Universe (New York: Dell, 1966), 231.

46. Fox and Dose, Molecular Evolution and the Origin of Life, 44–45.

47. Fox and Dose, Molecular Evolution and the Origin of Life, 44.

48. Fox and Dose, Molecular Evolution and the Origin of Life, 45.

49. Walker, Evolution of the Atmosphere, 224.

50. Kenneth M. Towe, "Early Precambrian Oxygen: A Case against Photosynthesis " Nature 274, no. 5672 (1978): 657–661, https://doi.org/10.1038/274657a0.

51. Studies summarized in Table 5-1: L. V. Berkner and L. C. Marshall, "On the Origin and Rise of Oxygen Concentration in the Earth's Atmosphere," Journal of the Atmospheric Sciences 22, no. 3 (May 1965): 225–61, https://doi.org/10.1175/1520-0469(1965)022<0225:OTOARO>2.0.CO;2; R. T. Brinkman, "Dissociation of Water Vapor and Evolution of Oxygen in the Terrestrial Atmosphere," Journal of Geophysical Research 74, no. 23 (October 1969): 5355–68, https://doi.org/10.1029/JC074i023p05355; J. C. G. Walker, "Oxygen and Hydrogen in the Primitive Atmosphere," Pure and Applied Geophysics 116, no. 2–3 (1978): 222–231, https://doi.org/10.1007/BF01636879 J. C. G. Walker, "The Early History of Oxygen and Ozone in the Atmosphere," Pure and Applied Geophysics 117, no. 3 (1978): 498–512, https://doi.org/10.1007/BF00876630; J. F. Kasting, S. C. Liu, and T. M. Donahue, "Oxygen Levels in the Prebiological Atmosphere," Journal of. Geophysical Research 84, no. 6 (1979): 3097–3107, https://doi.org/10.1029/JC084iC06p03097; Tim B. Vander Wood Mark H. Thiemens, "The Fate of the Hydroxyl Radical in the Earth's Primitive Atmosphere and Implications for the Production of Molecular Oxygen," Journal of Geophysical Research: Oceans 85, no. C3 (1980): 1605–1610, https://doi.org/10.1029/JC085iC03p01605; James F. Kasting and James C. G. Walker, "Limits on Oxygen Concentration in the Prebiological Atmosphere and the Rate of Abiotic Fixation of Nitrogen," Journal of Geophysical Research: Oceans 86, no. C2 (1981): 1147– 1158, https://doi.org/10.1029/JC086iC02p01147; J. H. Carver, "Prebiotic Atmospheric Oxygen Levels," Nature 292 (July 1981): 136– 38, https://doi.org/10.1038/292136a0; J. S. Levine,

"The Photochemistry of the Paleoatmosphere," Journal of Molecular Evolution 18, no. 3 (1982): 161–72, https://doi.org/10.1007/BF01733042; V. M. Canuto, J. S. Levine, T. R. Augustsson, and C. L. Imhoff, "UV Radiation from the Young Sun and Oxygen and Ozone Levels in the Prebiological Palaeoatmosphere," Nature 296, no. 5860 (1982): 816, https://doi.org/10.1038/296816a0.

52. L. V. Berkner and L. C. Marshall, "On the Origin and Rise of Oxygen Concentration in the Earth's Atmosphere," Journal of the Atmospheric Sciences 22, no. 3 (1965): 225–261, https://doi.org/10.1175/1520-0469(1965)022<0225:OTOARO>2.0.CO;2.

53. R. T. Brinkman, "Dissociation of Water Vapor and Evolution of Oxygen in the Terrestrial Atmosphere," Journal of Geophysical Research 74, no. 23 (October 1969): 5355–68, https://doi.org/10.1029/JC074i023p05355.

54. Brinkman, "Dissociation of Water Vapor," 5366.

55. Walker, Evolution of the Atmosphere, 224.

56. Leigh Van Valen, "The History and Stability of Atmospheric Oxygen," Science 171, no. 3970 (1971): 439–443, doi: 10.1126/science.171.3970.439.

57. Carver, "Prebiotic Atmospheric Oxygen Levels," 136.

58. H. D. Holland, personal communication, June 24, 1983.

59. Walker, "The Early History of Oxygen and Ozone in the Atmosphere," 498; Kasting, Liu, and Donahue, "Oxygen Levels in the Prebiological Atmosphere," 3097; Vander Wood and Thiemens, "The Fate of the Hydroxyl Radical in the Earth's Primitive Atmosphere and Implications for the Production of Molecular Oxygen," 1605; Kasting and Walker, "Limits on Oxygen Concentration, 1147.

60. Canuto et al., "UV Radiation from the Young Sun and Oxygen and Ozone Levels," 816.

61. Canuto et al., "UV Radiation from the Young Sun and Oxygen and Ozone Levels," 820.

62. News Release #30-72-7 from the Naval Research Laboratory, Washington, D.C., 1972; Preliminary Report, Lunar Surface Ultraviolet Camera/Spectrograph, Apollo 16 experiment S-201.

63. G. R. Carruthers, Naval Research Laboratory, personal communications, Feb. 20, 1979 and Sept. 28, 1981.

64. George R. Carruthers, Thornton Page, and Robert R. Meier, "Apollo 16 Lyman Alpha Imagery of the Hydrogen Geocorona," Journal of Geophysical Research 81, no. 10 (1976): 1664–1672, https://doi.org/10.1029/JA081i010p01664.

65. G. R. Carruthers, personal communication, Feb. 20, 1979.

66. Berkner and Marshall, "On the Origin and Rise of Oxygen Concentration," 225.

67. Levine, "The Photochemistry of the Paleoatmosphere," 161; Carver, "Prebiotic Atmospheric Oxygen Levels," 136; Michael L. Ratner and James C. G. Walker, "Atmospheric Ozone and the History of Life," Journal of the Atmospheric Sciences 29, no. 5 (1972): 803–808, https://doi.org/10.1175/1520-0469(1972)029<0803:AOATHO>2.0.CO;2; Alastair Joseph Blake and John Henry Carver, "The Evolutionary Role of Atmospheric Ozone," Journal of the Atmospheric Sciences 34, no. 5 (1977): 720–728, https://doi.org/10.1175/1520-0469(1977)034<0720:TEROAO>2.0.CO;2; Eigil Hesstvedt, S-E. Henriksen, and Hreinn Hjartarson, "On the Development of an Aerobic Atmosphere—A Model Experiment," Geophysica Norvegica 31 (1974): 1–8; James F. Kasting and T. M. Donahue, "The Evolution of Atmospheric Ozone," Journal of Geophysical Research: Oceans 85, no. C6 (1980): 3255–3263, https://doi.org/10.1029/JC085iC06p03255.

68. Carver, "Prebiotic Atmospheric Oxygen Levels," 136–8.

69. Walker, Evolution of the Atmosphere, 263.

70. J. W. Schopf (U.C.L.A., Dept. of Earth and Planetary Sciences), personal communication, June 23, 1983.

71. Walker, Evolution of the Atmosphere, 266.

72. Walker, "Oxygen and Hydrogen in the Primitive Atmosphere," 230.

73. F. V. Chukhrov, V. I. Vinogradov, and L. P. Ermilova,"On the Isotopic Sulfur Composition of some Precambrian Strata," Mineralium Deposita 5, no. 3 (1970): 209–222, https://doi.org/10.1007/BF00201988.

74. R. Eichmann and M. Schidlowski, EOS, Transactions, American Geophysical Union 56 (1975): 176.

75. Manfred Schidlowski, Rudolf Eichmann, and Christian E. Junge, "Precambrian Sedimentary Carbonates: Carbon and Oxygen Isotope geochemistry and Implications for the Terrestrial Oxygen Budget," Precambrian Research 2, no. 1 (1975): 1–69, https://doi.org/10.1016/0301-9268(75)90018-2; see also M. Schidlowski, in The Early History of the Earth, ed. B. Windley (New York: Wiley and Sons, 1976), 525.

76. M. Schidlowski, in Mineral Deposits and the Evolution of the Biosphere, 103.

77. Wallace S. Broecker, "A Boundary Condition on the Evolution of Atmo-

spheric Oxygen," Journal of Geophysical Research 75, no. 18 (1970): 3553–3557, https://doi.org/10.1029/JC075i018p03553.

78. S. Awramik et al., in Mineral Deposits and the Evolution of the Biosphere, 314.

79. M. G. Rutten, The Origin of Life by Natural Causes (New York: Elsevier Publishing Co., 1971), 319.

80. Levine, "The Photochemistry of the Paleoatmosphere," 167.

81. S. L. Miller and L. E. Orgel, The Origins of Life on the Earth (Englewood Cliffs, New Jersey: Prentice-Hall, 1974), 119; S. L. Miller, in Mineral Deposits and the Evolution of the Biosphere, 160.

82. Rutten, The Origin of Life by Natural Causes, 253.

83. Rutten, The Origin of Life by Natural Causes, 282.

84. Fox and Dose, Molecular Evolution and the Origin of Life, 44.

85. Holland, in Petrologic Studies, 447.

86. Charles F. Davidson, "NAS Symposium on the Evolution of the Earth's Atmosphere: Geochemical Aspects of Atmospheric Evolution," PNAS 53, no. 6 (1965): 1194–1205, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC219806/.

87. Karl Krejci-Graf, cited in Fox and Dose, Molecular Evolution and the Origin of Life, 44.

88. J. W. Schopf, personal communication, June 23, 1983.

89. Walker, Evolution of the Atmosphere, 262.

90. Walker, "Oxygen and Hydrogen in the Primitive Atmosphere," 230.

91. Miller and Orgel, The Origins of Life on Earth, 50.

92. P. R. Simpson and J. F. W. Bowles, "Uranium Mineralization of the Witwatersrand and Dominion Reef systems," Philosophical Transactions of the Royal Society of London, Series A, Mathematical and Physical Sciences 286, no. 1336 (1977): 527–548, https://doi.org/10.1098/rsta.1977.0130. Referenced in Kenneth M. Towe, . "Early Precambrian Oxygen: A Case against Photosynthesis," Nature 274, no. 5672 (1978): 657, https://doi.org/10.1038/274657a0.

93. James Trow, "Uraniferous Quartz-Pebble Conglomerates and Their Chemical Relation to CO2—Deficient Atmosphere Synchronous with Glaciations of Almost Any Age," read in the Dept. of Geology, Michigan State University, East Lansing, Michigan, March 16, 1978 (also presented at 1977 GSA Annual Meetings, Seattle, Washington).

94. Walker, Evolution of the Atmosphere, 262.

95. H. D. Holland, comment at a conference on "The Early History of the Earth" (University of Leicester, England, 1975), in Walker, Evolution of the Atmosphere, 262.

96. M. Muir, comment at a conference on "The Early History of the Earth" (University of Leicester, England, 1975), in Walker, Evolution of the Atmosphere, 262.

97. B. J. Skinner, in invited oral summation of contributions at US Geological Survey Quartz-Pebble workshop, Golden, CO, Oct. 13–15, 1975.

98. D. E. Grandstaff, "Origin of Uraniferous Conglomerates at Elliot Lake, Canada and Witwatersrand, South Africa: Implications for Oxygen in the Precambrian Atmosphere," Precambrian Research 13, no. 1 (1980): 1– 26, https://doi.org/10.1016/0301-9268(80)90056-X.

99. Grandstaff, "Origin of Uraniferous Conglomerates," 1.

100. Erich Dimroth and Michael M. Kimberley, "Precambrian Atmospheric Oxygen: Evidence in the Sedimentary Distributions of Carbon, Sulfur, Uranium, and Iron," Canadian Journal of Earth Sciences 13, no. 9 (1976): 1161–1185, https://doi.org/10.1139/e76-119.

فصل ششم: باورپذیربودن آزمایش‌ها و دخالت پژوهش‌گر

1. Wilhelm E. Groth and Hanns Weyssenhoff, "Photochemische bildung von aminosäuren aus mischungen einfacher gase," Naturwissenschaften 44, no. 19 (1957): 510–511, https://doi.org/10.1007/BF00638249; Groth and Weyssenhoff, "Photochemische Bildung organischer Verbindungen aus Mischungen einfacher Gase," Annalen der Physik 459, no. 1-5 (1959): 69–77; Groth and Weyssenhoff, "Photochemical Formation of Organic Compounds from Mixtures of Simple Gases," Planetary and Space Science 2, no. 2–3 (1960): 79–85, https://doi.org/10.1016/0032- 0633(60)90001-5; C. Ponnamperuma and J. Flores, Abstracts of the American Chemical Society, 1966 (reporting on the 152nd Meeting, Sept. 11–16, in New York); A. N. Terenin, in The Origin of Life on the Earth, ed. A. I. Oparin (Oxford: Pergamon Press, 1959), 136; N. Y. Dodonova and A. I. Sidorova, "Photosynthesis of Amino Acids from a Mixture of Simple Gases Under Influence of Ultraviolet Radiation in a Vacuum," Biophysics 6, no. 2 (1961): 14.

2. H. R. Hulett, "Limitations on Prebiological Synthesis," Journal of Theoretical Biology 24, no. 1 (1969): 56–72, https://doi.org/10.1016/S0022-5193(69)80006-8; J. W. S. Pringle,"The Evolution of Living Matter," New Biology 16 (1954): 54–67; Carl Sagan, On the Origin and Planetary Distri-

bution of Life," Radiation Research 15, no. 2 (1961): 174–192, https://doi.org/10.2307/3571249; Stanley Miller, Harold C. Urey, and J. Oro, "Origin of Organic Compounds on the Primitive Earth and in Meteorites," Journal of Molecular Evolution no. 1 (1976): 59–72, https://doi.org/10.1007/BF01796123.

3. Carl Sagan and Bishun N. Khare, "Long-wavelength Ultraviolet Photoproduction of Amino Acids on the Primitive Earth," Science 173, no. 3995 (1971): 417–420, DOI: 10.1126/science.173.3995.417; Khare and Sagan, in Molecules in the Galactic Environment, eds. M. A. Gordon, and L. E. Snyder (New York: John Wiley, 1973), 399; Kong-yi Hong, Jane-Huey Hong, and Ralph S. Becker, "Hot Hydrogen Atoms: Initiators of Reactions of Interest in Interstellar Chemistry and Evolution," Science 184, no. 4140 (1974): 984–987, doi: 10.1126/science.184.4140.984.

4. N. Friedmann, W. J. Haverland and S. L. Miller, in Chemical Evolution and the Origin of Life, eds. R. Buvet and C. Ponnamperuma (Amsterdam: North-Holland, 1971), 123.

5. Friedmann, Haverland, and Miller, in Chemical Evolution, 129.

6. J. P. Ferris and D. E. Nicodem, in The Origin of Life and Evolutionary Biochemistry, eds. K. Dose, S. W. Fox, G. A. Deborin, and T. E. Pavlovskaya (New York: Plenum Press 1974), 113.

7. Sanford M. Siegel and Barbara Z. Siegel, "Vulcanism, Mercurysensitized Photo-reactions and Abiogenetic Synthesis: A Theoretical Treatment," Origins of Life and Evolution of Biospheres 7, no. 3 (1976): 175, https://link.springer.com/article/10.1007/BF00926934.

8. Stanley L. Miller and Harold C. Urey, "Organic Compound Synthes on the Primitive Earth," Science 130, no. 3370 (19569): 245–251, doi:10.1126/science.130.3370.245; Stanley L. Miller and L. E. Orgel, The Origins of Life on the Earth (Englewood Cliffs, New Jersey: Prentice- Hall, 1974), 145; Stanley L. Miller, Harold Urey, and J. Oro, "Origin of Organic Compounds on the Primitive Earth and in Meteorites," Journal of Molecular Evolution 9, no. 1 (December 1976): 59–72, doi: 10.1007/bf01796123.

9. H. R. Hulett, "Limitations on Prebiological Synthesis," Journal of Theoretical Biology 24, no. 1 (July 1969): 56–72, https://doi.org/10.1016/S0022-5193(69)80006-8.

10. H. R. Hulett, in Proceedings of the Fourth Conference on Origins of Life: Chemistry and Radioastronomy, ed. Lynn Margulis (New York: Springer-Verlag, 1973), 95.

11. C. Sagan, in Proceedings of the Fourth Conference on Origins of Life, 95.

12. A. Bar-Nun, N. Bar-Nun, S. H. Bauer, and C. Sagan, “Shock Synthesis of Amino Acids in Simulated Primitive Environments,” Science 168, no. 3930 (1970), 470–72, doi:10.1126/ science.168.3930.470.

13. H. R. Hulett, “Limitations on Prebiological Synthesis,” 64.

14. C. E. Folsome, The Origin of Life (San Francisco: W. H. Freeman & Co., 1979), 62.

15. S. W. Fox and K. Dose, Molecular Evolution and the Origin of Life (New York: Marcel Dekker, 1977), 74–75.

16. K. Harada and S. W. Fox, “The Thermal Synthesis of Amino Acids from a Hypothetically Primitive Terrestrial Atmosphere,” The Origins of Prebiological Systems and of Their Molecular Matrices (New York: Academic Press, 1965), 187.

17. Stanley L. Miller, “Production of Some Organic Compounds under Possible Primitive Earth Conditions,” Journal of the American Chemical Society 77, no. 9 (1955): 2351-2361, https://doi.org/10.1021/ja01614a001.

18. Groth and Weyssenhoff, “Photochemical Formation,” 79; C. Ponnamperuma and J. Flores, Abstracts of the American Chemical Society, 136; Dodonova and Sidorova, “Photo-synthesis of Amino Acids,” 14; Khare and Sagan, in Molecules in the Galactic Environment, 399; Hong, Hong, and Becker, “Hot Hydrogen Atoms,” 984; Carl Sagan and Bishun N. Khare, “Long-wavelength Ultraviolet Photoproduction of Amino Acids on the Primitive Earth,” Science 173, no. 3995 (1971): 417– 420, doi: 10.1126/science.173.3995.417.

19. H. Sisler, C. VanderWerf, and A. Davidson, College Chemistry, 3rd ed. (New York: Macmillan, 1967), 326–7.

20. C. Sagan, in The Origins of Prebiological Systems, 195–6, in a discussion.

21. Sagan and Khare, “Long-wavelength Ultraviolet,” 417; Sagan, in Proceedings of the Fourth Conference on Origins of Life, 97.

22. L. V. Berkner and L. C. Marshall, “On the Origin and Rise of Oxygen Concentration in the Earth’s Atmosphere,” Journal of the Atmospheric Sciences 22, no. 3 (May 1965): 225–61, https://doi.org/10.1175/1520-0469(1965)022<0225:OTOARO>2.0.CO;2.

23. Dean H. Kenyon and Gary Steinman, Biochemical Predestination (New York: McGraw-Hill 1969), 284.

24. Lynn Margulis, ed., Origins of Life: Proceedings of the First Conference [held at Princeton, New Jersey, May 21–24, 1967] (New York: Gordon and Breach, 1970).

25. Alexander Rich, in Origins of Life: Proceedings of the First Conference, 183.

26. Leslie Orgel, in Origins of Life: Proceedings of the First Conference, 183.

27. A. I. Oparin, The Origin of Life, 2nd ed., trans. S. Morgulis (New York: Dover, 1953), 146–7.

۲۸- اگر اسیدهای آمینه در آزمایش‌های سنتز استرکر (فصل سوم) تشکیل می‌شدند، آلدئیدها باید وجود می‌داشتند و از طریق واکنش با HCN اضافی مصرف می‌شدند. این تفسیر با این واقعیت مطابقت دارد که محصول اصلی در این آزمایش‌ها اسید فرمیک است و احتمالا از طریق هیدرولیز HCN به دست می‌آید. نتیجه‌ی نهایی این است که در آزمایش‌های استرکر، اسیدهای آمینه می‌توانند در محفظه تجمع کنند؛ زیرا هیچ آلدئیدی برای واکنش با آن‌ها باقی نمی‌ماند.

29. Leslie E. Orgel and Rolf Lohrmann, "Prebiotic Chemistry and Nucleic Acid Replication," Accounts of Chemical Research 7, no. 11 (1974): 368– 377, https://doi.org/10.1021/ar50083a002.

30. Kenyon and Steinman, Biochemical Predestination, 30.

31. J. Brooks and G. Shaw, Origin and Development of Living Systems (New York: Academic Press, 1973), 212.

فصل هفتم: ترمودینامیک سامانه‌های زنده

1. Victor F. Weisskopf, "Views: The Frontiers and Limits of Science: Modern Science is a Powerful Tool for Acquiring Deeper Insights into the World around Us, but We Must Also Follow Other Avenues toward Reality," American Scientist 65, no. 4 (1977): 405–411, https://www.jstor.org/stable/27847961?seq=1#page_scan_tab_contents.

2. For a reversible flow of energy such as occurs under equilibrium conditions, the equality sign applies. For irreversible energy flow, the inequality applies.

3. Rudolf Clausius, "Ueber die bewegende Kraft der Wärme und die Gesetze, welche sich daraus für die Wärmelehre selbst ableiten lassen," Annalen der Physik 79, no. 4 (1850): 368– 397, 500–524, doi:10.1002/andp.18501550403. See English Translation: "On the Moving Force of Heat, and the Laws Regarding the Nature of Heat Itself Which Are Deducible Therefrom," Philosophical Magazine: Series 4 2 (1851): 1–21, 102–119. See also Rudolf Clausius, "Über verschiedene für die Anwendung bequeme Formen der Hauptgleichungen der mechanischen Wärmetheorie," Annalen der Physik 201, no. 7 (1865): 353–400.

4. R. Caillois, Coherences Aventureuses (Paris: Gallimard, 1976).

5. H. J. Morowitz, Energy Flow in Biology (New York and London: Academic Press, 1968), 2–3.

6. H. F. Blum, Time's Arrow and Evolution (Princeton: Princeton University Press, 1951).

۷- افزایش حجم ($\Delta V > 0$) مربوط به سیستم در حال انجام کار و در نتیجه از دست دادن انرژی است. کاهش حجم ($\Delta V < 0$) مربوط به کاری است که روی سیستم انجام می‌شود.

۸- روش اندازه‌گیری آنتروپی پیکربندی در توزیع ماده و آنتروپی حرارتی توزیع انرژی، یک‌سان است.

۹. اگر $\Delta E + P\Delta V$ مثبت باشد، عبارت آنتروپی در معادله‌ی ۹-۷ به دلیل علامت منفی پیش از آن باید منفی باشد. این عدم تساوی را تنها با مثبت‌بودن ΔS می‌توان جبران کرد که دلالت بر بی‌نظمی دارد.

10. Morowitz, Energy Flow in Biology, 67.

11. Morowitz, Energy Flow in Biology, 68.

12. Ilya Prigogine, Gregoire Nicolis, and Agnes Babloyantz, "Thermodynamics of Evolution," Physics Today 25, no. 11 (1972): 23, doi: 10.1063/1.3071090.

13. H. F. Blum, "Perspectives in Evolution," American Scientist 43 (1955): 595–610, https://www.jstor.org/stable/27826702.

14. G. Nicolis and I. Prigogine, Self-Organization in Nonequilibrium Systems (New York: John Wiley, 1977), 24.

15. S. L. Miller and L. E. Orgel, The Origins of Life on the Earth (Englewood Cliffs, New Jersey: Prentice-Hall, 1974), 162–3.

فصل هشتم: ترمودینامیک و پیدایش حیات

1. Peter M. Molton, "On the Likelihood of a Human Interstellar Civilization," Journal of the British Interplanetary Society 31 (1978): 203–8.

2. G. Nicolis and I. Prigogine, Self-Organization in Nonequilibrium Systems (New York: John Wiley, 1977), 25.

3. Ilya Prigogine, Gregoire Nicolis, and Agnes Babloyantz, "Thermodynamics of Evolution," Physics Today 25, no. 11 (1972): 23, doi: 10.1063/1.3071090.

۴- « کار» در فیزیک معمولا به جابه‌جایی ضرب در نیرو اشاره دارد اما در این فصل به مفهوم کلی‌تر، یعنی به تغییر در انرژی آزاد گیبس سیستم که با پلیمریزاسیون مونومرها به پلیمرها همراه است، اشاره دارد. توضیح مناسب برای پیدایش حیات نیز مستلزم یک مدل است.

۵- مدلی برای تشکیل دیگر اجزای حیاتی سلول، از جمله غشاها و مونتاژ آن‌ها.

6. L. E. Orgel, The Origins of Life (New York: John Wiley, 1973), 189ff; Michael Polanyi, "Life's Irreducible Structure," Science 160, no. 3834 (1968): 1308–1312, doi: 10.1126/science.160.3834.1308; Hubert P. Yockey, "A Calculation of the Probability of Spontaneous Biogenesis by Information Theory," Journal of Theoretical Biology 67, no. 3 (1977): 377–398, https://doi.org/10.1016/0022-5193(77)90044-3; Jeffrey S. Wicken, "Information Transformations in Molecular Evolution," Journal of Theoretical Biology 72, no. 1 (1978): 191–204, https://doi.org/10.1016/0022-5193(78)90025-5.

7. H. P. Yockey, personal communication, 9/29/82.

معنا به برخی قراردادهای مبتنی بر نماد بستگی دارد. برای مثال، واژه‌ی "gift" در انگلیسی به معنای «هدیه» و در آلمانی به معنای «زهر» و در فرانسوی بی‌معنا است.

8. Yockey, "A Calculation of the Probability," 383.

9. Orgel, The Origins of Life, 189.

۱۰- در این‌جا از "The END" استفاده می‌کنیم، اگرچه دلیلی وجود نداشته باشد که فرض کنیم نایلون یا کریستال حتی این مقدار اطلاعات را حمل می‌کنند. البته منظور ما این است که حتی اگر این‌طور باشد، ذره‌ای از اطلاعات در دریایی از زواید غرق می‌شود.

11. Yockey, "A Calculation of the Probability," 579.

12. Wicken, "Information Transformations," 191.

13. Orgel, The Origins of Life, 190.

14. Leon Brillouin, "Maxwell's Demon Cannot Operate: Information and Entropy. I." Journal of Applied Physics 22, no. 3 (1951): 334–337, https://doi.org/10.1063/1.1699951. Brillouin, "Thermodynamics and Information Theory," American Scientist 38, no. 4 (1950): 594–599, https://www.jstor.org/stable/27826339; Brillouin, "Life, Thermodynamics, and Cybernetics," American Scientist 37, no. 4 (1949): 554–568, https://www.jstor.org/stable/29773671.

15. E. Schrodinger, What is Life? (London: Cambridge University Press, 1945).

16. Werner Ehrenberg, "Maxwell's Demon," Scientific American 217, no. 5 (1967): 103–111, https://www.jstor.org/stable/24926178; Myron Tribus and Edward C. McIrvine, "Energy and Information," Scientific American 225, no. 3 (1971): 179–190, http://www.esalq.usp.br/lepse/imgs/conteudo_thumb/mini/Energy-and- Information.pdf.

17. Brillouin, "Maxwell's Demon Cannot Operate," 335.

۱۸- Wicken و Yockey اطلاعات را کمی متفاوت با Brillouin تعریف می‌کنند. ما از تعریف بریلوین در تحلیل خود استفاده می‌کنیم. این تفاوت تا آن‌جا که به تحلیل ما در این‌جا مربوط می‌شود، بی‌اهمیت است.

19. Some intersymbol influence arising from differential atomic bonding properties makes the distribution of matter not quite random. See Hubert P. Yockey, "Self Organization Origin of Life Scenarios and Information Theory," Journal of Theoretical Biology 91, no. 1 (1981): 13–31, https://doi.org/10.1016/0022-5193(81)90370-2.

20. In Handbook of Biochemistry and Molecular Biology, Physical and Chemical Data, 3rd edition, ed. Gerald D. Fasman (Cleveland: CRC Press, 1976).

21. H. Morowitz, Energy Flow in Biology (New York: Academic Press, 1968), 98.

22. H. Borsook and H. M. Huffman, Chemistry of Amino Acids and Proteins, ed. C. L. A. Schmidt (Springfield, Mass.: Charles C. Thomas Co., 1944), 822.

23. Wicken, "Information Transformations," 191.

24. Morowitz, Energy Flow in Biology, 98, 112.

25. D. W. Armstrong, F. Nome, J. H. Fendler, and J. Nagyvary, "Novel Prebiotic Systems: Nucleotide Oligomerization in Surfactant Entrapped Water Pools," Journal of Molecular Evolution 9, no. 3 (1977): 213–223, https://doi.org/10.1007/BF01796110.

26. Brillouin, "Maxwell's Demon," 338.

27. Yockey, "Self Organization," 13.

فصل نهم: تعیین چه‌گونگی انجام کار

1. Albert L. Lehninger, Biochemistry (New York: Worth Publishers, 1970), 782.

2. Hubert P. Yockey, "A Calculation of the Probability of Spontaneous Biogenesis by Information Theory," Journal of Theoretical Biology 67 (1977): 377–398, https://doi.org/10.1016/0022-5193(77)90044-3; R. W. Kaplan, "Theoretical Considerations on Probabilities of Biopolymers and Life's Origin," Radiation and Environmental Biophysics 11, no. 1 (1974): 31–40, https://doi.org/10.1007/BF01323098.

3. Manfred Eigen, "Self Organization of Matter and the Evolution of Biological Macromolecules," Naturwissenschaften 58, no. 10 (1971): 465–523, https://doi.org/10.1007/BF00623322.

4. Gary Steinman, "Sequence Generation in Prebiological Peptide Synthesis," Archives of Biochemistry and Biophysics 121, no. 2 (August 1967): 533–539, https://doi.org/10.1016/0003-9861(67)90113-0.

5. A. G. Cairns-Smith, The Life Puzzle (Edinburgh: Oliver and Boyd, 1971).

6. F. Crick, Of Molecules and Men (Seattle: University of Washington Press, 1966), 6–7.

7. Eigen, "Self Organization of Matter," 465; S. L. Miller and L. E. Orgel, The Origins of Life on the Earth (Englewood Cliffs, New Jersey: Prentice-Hall, 1974).

8. J. B. S. Haldane, "Data Needed for a Blueprint of the First Organism," The Origins of Prebiological Systems and of Their Molecular Matrices, ed. S. W. Fox (New York: Academic Press, 1965), 11.

9. T. Dobzhansky, in "Discussion [of Gerhard Schramm, 'Synthesis of Nucleosides and Poly-nucleotides with Metaphosphate Esters']," The Origins of Prebiological Systems and of Their Molecular Matrices, 310.

10. Ludwig von Bertalanffy, Robots, Men and Minds (New York: George Braziller, 1967), 82.

11. Gary Steinman and Marian N. Cole, "Synthesis of Biologically Pertinent Peptides under Possible Primordial Conditions," PNAS 58, no. 2 (1967): 735–42, doi: 10.1073/ pnas.58.2.735; Steinman, "Sequence Generation," 533.

12. A. Katchalsky, "Prebiotic Synthesis of Biopolymers on Inorganic Templates," Naturwissenschaften 60, no. 5 (1973): 215–220, https://doi.org/10.1007/BF00625709 Melvin Calvin, "Chemical Evolution: Life is a Logical Consequence of Known Chemical Principles Operating on the Atomic Composition of the Universe," American Scientist 63, no. 2 (1975): 169–177, https://www.jstor.org/stable/27845361; C. E. Folsome, The Origin of Life (San Francisco: W. H. Freeman, 1979), 104; Klaus Dose, "Prebiotic Polypeptides and the Origin of Biological Information," Naturwissenschaften 70, no. 8 (1983): 378–382, https://doi.org/10.1007/BF01047173.

13. Steinman, "Sequence Generation," 533; Steinman and Cole, "Synthesis of Biologically Pertinent Peptides," 735.

۱۴- دی‌پپتیدها بر حسب افزایش حجم زنجیره‌های جانبی باقی‌مانده‌های تشکیل‌دهنده فهرست شده‌اند. Gly گلیسین، Ala آلانین، Val والین، Leu لوسین، Ile ایزولوسین و Phe فنیل آلانین مثال:

Gly- Ala = گلیسیل آلانین. فراوانی پیوند دی‌پپتیدی استینمن و کول که به‌طور تجربی تعیین شد، نرمال‌سازی شدند و با فراوانی به دست آمده از طریق شمارش فراوانی‌های پیوند پپتیدی واقعی در ده پروتیین مقایسه شدند، با این‌که تمام باقی‌مانده‌های سریل و ترئونیل به عنوان گلیسین و تمام باقی‌مانده‌های آسپارتیل و گلوتامیل به عنوان آلانین شمارش می‌شوند. ده پروتیین مورد استفاده عبارت‌اند از: لیزوزیم تخم‌مرغ، ریبونوکلئاز، انسولین گوسفند، میوگلوبین نهنگ، سیتوکروم c مخمر، ویروس موزاییک تنباکو، بتا کورتیکوتروپین، گلوکاگون، هورمون محرک ملانوسیت و کیموتریپسینوژن.

Because of ambiguity regarding sequences used by S/C, all sequences are those shown in Atlas of Protein Sequence and Structure, volume V, ed. M. O. Dayhoff (National Biomedical Research Foundation, Georgetown University Medical Center, Washington, D.C., 1972). The experimentally determined dipeptide frequencies were obtained with aqueous solutions containing 0.01 M each amino acid, 0.125 N HCl, 0.1 M sodium dicyanamide. Kok and Bradley's (K/B) calculated dipeptide frequencies were obtained by counting actual peptide bond frequencies for the same ten proteins with (wa) and without (woa) SIC assumptions. The numbers in brackets are for one protein, enterotoxin B, with (wa) and without (woa) S/C assumptions. The numbers in parentheses are for twenty-five proteins with (wa) and without (woa) S/C assumptions. The twenty-five proteins are the ten used by S/C and alpha S1 Casein (bovine); azurin (bordetella bronchiseptica); carboxypeptidase A (bovine); cytochrome b5 (bovine); enterotoxin B; elastase (pig); glyceraldehyde 3-phosphate dehydrogenase (lobster); human growth hormone; human hemoglobin beta chain; histone IIB2 (bovine); immunoglobulin gamma-chain 1, V-I (human EU); penicillinase (bacillus licheniformis 749/c); sheep prolactin; subtilisin (bacillus amyloliquefaciens); and tryptophan synthetase alpha chain (Ecoli K-12). Sequences are those shown in Atlas of Protein Sequence and Structure, vol. V, ed. Dayhoff (1972). Note disagreement between S/C and K/B calculated results. Also K/B calculated results are at variance with S/C experimental values for one, ten, or twenty-five proteins, with (wa) or without (woa) S/C assumptions.

15. Hubert P. Yockey, "Self Organization Origin of Life Scenarios and Information Theory," Journal of Theoretical Biology 91, no. 1 (1981): 13–31, https://doi.org/10.1016/0022-5193(81)90370-2.

16. Katchalsky, "Prebiotic Synthesis," 215.

17. H. R. Hulett, "Limitations on Prebiological Synthesis," Journal of Theoretical Biology 24, no. 1 (1969): 56–72, https://doi.org/10.1016/S0022-5193(69)80006-8.

18. Katchalsky, "Prebiotic Synthesis," 216.

19. A. E. Wilder-Smith, The Creation of Life (Wheaton, Ill.: Harold Shaw, 1970), 67.

20. G. Nicolis and I. Prigogine, Self-Organization in Nonequilibrium Systems (New York: Wiley, 1977).

21. Ilya Prigogine, Gregoire Nicolis, and Agnes Babloyantz, Thermodynamics of Evolution," Physics Today 25, no. 11 (1972): 23– 31, doi: 10.1063/1.3071090.

22. Eigen, "Self Organization of Matter," 465.

23. Prigogine, Nicolis, and Babloyantz, "Thermodynamics of Evolution," 23– 31.

24. Prigogine, Nicolis, and Babloyantz, “Thermodynamics of Evolution,” 23–31; Nicolis and Prigogine, Self-Organization in Nonequilibrium Systems.

25. J. C. Walton, “Organization and the Origin of Life.” Origins 4, no. 1 (1977): 16 35.

26. P. T. Mora, “The Folly of Probability,” The Origins of Prebiological Systems and of Their Molecular Matrices, 39.

27. E. R. Harrison, in Hierarchical Structures, ed. L. L. Whyte, A. G. Wilson, and D. Wilson (New York: Elsevier, 1969), 87.

28. Nicolis and Prigogine, Self-Organization in Nonequilibrium Systems.

29. Eigen, “Self Organization of Matter,” 465; Eigen, “Molecular Selforganization and the Early Stages of Evolution,” Quarterly Reviews of Biophysics 4, no. 2–3 (1971): 149–212, https://doi.org/10.1017/S0033583500000627.

30. Kaplan, “Theoretical Considerations,” 31.

۳۱- تنها «سیستم‌های تکثیرکننده»ی شناخته‌شده (یعنی سیستم‌هایی که قادر به تکثیر بدون کمک بیوشیمی‌دانی ماهر هستند) سلول‌های زنده هستند. یکی از ساده‌ترین سلول‌ها باکتری Mycoplasma genitalium است.

A 1997 study estimated 468 proteins in M. genitalium, and a 2000 study estimated 483. See Daniel Fischer and David Eisenberg, “Assigning Folds to the Proteins Encoded by the Genome of Mycoplasma genitalium,” PNAS 94 (1997): 11929-11934, https://doi.org/10.1073/pnas.94.22.11929. See also Suganthi Balasubramanian, Tamara Schneider, Mark Gerstein, and Lynne Regan, “Proteomics of Mycoplasma genitalium: Identification and Dharacterization of Unannotated and Atypical Proteins in a Small Model Genome,” Nucleic Acids Research 28 (2000): 3075–82, doi: 10.1093/nar/28.16.3075. However, M. genitalium is not free-living; it’s a parasite. The smallest known free-living organism is Pelagibacter ubique, with over 1300 proteins. See Candidatus Pelagibacter ubique at The National Center for Biotechnology Information (website), https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?mode=Info&id=198252&lvl=3&lin=f&keep=1&srchmode=1&unlock.

32. J. Brooks and G. Shaw, Origin and Development of Living Systems (New York: Academic Press, 1963), 209.

33. S. W. Fox and K. Dose, Molecular Evolution and the Origin of Life, revised edition (New York: Marcel Dekker, 1977).

34. Fox has modified this picture in recent years by developing “low temperature” syntheses, i.e., 90°–120°C. See S. W. Fox, “Response to Comments on Thermal Polypeptides,” Journal of Molecular Evolution 8, no. 3 (1976): 301–304, https://doi.org/10.1007/BF01731004. See also Duane L. Rohlfing, “Ther-

mal Polyamino Acids: Synthesis at Less than 100 Degrees C," Science 193, no. 4247 (1976): 68–70, doi: 10.1126/science.935858.

35. P. A. Temussi, L. Paolillo, L. Ferrera, L. Benedetti, and S. Andini "Structural Characterization of Thermal Prebiotic Polypeptides," Journal of Molecular Evolution 7, no. 2 (1976): 105–110, https://doi.org/10.1007/BF01732469.

به پیوندهای پپتیدی مربوط به گروه β-کربوکسیل اسید آسپارتیک، گروه γ-کربوکسیل اسید گلوتامیک و گروه ε-آمینه لیزین اشاره دارد که هرگز در پروتیین‌های طبیعی یافت نمی‌شوند. پروتیین‌های طبیعی منحصرا از پیوندهای پپتیدی α استفاده می‌کنند.

36. It is noted, however, that Fox has long disputed this.

37. Miller and Orgel, The Origins of Life on the Earth, 144.

38. Folsome, The Origin of Life, 87.

39. Temussi, Paolillo, Ferrera, Benedetti, and Andini, "Structural Characterization," 105.

40. Some studies indicate less than 50% α-links in peptides formed by reacting random mixtures of amino acids. See Temussi, Paolillo, Ferrera, Benedetti, and Andini, "Structural Characterization," 105.

41. Krishna Bahadur and K. Ranganayaki, "Formation of Peptide Bonds in Aqueous Solution and Aqueous Line of Molecular Evolution," PNAS, India 27 (1958): 292.

42. S. W. Fox and K. Dose, Molecular Evolution and the Origin of Life (San Francisco: W. H. Freeman, 1972), 142.

43. Josée Hulshof and Cyril Ponnamperuma, "Prebiotic Condensation Reactions in an Aqueous Medium: a Review of Condensing Agents," Origins of Life 7, no. 3 (1976): 197– 224, https://doi.org/10.1007/BF00926938.

44. Clifford N. Matthews and Robert E. Moser, "Prebiological Protein Synthesis," PNAS 56, no. 4 (1966): 1087, doi: 10.1073/pnas.56.4.1087; Clifford N. Matthews, "The Origin of Proteins: Heteropolypeptides from Hydrogen Cyanide and Water," Origins of Life 6, no. 1–2 (January 1975): 155–162, https://doi.org/10.1007/BF01372400; C. Matthews, J. Nelson, P. Varma, and R. Minard, "Deuterolysis of Amino Acid Precursors: Evidence for Hydrogen Cyanide Polymers as Protein Ancestors," Science 198, no. 4317 (1977): 622–25, doi: 10.1126/science.21452; Clifford N. Matthews, "Heteropolypeptides on Titan?," Origins of Life 12, no. 3 (1982): 281–283, https://doi.org/10.1007/BF00926899.

45. Clifford N. Matthews and Robert E. Moser, "Peptide Synthesis from Hydrogen Cyanide and Water," Nature 215, no. 5107 (1967): 1230, https://doi.org/10.1038/2151230a0.

46. J. P. Ferris, D. B. Donner, and A. P. Lobo, “Possible Role of Hydrogen Cyanide in Chemical Evolution: Investigation of the Proposed Direct Synthesis of Peptides from Hydrogen Cyanide,” Journal of Molecular Biology 74, no. 4 (1973): 499–510, https://doi.org/10.1016/0022- 2836(73)90042-9.

47. James P. Ferris and Clifford N. Matthews, “HCN Did Not Condense to Give Heteropolypeptides on the Primitive Earth,” Science 203, no. 4385 (1979): 1135 1137, https://www.jstor.org/stable/1747399.

48. Ferris and Matthews, “HCN Did Not Condense,” 1136.

49. Katchalsky, “Prebiotic Synthesis,” 215.

50. Richard E. Dickerson, “Chemical Evolution and the Origin of Life,” Scientific American 239, no. 3 (1978): 70–87, https://www.jstor.org/stable/24955800.

51. Miller and Orgel, The Origins of Life on the Earth, 148.

فصل دهم: پیش‌سلول

1. William Day, Genesis on Planet Earth: The Search for Life’s Beginning (East Lansing, MI: The House of Talos Publications, 1979), 310.

2. Sidney W. Fox and Klaus Dose, Molecular Evolution and the Origin of Life (San Francisco: W. H. Freeman, 1972), 198.

3. A. I. Oparin, The Origin of Life on the Earth, trans. Ann Synge (New York: Academic Press, 1957), 301–321, and in The Origin of Prebiological Systems, ed. S. W. Fox (New York: Academic Press, 1965), 331.

4. K. Bahadur, Synthesis of Jeewanu, the Protocell (Allahabad: Ram Narain Lal Beni Prasad, 1966).

5. M. Labadie, G. Cohere, and C. Brechenmacher, “Recherches sur l’évolution prébiologique. II Etude morphologique des microsphérules obtenues à partir du cyanure d›ammonium,” Comptes Rendus des Seances de la Societe de Biologie 161 (1967): 1689–1693.

6. A. L. Herrera, Bull. Lab. Plasmogenie, Mex. 2 (1940), 3.

7. A. L. Herrera, “A New Theory of the Origin and Nature of Life,” Science 96, no. 2479 (1942): 14–14, doi: 10.1126/science.96.2479.14.

8. A. E. Smith, J. J. Silver, and G. Steinman, “Cell-like Structures from Simple Molecules Under Simulated Primitive Earth Conditions,” Experientia 24, no. 1 (1968): 36–38, https://doi.org/10.1007/BF02136777.

9. C. E. Folsome, R. D. Allen, and N. Ichinose, “Organic Microstructures as Products of Miller-Urey Electrical Discharges,” Precambrian Research 2, no. 3

(1975): 263–275, https://doi.org/10.1016/0301-9268(75)90012-1.

10. Arie Nissenbaum, Dean H. Kenyon, and J. Oro, "On the Possible Role of Organic Melanoidin Polymers as Matrices for Prebiotic Activity," Journal of Molecular Evolution 6, no. 4 (1975): 253–270, https://doi.org/10.1007/BF01794634; D. H. Kenyon and A. Nissenbaum, "Melanoidin and Aldocyanoin Microspheres: Implications for Chemical Evolution and Early Precambrian Micropaleontology," Journal of Molecular Evolution 7, no. 3 (1976): 245–251, https://doi.org/10.1007/BF01731491.

11. David W. Deamer and J. Oro, "Role of Lipids in Prebiotic Structures," Biosystems 12, no. 3–4 (1980): 167–175, https://doi.org/10.1016/0303-2647(80)90014-3.

12. William Stillwell, "Facilitated Diffusion as a Method for Selective Accumulation of Materials from the Primordial Oceans by a Lipid-vesicle Protocell," Origins of Life 10, no. 3 (1980): 277–292, https://doi.org/10.1007/BF00928406.

13. Kenyon and Nissenbaum, "Melanoidin and Aldocyanoin Microspheres," 246.

14. Kenyon and Nissenbaum, "Melanoidin and Aldocyanoin Microspheres," 246.

15. Kenyon and Nissenbaum, "Melanoidin and Aldocyanoin Microspheres," 246.

16. Sidney W. Fox and Clair E. Folsome, "Organic Microstructures and Terrestrial Protocells," Naturwissenschaften 64, no. 7 (July 1977): 380– 381, https://doi.org/10.1007/BF00368740.

17. Fox and Folsome, "Organic Microstructures and Terrestrial Protocells."

18. Sidney W. Fox and Tadayoshi Nakashima, "The Assembly and Properties of Protobio-logical Structures: The Beginnings of Cellular Peptide Synthesis," BioSystems 12, no. 3–4 (1980): 155–166, https://doi.org/10.1016/0303-2647(80)90013-1.

19. Deamer and Oro, "Role of Lipids in Prebiotic Structures," 171.

20. Day, Genesis on Planet Earth, 313.

21. C. E. Folsome, The Origin of Life: A Warm Little Pond (San Francisco: W. H. Freeman, 1979), 83.

22. Folsome, The Origin of Life: A Warm Little Pond, 83.

23. Stillwell, "Facilitated Diffusion as a Method for Selective Accumulation of Materials," 277.

24. Herrera, “A New Theory of the Origin and Nature of Life,” 14.

25. Smith, Silver, and Steinman, “Cell-like Structures from Simple Molecules,” 36.

26. K. A. Grossenbacher and C. A. Knight, in The Origin of Prebiological Systems and of Their Molecular Matrices, ed. S. W. Fox (New York: Academic Press, 1965), 173.

27. .K. Bahadur and J. L. Gupta, “Cytological Studies of Abiogenically Aynthesized Jeewanu Cell-like Micro-structures,” Zentralblatt fur Bakteriologie, Parasitenkunde, Infektionskrankheiten und Hygiene. Zweite naturwissenschaftliche Abt.: Allgemeine, landwirtschaftliche und technische Mikrobiologie 127, no. 7 (1972): 643–648.

28. K. Bahadur, Indian Natural Sciences Academy 39B (1973), 455.

29. A. I. Oparin, Genesis and Evolutionary Development of Life (New York: Academic Press, 1968).

30. Fox and Dose, Molecular Evolution and the Origin of Life, 198.

31. Kenyon and Nissenbaum, “Melanoidin and Aldocyanoin Microspheres,” 245.

32. R. J. Goldacre, in Surface Phenomena in Chemistry and Biology, ed. J. F. Danielli (New York: Pergamon Press, 1958), 278.

33. W. R. Hargreaves and D. W. Deamer, in Light Transducing Membranes: Structure, Function and Evolution, ed. D. W. Deamer (New York: Academic Press, 1978).

34. H. C. Bungenberg de Jong, “Die Koazervation und ihre Bedeutung für die Biologie,” Protoplasma 15, no. 1 (1932): 110–173, https://doi.org/10.1007/BF01610198; and in A. I. Oparin, ed., The Origin of Life on the Earth.

35. Stillwell, “Facilitated Diffusion as a Method for Selective Accumulation of Materials,” 277.

36. A. I. Oparin, The Origin of Life on the Earth, trans. Ann Synge (New York: Academic Press, 1957), 301.

۳۷- به واسطه‌ی نیروهای فیزیکی جاذبه به نیروهای تعاملی ضعیفی اشاره می‌کنیم که در زیر ذکر شده است: ۱- پیوند هیدروژنی ۲- یک دوقطبی، دوقطبی دیگر را جذب می‌کند (نیروهای دوقطبی–دوقطبی جاذبه‌های الکترواستاتیک ضعیفی هستند). ۳- نیروهای جانبی پیوستگی (نیروهای ضعیف بین مولکول‌های مشابه که احتمالا از نیروهای واندروالس تشکیل شده‌اند). ۴- آب‌دوستی و آب‌گریزی (حاصل سه نیروی قبلی) این نیروهای فیزیکی جاذبه ضد نیروهایی

هستند که پیوندهای شیمیایی را تشکیل می‌دهند: ۱– اشتراک الکترون‌ها (پیوند کووالانسی). ۲– انتقال الکترون (پیوندهای یونی) ۳– پیوند فلزی نیروهای شیمیایی بسیار قوی‌تر از نیروهای فیزیکی است و معمولا برای شکستن و تشکیل پیوندهای جدید به واکنش شیمیایی نیاز دارند اما نیروهای فیزیکی نیازی به واکنش شیمیایی ندارند.

38. S. W. Fox, K. Harada, G. Kramptiz, and G. Mueller, "Chemical Origin of Cells," Chemical and Engineering News 48 (June 22, 1970): 80–94, https://doi.org/10.1021/cenv048n026.p080.

39. Fox and Dose, Molecular Evolution and the Origin of Life, 220.

40. A. E. Wilder-Smith, The Creation of Life (Wheaton, Ill.: Harold Shaw Publishers, 1970), 84–85.

41. Wilder-Smith, The Creation of Life, 84–85.

42. Fox and Dose, Molecular Evolution and the Origin of Life, 233.

43. Fox et al., "Chemical Origin of Cells," 90.

44. Fox and Nakashima, "The Assembly and Properties of Protobiological Structures,"155.

45. Herrera, "A New Theory of the Origin and Nature of Life," 14.

46. Bahadur, Synthesis of Jeewanu, the Protocell.

47. Dean H. Kenyon and Gary Steinman, Biochemical Predestination (New York: McGraw-Hill, 1969), 251.

48. Fox et al., "Chemical Origin of Cells," 92.

49. Fox et al., "Chemical Origin of Cells," 92.

50. .Fox et al., "Chemical Origin of Cells," 92.

51. Fox et al., "Chemical Origin of Cells," 92.

52. Oparin, Genesis and Evolutionary Development of Life, 105.

53. Stanley L. Miller and Leslie E. Orgel, The Origins of Life on the Earth (Englewood Cliffs, New Jersey: Prentice-Hall, 1974), 144.

54. Miller and Orgel, The Origins of Life on the Earth, 144.

55. P. A. Temussi, "Response to Comments on Thermal Polypeptides," Journal of Molecular Evolution 8, no. 3 (1976): 301–304, https://doi.org/10.1007/BF01731004.

56. Folsome, The Origin of Life: A Warm Little Pond, 87.

57. Stanley L. Miller and Harold C. Urey, "Organic Compound Synthesis on the Primitive Earth," Science 130, no. 3370 (1959): 245–251, doi:10.1126/science.130.3370.245.

58. Miller and Orgel, The Origins of Life on the Earth, 145.

59. Folsome, The Origin of Life: A Warm Little Pond, 87.

60. Day, Genesis on Planet Earth, 319.

61. Day, Genesis on Planet Earth, 319.

62. Day, Genesis on Planet Earth, 320.

63. Folsome, The Origin of Life: A Warm Little Pond, 85.

64. Folsome, The Origin of Life: A Warm Little Pond, 84.

65. Alec D. Bangham and R. W. Horne, "Negative Staining of Phospholipids and their Structural Modification by Surface-active Agents as Observed in the Electron Microscope," Journal of Molecular Biology 8, no. 5 (1964): 660-IN10, https://doi.org/10.1016/S0022-2836(64)80115-7.

66. Deamer and Oro, "Role of Lipids in Prebiotic Structures," 171.

67. Deamer and Oro, "Role of Lipids in Prebiotic Structures," 171.

68. Stillwell, "Facilitated Diffusion as a Method for Selective Accumulation of Materials," 290.

69. William Stillwell, "Facilitated Diffusion of Amino Acids across Bimolecular Lipid Membranes as a Model for Selective Accumulation of Amino Acids in a Primor-dial Protocell,"BioSystems 8, no. 3 (1976), 111–117, https://doi.org/10.1016/0303-2647(76)90014-9.

70. Deamer and Oro, "Role of Lipids in Prebiotic Structures," 173.

71. "Role of Lipids in Prebiotic Structures," 171.

72. Stillwell, "Facilitated Diffusion of Amino Acids," 111.

73. Stillwell, "Facilitated Diffusion of Amino Acids," 112.

74. Folsome, Allen, and Ichinose, "Organic Microstructures," 263; Folsome, The Origin of Life: A Warm Little Pond, 87–90.

75. Fox and Folsome, "Organic Microstructures and Terrestrial Protocells."

76. D. E. Green and R. F. Goldberger, Molecular Insights into the Living Process (New York: Academic Press, 1967), 407.

فصل یازدهم: خلاصه و نتیجه‌گیری

1. Michael Polanyi, “Life Transcending Physics and Chemistry,” Chemical Engineering News 45, no. 35 (August 21, 1967): 54.

2. N. W. Pirie, “Some Assumptions Underlying Discussion on the Origins of Life,” Annals of the New York Academy of Science 66 (1957): 369, https://doi.org/10.1111/j.1749-6632.1957.tb49672.x.

3. Peter T. Mora, “Urge and Molecular Biology,” Nature 199 (July 1963): 212–219, https://doi.org/10.1038/199212a0.

4. Spoken by the fictional lawyer “Perry Mason,” in Erle Stanley Garner, The Case of the Perjured Parrot (New York: William Morrow and Company, 1939).

فصل دوازدهم: سخن پایانی

1. This section draws heavily on the theoretical analysis of John C. Walton in an article entitled “Organization and the Origin of Life,” Origins 4, no. 1 (1977): 16–35, https://www.grisda.org/origins-04016.

2. Walter M. Elsasser, The Physical Foundation of Biology: An Analytical Study (New York and London: Pergamon Press, 1958); Elsasser, Atom and Organism: A New Theoretical Approach to Biology (Princeton: Princeton University Press, 1966).

3. Martin A. Garstens, “Statistical Mechanics and Theoretical Biology,” in Toward a Theoretical Biology, ed. C. H. Waddington, vol. 2, Sketching Theoretical Biology (Piscataway, NJ: Transaction Publishers, 1969), 285– 292; Garstens, “Remarks on Statistical Mechanics and Theoretical Biology,” in Toward a Theoretical Biology, ed. C. H. Waddington, vol. 3, Organization, Stability, and Process (Piscataway, NJ: Transaction, 1970), 167–73. Both titles, and in fact all four volumes in the series, are now available from Routledge (Taylor & Francis).

4. Peter T. Mora, “Urge and Molecular Biology,” Nature 199, no. 4890 (1963): 212–219, https://doi.org/10.1038/199212a0.

5. E. P. Wigner, “The Probability of the Existence of a Self-Reproducing Unit,” in The Logic of Personal Knowledge: Essays Presented to M. Polanyi, eds. Thomas Langford and William Poteat (London: Routledge and Kegan Paul, 1961), 231.

6. J. von Neumann, Mathematische Grundlagen der Quantenmechanik [Berlin: Julius Springer, 1932], trans. Robert T. Beyer (Princeton: Princeton University Press, 1955), chap. 5.

7. Wigner, "The Probability of the Existence of a Self-Reproducing Unit," 235.

8. Peter T. Landsberg, "Does Quantum Mechanics Exclude Life?," Nature 203, no. 4948 (1964): 928–930, https://doi.org/10.1038/203928a0.

9. Michael Polanyi, "Life Transcending Physics and Chemistry," Chemical Engineering News 45, no. 35 (August 21, 1967): 54.

10. Christopher Longuet-Higgins, "What Biology Is About," in Sketching Theoretical Biology, 227–235.

11. E. Schrodinger, What is Life? (New York: MacMillan: 1945). Howard H. Pattee, "The Physical Basis of Coding and Reliability in

12. Biological Evolution," in Sketching Theoretical Biology, 268–284; Pattee, "The Problem of Biological Hierarchy," in Organization, Stability, and Process, 117–136; Pattee, "Laws and Constraints, Symbols and Languages," in Toward a Theoretical Biology, ed. C. H. Waddington, vol. 4, Biological Processes in Living Systems (Piscataway, NJ: Transaction, 1972), 248–258.

13. David Bohm, "Some Remarks on the Notion of Order," in Sketching Theoretical Biology, 18–40.

14. S. Arrhenius, Worlds in the Making (New York: Harper and Row, 1908).

15. J. Brooks and G. Shaw, Origin and Development of Living Systems (London and New York: Academic Press, 1973), 360.

16. F. Hoyle and N. C. Wickramasinghe: Lifecloud (London: J. M. Dent, 1978); Diseases from Space (London: J. M. Dent, 1979); Space Travelers: The Bringers of Life (Cardiff: University of Cardiff Press, 1981); Evolution from Space (London: J. M. Dent, 1981).

17. More recent reports challenge this interpretation. See Michael H. Engel and Bartholomew Nagy, "Distribution and Enantiomeric Composition of Amino Acids in the Murchison Meteorite," Nature 296 (1982), 837–40, https://doi.org/10.1038/296837a0.

18. C. Ponnamperuma, quoted in "Odds Favor Life beyond the Earth," Knight-Ridder news wire, Dallas Times Herald, January 10, 1979, B3.

19. Francis H. C. Crick and Leslie E. Orgel, "Directed Panspermia," Icarus 19, no. 3 (1973): 341–346, https://doi.org/10.1016/0019-1035(73)90110- 3.

20. John A. Ball, "The Zoo Hypothesis," Icarus 19, no. 3 (1973): 347–349, https://doi.org/10.1016/0019-1035(73)90111-5.

21. T. Gold, Air Force and Space Digest, May 1960, 65.

22. Brooks and Shaw, Origin and Development of Living Systems, 360.

23. A. Dauvillier, The Photochemical Origin of Life (New York: Academic Press, 1965), 2.

24. Francis Crick, Life Itself (New York: Simon and Schuster, 1981), 79.

25. Crick, Life Itself, 144.

26. Crick, Life Itself, 153.

27. Robert T. Rood and James S. Trefil, Are We Alone? (New York: Charles Scribner's Sons, 1981); I. S. Shklovskii and Carl Sagan, Intelligent Life in the Universe (San Francisco: Holden-Day, 1966); Frank Tipler, "Extraterrestrial Intelligent Beings Do Not Exist," Physics Today 34, No. 4 (April 1981): 9, 70ff, https://doi.org/10.1063/1.2914542.

28. Tipler, 71.

29. Tipler, 71.

30. Hoyle and Wickramasinghe, Evolution From Space.

31. Hoyle and Wickramasinghe, Evolution From Space, 148, 24, 150, 30, 31.

32. Hoyle and Wickramasinghe, Evolution From Space, 143, 130, 130, 96, 96, 130.

33. Hoyle and Wickramasinghe, Evolution From Space, 33.

34. Hoyle and Wickramasinghe, Evolution From Space, 130, 147.

35. Hoyle and Wickramasinghe, Evolution From Space, 51.

36. Hoyle and Wickramasinghe, Evolution From Space, 31, 139.

37. Hoyle and Wickramasinghe, Evolution from Space, 142–145. The present authors (Thaxton, Bradley, and Olsen) see such a scheme of intermediate intelligences also in the writings of Plotinus, the founder of neo- Platonism. See Plotinus, Enneads, trans. Stephen MacKenna (London: Faber and Faber, 1966).
این احتمال وجود دارد که هویل و ویکراماسینگه تحت تاثیر فلوطین و/یا تفکر دینی شرقی باشند که در برخی اشکال آن امکان وجود هوش‌های واسطه یا قدرت‌های خلاق در جهان وجود دارد. ویکراماسینگه بودایی است.

38. Hoyle and Wickramasinghe, Evolution From Space, 126.

39. Hoyle and Wickramasinghe, Evolution From Space, 127.

40. Hoyle and Wickramasinghe, Evolution From Space, 127.

41. Hoyle and Wickramasinghe, Evolution From Space, 127.

۴۲- باید اذعان داشت که تفکر مبتنی بر ماده‌ی خنثی و بی‌اثر تا پیش از انقلاب علمی قرن ۱۶ و

۱۷ مانند دوران ما درک نمی‌شد. اما این موضوع در رابطه با نخستین حیات اهمیت چندانی ندارد؛ زیرا همان‌طور که در فصل دوم اشاره شد، کلیسا پیدایش خودبه‌خودی را تنها به عنوان پیدایش ثانویه در نظر گرفت.

43. J. D. Bernal, The Origin of Life (London: George Weidenfield and Nicholson, 1967), 141.

44. J. W. N. Sullivan, The Limitations of Science (11th printing; New York: Mentor Books, 1963). See back cover of Mentor edition for the time reference of the quotation.

45. Sullivan, The Limitations of Science, 94.

46. Sullivan, The Limitations of Science, 94.

47. A. Einstein, quoted in Robert Jastrow, God and the Astronomers (New York: W. W. Norton & Company, 1978), 113.

48. Hans Gaffron, in Evolution After Darwin, ed. Sol Tax, vol. 1, The Evolution of Life (Chicago: University of Chicago Press, 1960), 45.

49. Louis de Broglie, The Revolution in Physics (New York: Noonday Press, New York, 1953), 14.

50. Jastrow, God and the Astronomers.

51. National Science Teachers Association, "Inclusion of Nonscience Theories in Science Instruction," position statement, The Science Teacher, April 1981, 33.

52. Pierre-Simon Laplace, cited in E. T. Bell, Men of Mathematics (New York: Simon and Schuster, 1937), 181.

53. L. E. Orgel, The Origins of Life (New York: John Wiley and Sons, 1973), 192.

54. For a critical evaluation of the long-standing tendency to reject miracles in modern thought, see Norman L. Geisler, Miracles and Modern Thought (Grand Rapids, Michigan: Zondervan, 1982), chaps. 1–8.

55. Preston Cloud, in A Compendium of Information on the Theory of Evolution and the Evolution-Creationism Controversy, ed. Jerry P. Lightner (Reston, VA: National Association of Biology Teachers, 1978), 83.

56. William Stansfield, The Science of Evolution (New York: MacMillan, 1977), 10.

57. A. N. Whitehead, Science and the Modern World (New York: The Free Press, 1967), chap. 1. [Originally published in 1925]

58. Melvin Calvin, Chemical Evolution (New York: Oxford University Press, 1969), 258.

59. Michael B. Foster, “The Christian Doctrine of Creation and the Rise of Modern Natural Science,” Mind XLIII (October 1934): 446–468, https://www.jstor.org/stable/2250108.

60. R. Hooykaas, Religion and the Rise of Modern Science (Grand Rapids, MI: Wm. B. Eerd-mans, 1972).

61. Loren Eiseley, Darwin’s Century: Evolution and the Men Who Discovered It (Garden City, New York: Doubleday, Anchor, 1961), 62.

62. C. F. von Weizsacker, The Relevance of Physics (New York: Harper and Row, 1964), 163.

63. Stanley Jaki, Science and Creation (Edinburgh and London: Scottish Academic Press, 1974).

64. J. Robert Oppenheimer, “On Science and Culture,” Encounter 19, no. 4 (October 1962): 3–10.

65. Langdon Gilkey, Maker of Heaven and Earth (Garden City, New York: Doubleday, Anchor, 1959), 9, 125, 129ff.

66. Eiseley, Darwin’s Century, 62.

67. Hilde Hein, On the Nature and Origin of Life (New York: McGraw-Hill, 1971), 93.

68. Hein, On the Nature and Origin of Life.

69. Michael Polanyi, Personal Knowledge (New York: Harper and Row, 1958).

70. Karl Popper, The Logic of Scientific Discovery (New York: Basic Books, 1959); Popper, Conjectures and Refutations: The Growth of Scientific Knowledge (New York: Basic Books, 1962).

71. Thomas S. Kuhn, The Structure of Scientific Revolutions, 2nd ed. (Chicago: University of Chicago Press, 1970).

72. Stephen Toulmin, Foresight and Understanding (New York: Harper Torchbooks, 1963).

73. David Bohm, “Further Remarks on Order,” in Sketching Theoretical Biology, 41.

74. Bohm, “Further Remarks on Order,” 42.

۷۵- طبیعت‌گرایی غربی جهان را با عبارات مادی تعریف کرده و خالق مطلقی را که واقعا از

خلقت متمایز است انکار می‌کند. اگرچه، همان‌طور که در دیدگاه هویل و ویکراماسینگ دیدیم، گاهی خالقی برای جهان مطرح شده است.

76. Distinctions within theism are beyond the scope of the present work.

77. Ian G. Barbour, in Science Ponders Religion, ed. Harlow Shapley (New York: Appleton-Century-Crofts, 1960), 200.

78. George Wald, "The Origin of Life," in Life: Origin and Evolution [readings from Scientific American, with introductions by Clair Edwin Folsome] (San Francisco: W. H. Freeman, 1979), 47.

79. Clair E. Folsome, in Life: Origin and Evolution (San Francisco: W. H. Freeman, 1979), 2–4.

80. Folsome, in Life: Origin and Evolution, 3.

81. Folsome, in Life: Origin and Evolution, 3.

82. P. Fong, in Biogenesis, Evolution, Homeostasis, ed. A. Locker (New York: Springer-Verlag, 1973), 93.

83. Hubert P. Yockey, "Self Organization Origin of Life Scenarios and Information Theory," Journal of Theoretical Biology 91, no. 1 (1981): 13–31, https://doi.org/10.1016/0022-5193(81)90370-2.

84. A. E. Wilder-Smith, The Creation of Life (Wheaton, Illinois: Harold Shaw Publishers, 1970), 161ff.

85. Calvin, Chemical Evolution, 252.

86. P. William Davis and E. Pearl Solomon, The World of Biology (New York: McGraw-Hill, 1974), 414.

87. J. Bergman, Teaching about the Creation/Evolution Controversy [Fastback No. 134] (Bloomington, Indiana: Phi Delta Kappa Educational Foundation, 1979).

88. Charles Darwin, The Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life, 6th ed. (London: John Murray, 1872).

بخش دوم

وضعیت کنونی پژوهش‌های منشا حیات

فصل سیزدهم: ما هنوز از منشا حیات بی‌اطلاع هستیم

1. Some portions of this chapter have been adapted or copied from the author's previous article: James Tour, "Time Out," Inference: International Review of Science 4, no. 4 (July 2019), https://inferencereview. com/article/time-out.

2. "Wikipedia: Miller-Urey Experiment," Wikimedia Foundation, last modified July 29, 2019, 11:44, https://en.wikipedia.org/wiki/Miller- Urey_experiment. Stanley L. Miller, "A Production of Amino Acids Under Possible Primitive Earth Conditions," Science 117, no 3046 (May 15, 1953): 528–529, doi:10.1126/science.117.3046.528. Stanley L. Miller and Harold C. Urey, "Organic Compound Synthesis on the Primitive Earth," Science 130, no 3370 (July 31, 1959): 245–251, doi:10.1126/science.130.3370.245.

3. A. G. Cairns-Smith, Genetic Takeover (New York: Cambridge University Press, 1982).

4. "Wikipedia: History of Perpetual Motion Machines," Wikimedia Foundation, last modified July 8, 2019, 08:40, https://en.wikipedia.org/wiki/History_of_perpetual_motion_machines.

5. Laura M. Barge, Erika Flores, Marc M. Baum, David G. VanderVelde, and Michael J. Russell, "Redox and pH Gradients Drive Amino Acid Synthesis in Iron Oxyhydroxide Mineral Systems," PNAS 116, no. 11 (March 12, 2019) 4828-4833, doi.org/10.1073/ pnas.1812098116.

6. Arielle Samuelson, "NASA Study Reproduces Origins of Life on Ocean Floor" (February 25, 2019), NASA Science: Solar System Exploration, last modified February 27, 2019, https://solarsystem.nasa.gov/news/863/nasa-study-reproduces-origins-oflife- on-ocean-floor/.

7. James Tour, "Animadversions of a Synthetic Chemist," Inference: International Review of Science 2, no. 2 (May 2016), https://inferencereview. com/article/animadversions-of-a-synthetic-chemist.

8. "Wikipedia: Protocell," Wikimedia Foundation, last modified July 24, 2019, 12:57, https://en.wikipedia.org/wiki/Protocell.

9. Dimitri Fayolle, Emiliano Altamura, Alice D'Onofrio, Warren Madanamothoo, Bernard Fenet, Fabio Mavelli, René Buchet, Pasquale Stano, Michele Fiore and Peter Strazewski, "Crude Phosphorylation Mixtures Containing Racemic Lipid Amphiphiles Self-Assemble to Give Stable Primitive Compartments,"

Scientific Reports 7 (December 22, 2017), doi:10.1038/s41598-017-18053-y.

10. Anders N. Albertsen, Jan K. Szymański, and Juan Pérez-Mercader, “Emergent Properties of Giant Vesicles Formed by a Polymerization- Induced Self-Assembly (PISA) Reaction,” Scientific Reports 7 (January 27, 2017), doi:10.1038/srep41534.

11. Albertsen, “Emergent Properties of Giant Vesicles.”

12. Alvin Powell, “Mimicking Life in a Chemical Soup,” The Harvard Gazette, March 31, 2017, https://news.harvard.edu/gazette/story/2017/03/harvard-researchercreates- chemical-system-that-mimics-early-cell-behavior/. Harvard University, “Researcher Creates Chemical System That Mimics Early Cell Behavior,” Science X (website), April 3, 2017, https://phys.org/news/2017–04-chemical mimics-early-cellbehavior. html. Ava Jones, “Harvard Scientist Discovers Phoenix Vesicles in Quest to Mimic Life,” University Herald, April 4, 2017, https://www.universityherald.com/articles/71576/20170404/harvardscientist- discovers-phoenix-vesicles-quest-mimic-life.htm. “Researcher Creates Chemical Complement That Mimics Early Dungeon Behavior, Health Medicine Network (website), no date, http://healthmedicinet.com/researcher-creates-chemical-system-thatmimics- early-cell-behavior/.

13. James Tour, “An Open Letter to My Colleagues,” Inference: International Review of Science 3, no. 2 (August 2017), https://inferencereview. com/article/an-open-letter-to-my-colleagues.

14. Roger A. Laine, “Invited Commentary: A Calculation of All Possible Oligosaccharide Isomers Both Branched and Linear Yields 1.05 × 1012 Structures for a Reducing Hexasaccharide: the Isomer Barrier to Development of Single-Method Saccharide Sequencing or Synthesis Systems,” Glycobiology 4, no. 6 (December 1994): 759–767, doi:10.1093/ glycob/4.6.759.

15. Martin J Van Kranendonk, Tara Djokic, and David Deamer, “Life Springs,” Scientific American 317, no. 2 (July 2017): 28–35, doi:10.1038/scientificamerican0817-28.

16. “Wikipedia: Carothers Equation,” Wikimedia Foundation, last modified December 7, 2017, 00:28, https://en.wikipedia.org/wiki/Carothers_equation.

17. Avanti Polar Lipids (website), https://avantilipids.com/techsupport/ liposome-preparation/. Barbara Bianca Gerbelli, Emerson Rodrigo da Silva, Bruna Miranda Soares, Wendel Andrade Alves, and Elisabeth Andreoli de Oliveira, “Multilamellar-to-Unilamellar Transition Induced by Diphenylalanine in Lipid Vesicles,” Langmuir 34, no. 5 (December 28, 2017): 2171–2179, doi:10.1021/acs.langmuir.7b03869.

18. Van Kranendonk,“Life Springs.”

19. Van Kranendonk,"Life Springs."

20. Van Kranendonk,"Life Springs."

21. Van Kranendonk,"Life Springs."

22. Ed Regis, What is Life?: Investigating the Nature of Life in the Age of Synthetic Biology (Oxford: Oxford University Press, 2009), 103.

23. "Wikipedia: Interactome," Wikimedia Foundation, last modified June 3, 2019, 15:10, https://en.wikipedia.org/wiki/Interactome.

24. James M. Tour, Masatoshi Kozaki, and Jorge M. Seminario, "Molecular Scale Electronics: A Synthetic/Computational Approach to Digital Computing," Journal of the American Chemical Society 120, no. 33 (1998), 8486–8493, doi:10.1021/ja9808090.

25. Peter Tompa and George D. Rose, "The Levinthal Paradox of the Interactome," Protein Science 20, no. 12 (October 10, 2011): 2074–2079, https://doi.org/10.1002/pro.747.

26. Tompa and Rose, "The Levinthal Paradox."

27. Tompa and Rose, "The Levinthal Paradox."

28. Daniel G. Gibson, John I. Glass, Carole Lartigue, Vladimir N. Noskov, Ray-Yuan Chuang, Mikkel A. Algire, Gwynedd A. Benders, Michael G. Montague, Li Ma, Monzia M. Moodie, Chuck Merryman, Sanjay Vashee, Radha Krishnakumar, Nacyra Assad-Garcia, Cynthia Andrews- Pfannkoch, Evgeniya A. Denisova, Lei Young, Zhi-Qing Qi, Thomas H. Segall-Shapiro, Christopher H. Calvey, Prashanth P. Parmar, Clyde A. Hutchison III, Hamilton O. Smith, and J. Craig Venter, "Creation of a Bacterial Cell Controlled by a Chemically Synthesized Genome," Science 329, no. 5987 (July 2, 2010): 52–56, doi:10.1126/science.1190719.

29. Clyde A. Hutchison III, Ray-Yuan Chuang, Vladimir N. Noskov, Nacyra Assad-Garcia, Thomas J. Deerinck, Mark H. Ellisman, John Gill, Krishna Kannan, Bogumil J. Karas, Li Ma, James F. Pelletier, Zhi-Qing Qi, R. Alexander Richter, Elizabeth A. Strychalski, Lijie Sun, Yo Suzuki, Billyana Tsvetanova, Kim S. Wise, Hamilton O. Smith, John I. Glass, Chuck Merryman, Daniel G. Gibson, and J. Craig Venter, "Design and Synthesis of a Minimal Bacterial Genome," Science 351, no. 6280 (March 25, 2016): aad6253, doi 10.1126/science.aad6253.

30. Henrike Niederholtmeyer, Cynthia Chaggan, and Neal K. Devaraj, "Communication and Quorum Sensing in Non-Living Mimics of Eukaryotic Cells," Nature Communications 9 (November 28, 2018), https://doi.org/10.1038/s41467-018-07473-7.

31. Mitch Leslie, "Biologists Create the Most Lifelike Artificial Cells Yet," Science (November 19, 2018), doi:10.1126/science.aaw1173.

32. "Cell Free Protein Expression," ThermoFisher Scientific (website), https://www.thermofisher.com/us/en/home/life-science/proteinbiology/ protein-biology-learning-center/protein-biology-resourcelibrary/ pierce-protein methods/cell-free-protein-expression.html.

33. University of California, "Copycat Cells Command New Powers of Communication," Science X (website) December 7, 2018, https://phys.org/news/2018-12-copycat-cells-powers.html.

34. Leslie, "Biologists Create the Most Lifelike Artificial Cells Yet."

35. Jack Szostak, "How Did Life Begin? Untangling the Origins of Organisms Will Require Experiments at the Tiniest Scales and Observations at the Vastest," Nature (May 9, 2018), https://www.nature.com/articles/d41586-018-05098-w.

36. Jack Szostak, "How Did Life Begin? Untangling the Origins of Organisms Will Require Experiments at the Tiniest Scales and Observations at the Vastest," Scientific American 318, no. 6 (June 2018): 65–67, doi:10.1038/scientificamerican0618-65.

37. The figure can be viewed at https://www.nature.com/articles/d41586-018-05098-w.

38. Dougal Ritson and John D. Sutherland, "Prebiotic Synthesis of Simple Sugars by Photoredox Systems Chemistry," Nature Chemistry 4 (2012): 895–899, doi:10.1038/ nchem.1467.

39. James Tour, "Animadversions of a Synthetic Chemist," Inference: International Review of Science 2, no. 2 (May 2016), https://inferencereview. com/article/animadversions-of-a-synthetic-chemist.

40. Jason Socrates Bardi, "Study Suggests Component of Volcanic Gas May Have Played a Significant Role in the Origins of Life on Earth," Scripps Research Institute News & Views 3, no. 30 (October 11, 2004), https://www.scripps.edu/newsandviews/e_20041011/ghadiri.html.

41. A. G. Cairns-Smith, Genetic Takeover (New York: Cambridge University Press, 1982).

42. Edward J. Steele, Shirwan Al-Mufti, Kenneth A. Augustyn, Rohana Chandrajith, John P. Coghlan, S. G. Coulson, Sudipto Ghosh, Mark Gillman, Reginald M. Gorczynski, Brig Klyce, Godfrey Louis, Kithsiri Mahanama, Keith R. Oliver, Julio Padron, Jiangwen Qu, John A. Schuster, W. E. Smith, Duane P. Snyder, Julian A. Steele, Brent J. Stewart, Robert Temple, Gensuke Tokoro,

Christopher A. Tout, Alexander Unzicker, Milton Wainwright, Jamie Wallis, Daryl H. Wallis, Max K. Wallis, John Wetherall, D. T. Wickramasinghe, J. T. Wickramasinghe, N. Chandra Wickramasinghe, Yongsheng Liu, "Cause of Cambrian Explosion—Terrestrial or Cosmic?" Progress in Biophysics and Molecular Biology 136 (August 2018): 3–23, https://doi.org/10.1016/j.pbiomolbio.2018.03.004.

43. Steele, "Cause of Cambrian Explosion."

44. John D. Sutherland, "Opinion: Studies on the Origin of Life—the End of the Beginning," Nature Reviews Chemistry 1 (January 18, 2017), https://doi.org/10.1038/s41570-016-0012.

45. Clémentine Gibard, Subhendu Bhowmik, Megha Karki, Eun-Kyong Kim, and Ramanarayanan Krishnamurthy, "Phosphorylation, Oligomerization and Self-Assembly in Water Under Potential Prebiotic Conditions," Nature Chemistry 10 (2018): 212–217, https://www.nature.com/articles/nchem.2878.

46. Clemens Richert, "Prebiotic Chemistry and Human Intervention," Nature Communications 9 (December 12, 2018), https://doi.org/10.1038/s41467- 018-07219-5.

47. Shiloh Rea, "Uncertainty Perception Drives Public's Trust, Mistrust of Science," Carnegie Mellon University, Dietrich College of Humanities and Social Sciences (website), February 22, 2017, https://www.cmu.edu/dietrich/news/newsstories/ 2017/february/broomell-scientific-uncertainty.html; Tania Lombrozo, "Science Isn't Partisan, But Public Perception Of Science Often Is," NPR: Cosmos & Culture (website), April 24, 2017, https://www.npr.org/sections/13.7/2017/04/24/525360310/science-isn tpartisan- but-public-perception-of-science-often-is; Benjamin Wermund, "University Presidents: We've Been Blindsided," Politico, December 19, 2017, https://www.politico.com/story/2017/12/19/college-universitybacklash- elitism-296898.

فصل چهاردهم: چالش‌های ترمودینامیکیِ منشا حیات

1. The probability for E. coli, as calculated by Morowitz, is 10-1011; for the discussion see Chapter 7 above, section "Closed Systems Near Equilibrium", and for the number see H. J. Morowitz, Energy Flow in Biology (New York: Academic Press, 1968), 67.

2. A. Lazcano, "Complexity, Self-Organization and the Origin of Life: The Happy Liaison?," in Origins of Life: Self-Organization and/or Biological Evolution?, eds. Marie-Christine Maurel and Maryvonne Gerin (Les Ulis, France: EDP Sciences, 2009), 13–22, https://doi.org/10.1051/orvie/2009002.

3. Noam Lahav, Shlomo Nir, and Avshalom C. Elitzur, “The Emergence of Life on Earth,” Progress in Biophysics and Molecular Biology 75, no. 1– 2 (January 2001): 75–120, https://doi.org/10.1016/S00796107(01)00003

4. Werner Ebeling and Rainer Feistel, “About Self-Organization of Information and Synergetics,” in Complexity and Synergetics, eds. Stefan C. Müller, Peter J. Plath, Günter Radons, and Armin Fuchs (Cham: Springer International Publishing, 2018), 3–8, https://doi.org/10.1007/978-3-319-64334-2_1.

5. James J. Kay, “Ecosystems as Self-Organizing Holarchic Open Systems: Narratives and the Second Law of Thermodynamics” in Handbook of Ecosystems Theories and Management, eds. Sven Erik Jorgensen and Felix Muller (Boca Raton, FL: CRC Press, 2000),135– 160.

6. Nick Lane, “Proton Gradients at the Origin of Life,” BioEssays 39, no. 6 (2017); Anthonie W. J. Muller, “Thermosynthesis as Energy Source for the RNA World: A Model for the Bioenergetics of the Origin of Life,” BioSystems 82, no. 1 (2005): 93–102.

7. Denis J. Evans and Debra J. Searles, “The Fluctuation Theorem,” Advances in Physics 51, no. 7 (2002): 1529–85, https://doi.org/10.1080/00018730210155133.

به لحاظ فنی، نمی‌توان آنتروپی را بدون در نظر گرفتن تعادل محاسبه کرد؛ زیرا دما به‌خوبی تعریف نشده است. نسخه‌ی متعارف ESFT از کمیت آنتروپی‌مانندی استفاده می‌کند که به عنوان عملکرد اتلاف شناخته می‌شود و نسخه‌ی تعمیم‌یافته‌تری از تولید آنتروپی خودبه‌خودی است.

See James C. Reid et al., “The Dissipation Function: Its Relationship to Entropy Production, Theorems for Nonequilibrium Systems and Observations on Its Extrema,” in Beyond the Second Law: Entropy Production and Non-Equilibrium Systems, ed. Joseph J. Vallino et al. (New York: Springer, 2014), 31–47.

۸- سیستم‌های اتلافی را میدان‌های اتلافی هدایت می‌کنند که انرژی حالت پایه‌ی سیستم را تغییر نمی‌دهند بلکه انرژی واردشده به سیستم در اثر این میدان‌ها می‌تواند به‌طور کامل به گرما تبدیل شده و در محیط اطراف پخش شود. برای مثال، می‌توان به استفاده از میدان الکتریکی برای یک مقاومت یا استفاده از نور برای محلولی از مواد شیمیایی در حال تعامل اشاره کرد. در مقابل، انرژی داده‌شده می‌تواند به عنوان انرژی پتانسیل در سیستم ذخیره شود. برای مثال، استفاده از میدان الکتریکی برای کلرید سدیم جامد، انرژی پتانسیل مربوط به نیروهای بین مولکولیِ بین مولکول‌های سازنده را افزایش می‌دهد.

See Denis J. Evans, Debra J. Searles, and Stephen R. Williams, Fundamentals of Classical Statistical Thermodynamics: Dissipation, Relaxation, and Fluctuation Theorems (Weinheim, Germany: Wiley-VCH, 2016), 23.

9. The probability density ratio for p(S)/p(–S) can be converted to an upper bound for the probability of entropy, S, taking on the negative value of −A or less by recognizing that p(S) < p(–S)e–A for values of S less than −A. Therefore, P(S < –A) < P(S > A)e–A < e–A.

۱۰- برخی فیزیک‌دانان استدلال کرده‌اند که راه حل پیشنهادی ناقص است و باید با این واقعیت ترکیب شود که جهان ما در وضعیت آنتروپی پایین آغاز شده است.
See P. C. W. Davies, “The Arrow of Time,” Astronomy and Geophysics 46, no. 1 (February 1, 2005): 1.26–1.29, https://doi.org/10.1046/j.1468-4004.2003.46126.x.

11. H. J. Morowitz, Energy Flow in Biology (New York: Academic Press, 1968), 97.

12. The approximate weight of a bacterium is 10-12g, which yields a drop in entropy on the order of 10-13 joules/deg. See Ron Sender, Shai Fuchs, and Ron Milo, “Revised Estimates for the Number of Human and Bacteria Cells in the Body,” PLoS Biology 14, no. 8 (2016), https://doi.org/10.1371/journal.pbio.1002533.

۱۳- تغییر در انرژی آزاد هلمولتز (F) برابر است با تغییر در انرژی داخلی یک سیستم (U) منهای دما ضرب در تغییر در آنتروپی ($S: \Delta F = \Delta U - T\Delta S$). در سیستمی که حجم آن ثابت است، ΔF برای فرآیندهای خودبه‌خودی همیشه منفی است. اگر فشار ثابت نگه داشته شود، فرآیندهای خودبه‌خودی با تغییر منفی در انرژی آزاد گیبس (G) مطابقت دارد که برابر با تغییر آنتالپی (H) منهای دما در تغییر آنتروپی است: $\Delta G = \Delta H - T\Delta S$ تغییر در آنتالپی نشان‌دهنده‌ی تغییر انرژی یک انتقال است که برای کار انجام‌شده روی محیط و به دلیل تغییر حجم تنظیم شده است: $\Delta H = \Delta U + P\Delta V$ تغییرات مثبت آنتالپی نشان‌دهنده‌ی گرمای جذب‌شده از محیط و تغییرات منفی نشان‌دهنده‌ی گرمای آزادشده است. فیزیک‌دانان و مهندسان شیمی معمولا با انرژی آزاد هلمولتز کار می‌کنند، در حالی که شیمی‌دان‌ها معمولا با انرژی آزاد گیبس کار می‌کنند.

۱۴- رویکرد کلی و یک‌سانی را که در مورد Evans–Searles FT اعمال شده، می‌توان در مورد Crooks FT و برای نشان دادن این‌که احتمال جذب گرما با مقدار Q یا بیش‌تر به‌طور تصاعدی با Q کاهش می‌یابد، به کار برد.

15. Morowitz, Energy Flow in Biology, 65.
این تخمین با محاسبه‌ی تفاوت بین میانگین انرژی پیوند در یک باکتری و انرژی موجود در مولکول‌های زمین کهن انجام شد.

۱۶- آنتروپی و انرژی آزاد توابع حالت (در علم ترمودینامیک state functions) هستند، بنابراین به مسیر وابسته‌اند. احتمالات، نمایی از آن توابع هستند. برای درک اهمیت موضوع، تصور کنید مسیر غیر حیات به حیات را به سه مرحله تقسیم کرده‌اید که همواره به سمت آنتروپی پایین‌تر (یا انرژی آزاد بالاتر) حرکت می‌کنند. در این صورت $\Delta S = -\Delta S1 - \Delta S2 - \Delta S3 -$ و احتمالات مرتبط با نوسانات تصادفی که هر مرحله را هدایت می‌کنند، $e\text{–}\Delta S1, e\text{–}\ \Delta SS2$ و $e\text{–}\Delta SS3$ خواهند بود. این احتمال که هر سه نوسان به‌طور متوالی اتفاق بیفتند $e\text{–}\Delta SS1$ $\cdot\ e\text{–}\Delta S2 = e\text{–}\Delta S1\text{–}\Delta S2\text{–}\Delta S3$ است. احتمال تحقق سه مرحله مشابه یک مرحله‌ی ترکیبی است.

۱۷- در فرمول‌بندی کروکس Crooks، نخست فرض بر این بود که کار، W، ناشی از نیروهای فیزیکی یا زمینه‌های کاربردی است. اما می‌توان آن را طوری فرمول‌بندی کرد که مشارکت‌های حاصل از کار شیمیایی واکنش‌دهنده‌های پر انرژی را نیز شامل شود.
See Riccardo Rao and Massimiliano Esposito, “Conservation Laws and Work Fluctuation Relations in Chemical Reaction Networks,” The Journal of Chemical Physics 149, no. 24 (December 28, 2018): 245101, https://doi.org/10.1063/1.5042253.

18. Carsten Bolm et al., “Mechanochemical Activation of Iron Cyano Complexes: A Prebiotic Impact Scenario for the Synthesis of α-Amino Acid Derivatives,” Angewandte Chemie International Edition 57, no. 9 (February 23, 2018): 2423–26, https://doi.org/10.1002/anie.201713109.

19. Helen Greenwood Hansma, “Possible Origin of Life between Mica Sheets: Does Life Imitate Mica?,” Journal of Biomolecular Structure & Dynamics 31, no. 8 (2013): 888–95, https://doi.org/10.1080/07391102.2012.718528.

20. Charles S. Cockell, “The Origin and Emergence of Life under Impact Bombardment,” Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences 361, no. 1474 (October 29, 2006): 1845–55; discussion 1856, https://doi.org/10.1098/rstb.2006.1908.

21. Muller, “Thermosynthesis as Energy Source for the RNA World: A Model for the Bioenergetics of the Origin of Life.”

22. Nick Lane, John F. Allen, and William Martin, “How Did LUCA Make a Living? Chemiosmosis in the Origin of Life,” BioEssays 32, no. 4 (2010): 271–80, https://doi.org/10.1002/bies.200900131.

23. S. R. De Groot, Non-Equilibrium Thermodynamics (Mineola: Dover Publications, 2013), 20–23.

24. The simplest known organism is Mycoplasma pneumoniae. Its energy production for maintenance is roughly 50,000 ATP/s—see Judith A. H. Wodke et al., “Dissecting the Energy Metabolism in Mycoplasma Pneumoniae through Genome-Scale Metabolic Modeling,” Molecular Systems Biology 9 (2013): 653, https://doi.org/10.1038/msb.2013.6. ATP molecules provide 30,000 J/mol of energy—see Victor W. Rodwell et al., Harper’s Illustrated Biochemistry (New York: McGraw-Hill Education, n.d.), 107. The size of Mycoplasma is around .15 mm—see Laleh Nikfarjam and Parvaneh Farzaneh, “Prevention and Detection of

25. Mycoplasma Contamination in Cell Culture,” Cell Journal 13, no. 4 (2012): 204. Therefore, the energy production density is on the order of 1 W/g. Mycoplasma pneumoniae is a parasite, so it lacks many of the metabolic processes of free-living prokaryotes. As a result, the first cell would have required a

larger genome, thus increasing energy requirements—see Stephen J. Giovannoni et al., “Genetics: Genome Streamlining in a Cosmopolitan Oceanic Bacterium,” Science 309, no. 5738 (2005): 1242–45, https://doi.org/10.1126/science.1114057. In addition, if enzymes or other processes were less efficient, the required energy output would have also increased.

26. Michael Lynch and Georgi K. Marinov, “The Bioenergetic Costs of a Gene,” Proceedings of the National Academy of Sciences of the United States of America 112, no. 51 (December 22, 2015): 15690–95, https://doi.org/10.1073/pnas.1514974112.

27. Barry Herschy et al., “An Origin-of-Life Reactor to Simulate Alkaline Hydrothermal Vents,” Journal of Molecular Evolution 79, no. 5–6 (December 27, 2014): 213–227, https://doi.org/10.1007/s00239-014- 9658-4. The energy production corresponds to electrons in hydrogen gas reducing carbon dioxide to form formaldehyde.

۲۸- شبیه‌سازی راکتور می‌تواند پس از یک پرش اولیه تقریبا ۲۰ نانومولار (nM) افزایش غلظت فرمالدئید را در ۱۰ دقیقه در ظرف تقریبا ۱ لیتری و از طریق کاهش دی‌اکسیدکربن ایجاد کند. کل این فرآیند دو الکترون، n=2، و افزایش پتانسیل کاهش، Er، کم‌تر از ۲۰۰ میلی‌ولت است. با استفاده از ΔG=nFEr می‌توان پتانسیل کاهش را به تغییر انرژی آزاد برای تولید یک مول فرمالدئید تبدیل کرد.
See Carl H. Hamann, A. Hamnett, and Wolf Vielstich, Electrochemistry (Weinheim, Germany: Wiley-VCH, 2007), 78. The corresponding power generation density is on the order of 1 nW/g.

۲۹- غلظت نهایی فرمالدئید کم‌تر از ۱۰۰ نانومولار بود در حالی که مقدار مورد استفاده در آزمایش‌ها برای تولید ریبوز حدود ۰٫۵ مولار است (Herschy et al). فرآیندهایی مانند ترموفورز تنها می‌توانند مواد آلی را در شرایط ایده‌آل به میزان هزاران‌بار غلیظ‌تر کنند که برای کمک به هر سناریو منشا حیاتی بسیار کوچک است. افزون بر این، ممکن است فرمالدئید اندازه‌گیری‌شده از شیب غلظت پروتون به دست نیامده باشد.
See J. Baz Jackson, “The ‘Origin-of-Life Reactor’ and Reduction of CO2 by H2 in Inorganic Precipitates,” J Mol Evol 85, no. 1–2 (2017): 1–7, https://doi.org/10.1007/s00239-017-9805-9.

30. Peter Tompa and George D. Rose, “The Levinthal Paradox of the Interactome,” Protein Science 20, no. 12 (2011): 2074–79, https://doi.org/10.1002/pro.747.

31. Norio Kitadai and Shigenori Maruyama, “Origins of Building Blocks of Life: A Review,” Geoscience Frontiers 9, no. 4 (2018): 1117–53, https://doi.org/10.1016/j.gsf.2017.07.007.

۳۲- بر اساس نظریه‌ی دنیای RNA، زنجیره‌های RNA معروف به ریبوزیم می‌توانند نقش آنزیم‌های اولیه را ایفا کنند. اما ریبوزیم‌ها تنها از چهار نوکلئوتید گوناگون تشکیل شده‌اند در حالی

که پروتیین‌ها از بیست اسید آمینه‌ی گوناگون با زنجیره‌های جانبی بسیار متنوع‌تر تشکیل شده‌اند. بنابراین، ریبوزیم‌ها فاقد ظرفیت پروتیین برای ایجاد تنوع زیادی از واکنش‌ها هستند. حتی اگر کسی این محدودیت‌ها را نادیده بگیرد، نظریه‌ی دنیای RNA با چالش‌های اطلاعاتی مشابهی روبه‌رو خواهد شد.

See Stephen Meyer, Signature in the Cell: DNA and the Evidence for Intelligent Design (San Francisco: HarperOne, 2009): 294–321.

33. Hans Bisswanger, Practical Enzymology (Weinheim, Germany: Wiley-Blackwell, 2011), 1.

34. Bryson D. Bennett et al., “Absolute Metabolite Concentrations and Implied Enzyme Active Site Occupancy in Escherichia Coli,” Nature Chemical Biology 5, no. 8 (August 2009): 593–99, https://doi.org/10.1038/nchembio.186.

35. Alan W. Schwartz, “Intractable Mixtures and the Origin of Life,” Chemistry and Biodiversity 4, no. 4 (2007): 656–64, https://doi.org/10.1002/cbdv.200790056.

36. Elizaveta Guseva, Ronald N Zuckermann, and Ken A. Dill, “Foldamer Hypothesis for the Growth and Sequence Differentiation of Prebiotic Polymers,” Proceedings of the National Academy of Sciences 114, no. 36 (September 5, 2017): E7460-E7468. The probability by mass for a chain forming of length l follows the Flory–Schulz distribution: f (l) = a2l (1 – a)l–1 here l is the chain length and a is the probability that any monomer addition terminates a chain. For the extremely optimistic parameters used in the article (average l = 2), the probability of a chain of 150 amino acids or greater forming is less than 1 in 1050, which is clearly implausible. Most of the essential proteins in cells are longer than 150 amino acids. See J. Zhang, “Protein-Length Distributions for the Three Domains of Life,” Trends in Genetics 16, no. 3 (March 2000): 107–9.

37. Barbara A. Cohen and Christopher F. Chyba, “Racemization of Meteoritic Amino Acids,” Icarus 145, no. 1 (2000): 272–81, https://doi.org/10.1006/icar.1999.6328.

38. C. Born et al., “Estimation of Disruption of Animal Cells by Laminar Shear Stress,” Biotechnology and Bioengineering 40, no. 9 (1992): 1004– 10, https://doi.org/10.1002/bit.260400903.

39. D. Brune and S. Kim, “Predicting Protein Diffusion Coefficients,” Proceedings of the National Academy of Sciences 90, no. 9 (1993): 3835–39, https://doi.org/10.1073/pnas.90.9.3835.

40. A. Radzicka and R. Wolfenden, “Rates of Uncatalyzed Peptide Bond Hydrolysis in Neutral Solution and the Transition State Affinities of Proteases,” Journal of the American Chemical Society 118, no. 26 (1996): 6105–9, https://doi.org/10.1021/ja954077c.

41. D. A. Parsell and R. T. Sauer, "The Structural Stability of a Protein Is an Important Determinant of Its Proteolytic Susceptibility in Escherichia Coli," Journal of Biological Chemistry 264, no. 13 (1989): 7590–95.

42. Harold S. Bernhardt, "The RNA World Hypothesis: The Worst Theory of the Early Evolution of Life (except for All the Others)," Biology Direct 38, no. 3 (2012): 20, https://doi.org/10.1186/1745-6150-7-23.

43. For a discussion on the measure of functional information in proteins, see Winston Ewert, William A. Dembski, and Robert J. Marks II, "Algorithmic Specified Complexity," in Engineering and the Ultimate: An Interdisciplinary Investigation of Order and Design in Nature and Craft, eds. Jonathan Bartlett, Dominic Halsmer, and Mark Hall (Blyth Institute Press, 2014), 131–49.

44. Shiyi Shen and Jack A. Tuszynski, "Semantic Analysis for Protein Primary Structure," in Theory and Mathematical Methods for Bioinformatics, Biological and Medical Physics, Biomedical Engineering (Berlin, Heidelberg: Springer, 2008), 395–430, https://doi.org/10.1007/978-3-540-74891-5_15.

45. Arnaud Pocheville, Paul Griffiths, and Karola Stotz, "Comparing Causes —an Information-Theoretic Approach to Specificity, Proportionality and Stability," in Logic, Methodology, and Philosophy of Science: Proceedings of the Fifteenth International Congress, eds. Hannes Leitgeb, Ilkka Niiniluoto, Päivi Seppälä and Elliot Sober (Helsinki, Finland: College Publications, 2017), 250–275.

46. Yaşar Demirel, "Information in Biological Systems and the Fluctuation Theorem," Entropy 16, no. 4 (2014): 1931–48.

47. William A. Dembski, Winston Ewert, and Robert J. Marks, "Measuring Meaningful Information in Images: Algorithmic Specified Complexity," IET Computer Vision 9, no. 6 (2015): 884–894, https://doi.org/10.1049/iet-cvi.2014.0141.

48. Winston Ewert, Robert J. Marks, and William A. Dembski, "On the Improbability of Algorithmic Specified Complexity," in Proceedings of the Annual Southeastern Symposium on System Theory (Waco, TX: Institute of Electrical and Electronic Engineers, 2013), https://doi.org/10.1109/SSST.2013.6524962. $ASC(X,C,P) = -\log_2 P(X) - K(X|C)$ where X is an event, C is the event's context, P(X) is the probability for the occurrence of X, and K(X|C) is the Kolmogorov complexity of X given C. A helpful illustration is calculating the ASC for a royal flush in a hand of poker. The number of possible poker hands is $_{52}C_5$ = 2,598,960, which yields $-\log_2 P(X) = 21.3$ bits. The context is ten possible poker hands (i.e. two pair, full house, etc.), and the royal flush category includes four hands, so $K(X|C) = -\log_2 10 + -\log_2 4 = 5.3$ bits. The ASC value is then $21.3 - 5.3 = 16$ bits. The probability of being dealt two consecutive

hands with as high of an ASC measure as two royal flushes is then less than 2-16 · 2-16 = 2-32, which is around 1 chance in 4 billion. Such a fortuitous occurrence would raise suspicions in a single night of poker. Note that the ASC value increases for more improbable outcomes and for fewer and more improbable categories. See Robert J. Marks, William A. Dembski, and Winston Ewert, Introduction to Evolutionary Informatics (Singapore: WSPC, 2017), 261–262.

49. Robert A. Freitas and William B. Zachary, “A Self-Replicating Growing Lunar Factory,” in Proceedings of the Fifth Princeton/AIAA Conference (Princeton, NJ: American Institute of Aeronautics and Astronautics, 1981), https://doi.org/doi:10.2514/6.1981-3226.

50. J. I. Glass et al., “Essential Genes of a Minimal Bacterium,” Proceedings of the National Academy of Sciences 103, no. 2 (2006): 425–30, https://doi.org/10.1073/pnas.0510013103.

51. Giovannoni et al., “Genetics: Genome Streamlining in a Cosmopolitan Oceanic Bacterium.”

52. Douglas D. Axe, “Estimating the Prevalence of Protein Sequences Adopting Functional Enzyme Folds,” Journal of Molecular Biology 341, no. 5 (2004): 1295–1315, https://doi.org/10.1016/j.jmb.2004.06.058.

53. Winston Ewert, William A. Dembski, and Robert J. Marks II, “Algorithmic Specified Complexity,” in Engineering and the Ultimate: An Interdisciplinary Investigation of Order and Design in Nature and Craft, eds. Jonathan Bartlett, Dominic Halsmer, and Mark Hall (Blyth Institute Press, 2014), 145–146.

54. James F. Coppedge, Evolution: Possible or Impossible? (Grand Rapids, MI: Zondervan, 1973).

55. The log base 2 of 1060 = 199.3.

56. Joana C. Xavier, Kiran Raosaheb Patil, and Isabel Rocha, “Systems Biology Perspectives on Minimal and Simpler Cells,” Microbiology and Molecular Biology Reviews 78, no. 3 (September 1, 2014): 487–509, https://doi.org/10.1128/MMBR.00050-13.

57. Eva Yus et al., “Impact of Genome Reduction on Bacterial Metabolism and Its Regulation,” Science 326, no. 5957 (2009): 1263–68, https://doi.org/10.1126/science.1177263.

58. Thomas Traut, Allosteric Regulatory Enzymes (New York: Springer, 2008), https://doi.org/10.1007/978-0-387-72891-9.

59. Sebastian Kühner et al., “Proteome Organization in a Genome-Reduced Bacterium,” Science 326, no. 5957 (2009): 1235–40, https://doi.org/10.1126/science.1176343.

60. Ulla Kaukinen et al., “The Reactivity of Phosphodiester Bonds within Linear Single-Stranded Oligoribonucleotides Is Strongly Dependent on the Base Sequence,” Nucleic Acids Research 30, no. 2 (2002): 468–474, https://doi.org/10.1093/nar/30.2.468.

61. Kazuyuki Shimizu, “Metabolic Regulation of a Bacterial Cell System with Emphasis on Escherichia Coli Metabolism,” ISRN Biochemistry (2013): 1–47, https://doi.org/10.1155/2013/645983.

62. Ralf Steuer and Björn H. Junker, “Computational Models of Metabolism: Stability and Regulation in Metabolic Networks,” Advances in Chemical Physics 142, no. 105 (2008): 110–112, https://doi.org/10.1002/9780470475935.ch3.

فصل پانزدهم: نجوم در مورد پیدایش حیات چه می‌گوید

۱- گرچه پرونده‌ی حیات مریخی در سال‌های میانی به‌خوبی پیش نرفت، اکتشافات حوزه‌ی پژوهش‌های سیاره‌ای فراخورشیدی فوق‌العاده زیاد بود.

2. Audrey Bouvier and Meenakshi Wadhwa, “The Age of the Solar System Redefined by the Oldest Pb-Pb Age of a Meteoritic Inclusion,” Nature Geoscience Letters 3 (2010): 637–641, doi:10.1038/ngeo941.

3. A. Bonanno and H. E. Frohlich, “A Bayesian Estimation of the Helioseismic Solar Age,” Astronomy & Astrophysics 580 (2015): A130, doi:10.1051/0004-6361/201526419.

4. Samuel A. Bowring and Ian S. Williams, “Priscoan (4.00-4.03 Ga) Orthogneisses from Northwest Canada,” Contributions to Mineralogy and Petrology 134 (1999): 3–16, doi:10.1007/s004100050.

5. John M. Valley, Aaron J. Cavosie, Takayuki Ushikubo, David A. Reinhard, Daniel F. Lawrence, David J. Larson, Peter H. Clifton, Thomas F. Kelly, Simon A. Wilde, Desmond E. Moser, and Michael J. Spicuzza, “Hadean Age for a Post-Magma-Ocean Zircon Confirmed by Atom- Probe Tomography,” Nature Geoscience Letters 7 (2014): 219–223, doi:10.1038/ngeo2075.

6. John M. Valley, “A Cool Early Earth?,” Scientific American 293 no. 4 (November 2005): 58–65.

7. Keyron Hickman-Lewis, Barbara Cavalazzi, Frédéric Foucher, and Frances Westall, “Most Ancient Evidence for Life in the Barberton Greenstone Belt: Microbial Mats and Biofabrics of the ~3.47 Ga Middle Marker Horizon,” Precambrian Research 312 (2018): 45–67, doi:10.1016/j.precamres.2018.04.007.

8. Yoko Ohtomo, Takeshi Kakegawa, Akizumi Ishida, Toshiro Nagase, and Minik T. Rosing, “Evidence for Biogenic Graphite in Early Archaean Isua

Metasedimentary Rocks," Nature Geoscience 7 (2014): 25–28, doi:10.1038/ngeo2025. Allen P. Nutman, Vickie C. Bennett, Clark R. L. Friend, Martin J. Van Kranendonk, and Allan R. Chivas, "Rapid Emergence of Life Shown by Discovery of 3,700-Million-Year-Old Microbial Structures," Nature 537 (2016): 535–538, doi:10.1038/nature19355.

9. Simon J. Lock, Sarah T. Stewart, Michail I. Petaev, Zoë M. Leinhardt, Mia T. Mace, Stein B. Jacobsen, and Matija Cuk, "The Origin of the Moon Within a Terrestrial Synestia," Journal of Geophysical Research: Planets 123 (2018): 910–951, doi: 10.1002/2017JE005333.

10. J. O. Dickey, P. L. Bender, J. E. Faller, R. L. Ricklefs, J. G. Ries, P. J. Shelus, C. Veillet, A. L. Whipple, J. R. Wiant, J. G. Williams, and C. F. Yoder, "Lunar Laser Ranging: A Continuing Legacy of the Apollo Program," Science 265, no. 5171 (1994): 482–490, doi: 10.1126/science.265.5171.482.

11. Fouad Tera, D. A. Papanastasiou, and G. J. Wasserburg, "Isotopic Evidence for a Terminal Lunar Cataclysm," Earth and Planetary Science Letters 22 (1974): 1–21, doi:10.1016/0012-821X(74)90059-4.

12. A. Morbidelli, D. Nesvorny, V. Laurenz, S. Marchi, D. C. Rubie, L. Elkins-Tanton, M. Wieczorek, and S. Jacobson, "The Timeline of the Lunar Bombardment: Revisited," Icarus 305 (2018): 262–276, doi:10.1016/j.icarus.2017.12.046; Adam Mann, "Bashing Holes in the Tale of Earth's Troubled Youth," Nature 553 (2018): 393–395, doi:10.1038/d41586-018-01074-6.

13. John C. Armstrong, Llyd E. Wells, and Guillermo Gonzalez, "Rummaging Through Earth's Attic for Remains of Ancient Life," Icarus 160 (2002): 183–196, doi:10.1006/ icar.2002.6957; John C. Armstrong, "Distributions of Impact Locations and Velocities of Earth Meteorites on the Moon," Earth, Moon, and Planets 107 (2010): 43–54, doi:10.1007/ s11038-010-9355-2; Ian A. Crawford, Emily C. Baldwin, Emma A. Taylor, Jeremy A. Bailey, and Kostas Tsembelis, "On the Survivability and Detectability of Terrestrial Meteorites on the Moon," Astrobiology 8 (2008): 242–252, doi:10.1089/ast.2007.0215.

14. Ian. A. Crawford, M. Anand, C. S. Cockell, H. Falke, D. A. Green, R. Jaumann, M. A. Wieczorek, "Back to the Moon: The Scientific Rationale for Resuming Lunar Surface Exploration," Planetary and Space Science 74 (2012): 3–14, doi:10.1016/j.pss.2012.06.002; Ian A. Crawford and Katherine H. Joy, "Lunar Exploration: Opening a Window into the History and Evolution of the Inner Solar System," Philosophical Transactions of the Royal Society A 372 (2014): 20130315, doi:10.1098/rsta.2013.0315.

15. J. J. Bellucci, A. A. Nemchin, M. Grange, K. L. Robinson, G. Collins, M. J. Whitehouse, J. F. Snape, M. D. Norman, and D. A. Kring, "Terrestrial- Like Zircon in a Clast from an Apollo 14 Breccia," Earth and Planetary Science

Letters 510 (2019): 173–185, doi:10.1016/j. epsl.2019.01.010.

16. Richard Matthewman, Richard W. Court, Ian A. Crawford, Adrian P. Jones, Katherine H. Joy, and Mark A. Sephton, “The Moon as a Recorder of Organic Evolution in the Early Solar System: A Lunar Regolith Analog Study,” Astrobiology 15 (2015): 154–168, doi:10.1089/ast.2014.1217.

17. W. F. Bottke, D. Vokrouhlicky, S. Marchi, T. Swindle, E. R. D. Scott, J. R. Weirich, and H. Levison, “Dating the Moon-Forming Impact Event with Asteroidal Meteorites,” Science 348 (2015): 321–323, doi:10.1126/science.aaa0602.

18. S. Marchi, W. F. Bottke, L. T. Elkins-Tanton, M. Bierhaus, K. Wuennemann, A. Morbidelli, and D. A. Kring, “Widespread Mixing and Burial of Earth’s Hadean Crust by Asteroid Impacts,” Nature 511 (2014): 578–582, doi:10.1038/nature13539.

19. Llyd E. Wells, John C. Armstrong, and Guillermo Gonzalez, “Reseeding of Early Earth by Impacts of Returning Ejecta During the Late Heavy Bombardment,” Icarus 162 (2002): 38–46, doi:10.1016/S0019- 1035(02)00077-5.

20. Richard Lathe, “Fast Tidal Cycling and the Origin of Life,” Icarus 168 (2004): 18–22, doi:10.1016/j.icarus.2003.10.018.

21. Richard Lathe, “Tidal Chain Reaction and the Origin of Replicating Biopolymers,” International Journal of Astrobiology 4 (2005): 19–31, doi:10.1017/S1473550405002314.

22. P. Varga, K. R. Rybicki, and C. Denis, “Comment on the Paper ‘Fast Tidal Cycling and the Origin of Life’ by Richard Lathe,” Icarus 180 (2006): 274–276, doi:10.1016/j.icarus.2005.04.022.

23. Richard Lathe, “Early Tides: Response to Varga et al.,” Icarus 180 (2006): 277–280, doi:10.1016/j.icarus.2005.08.019.

24. Matija Cuk, Douglas P. Hamilton, Simon J. Lock, and Sarah T. Stewart, “Tidal Evolution of the Moon from a High-Obliquity, High-Angular- Momentum Earth,” Nature 539 (2016), 402–406, doi:10.1038/nature19846.

25. Chris J. Hawkesworth, Peter A. Cawood, Bruno Dhuime, and Tony I. S. Kemp, “Earth’s Continental Lithosphere through Time,” Annual Review of Earth and Planetary Sciences 45 (2017): 169–198, doi: 10.1146/annurev- earth-063016- 020525.

26. Chrisantha Fernando, Günter Von Kiedrowski, and Eörs Szathmáry, “A Stochastic Model of Nonenzymatic Nucleic Acid Replication: ‘Elongators’ Sequester Replicators,” Journal of Molecular Evolution 64 (2007): 572–585, doi:10.1007/s00239-006-0218-4.

27. Fernando et al., “A Stochastic Model of Nonenzymatic Nucleic Acid Replication.

28. Finn Werner and Dina Grohmann, “Structure, Function, and Evolution of Archaeo-Eukaryotic RNA Polymerases—Gatekeepers of the Genome,” in Molecular Machines in Biology: Workshop of the Cell, ed. Joachim Frank (Cambridge: Cambridge University Press, 2011), 79.

29. Steven A. Benner, Hyo-Joong Kim, and Matthew A. Carrigan, “Asphalt, Water, and the Prebiotic Synthesis of Ribose, Ribonucleosides, and RNA,” Accounts of Chemical Research 45 (2012): 2025–2034, https://doi.org/10.1021/ar200332w.

30. Harold S. Bernhardt, “The RNA World Hypothesis: The Worst Theory of the Early Evolution of Life (Except for All the Others),” Biology Direct 7 (2012): 23, doi:10.1186/1745-6150-7-23. Note especially the comments from one of the reviewers, Eugene Koonin, at the end of the article.

31. Günter Wächtershäuser, “Evolution of the First Metabolic Cycles,” Proceedings of the National Academy of Science 87 (1990): 200–204.

32. Laura M. Barge, Erika Flores, Marc M. Baum, David G. VanderVelde, and Michael J. Russell, “Redox and pH Gradients Drive Amino Acid Synthesis in Iron Oxyhydroxide Mineral Systems,” Proceedings of the National Academy of Sciences 116, no. 11 (2019): 4828–4833, doi:10.1073/pnas.1812098116. See James Tour’s chapter for comments on this study.

33. John D. Sutherland, “Studies on the Origin of Life—the End of the Beginning,” Nature Reviews Chemistry 1, no. 12 (2017): 2, doi:10.1038/s41570-016-0012.

34. Long-Fei Wu and John D. Sutherland, “Provisioning the Origin and Early Evolution of Life,” Emerging Topics in Life Sciences (2019): 1, doi:10.1042/ETLS20190011. By “translation” they mean the genetic process of replication involving DNA or its equivalent.

35. Long-Fei Wu and Sutherland, “Provisioning the Origin and Early Evolution of Life.”

36. Long-Fei Wu and Sutherland, “Provisioning the Origin and Early Evolution of Life.”

37. Stuart A. Harrison and Nick Lane, “Life as a Guide to Prebiotic Nucleotide Synthesis,” Nature Communications 9, no. 5176 (2018): 1, doi:10.1038/s41467-018-07220-y.

38. Harrison and Lane, “Life as a Guide to Prebiotic Nucleotide Synthesis.”

39. Dustin Trail, E. Bruce Watson, and Nicholas D. Tailby, “The Oxidation State of Hadean Magmas and Implications for Early Earth’s Atmosphere,” Nature 480 (2011): 79–82, doi:10.1038/nature10655.

40. E. A. Frank, W. D. Maier, S. S. J. Mojzsis, “Highly Siderophile Element Abundances in Eoarchean Komatiite and Basalt Protoliths,” Contributions to Mineralogy and Petrology 171 (2016): 29, doi:10.1007/s00410-016-1243-y. Christopher W. Dale, Thomas S. Kruijer, and Kevin W. Burton, “Highly Siderophile Element and 182W Evidence for a Partial Late Veneer in the Source of 3.8 Ga Rocks from Isua, Greenland,” Earth and Planetary Science Letters 458 (2017): 394– 404, doi:10.1016/j.epsl.2016.11.001.

41. H. Genda, R. Brasser, and S. J. Mojzsis, “The Terrestrial Late Veneer from Core Disruption of a Lunar-Sized Impactor,” Earth and Planetary Science Letters 480 (2017): 25–32, doi:10.1016/j.epsl.2017.09.041.

42. Genda et al., “The Terrestrial Late Veneer.”

43. The phenomena associated with high solar activity include stronger solar wind, more frequent and powerful flares, and more UV radiation.

44. Maxwell M. Thiemens, Peter Sprung, Raul O. C. Fonseca, Felipe P. Leitzke, and Carston Munker, “Early Moon Formation Inferred from Hafnium-Tungsten Systematics,” Nature Geoscience (2019), doi:10.1038/s41561-019-0398-3.

45. Kohei Shimamura, Fuyuki Shimojo, Aiichiro Nakano, and Shigenori Tanaka, “Meteorite Impact-Induced Rapid NH3 Production on Early Earth: Ab Initio Molecular Dynamics Simulation,” Scientific Reports 6, no. 38953 (2016), doi:10.1038/srep38953.

46. Zita Martins, Mark C. Price, Nir Goldman, Mark A. Sephton, and Mark J. Burchell, “Shock Synthesis of Amino Acids from Impacting Cometary and Icy Planet Surface Analogues,” Nature Geoscience 6 (2013): 1045– 1049, doi:10.1038/ngeo1930.

47. George G. Managadze, Michael H. Engel, Stephanie Getty, Peter Wurz, William B. Brinckerhoff, Anatoly G.Shokolov, Gennady V.Sholin. Sergey A. Terent’ev, Alexander E. Chumikov, Alexander S. Skalkin, Vladimir D. Blank, Vyacheslav M.P rokhorov, Nina G. Managadze, and Konstantin A. Luchnikov, “Excess of L-alanine in Amino Acids Synthesized in a Plasma Torch Generated by a Hypervelocity Meteorite Impact Reproduced in the Laboratory,” Planetary and Space Science 131 (2016): 70–78, https://doi.org/10.1016/j.pss.2016.07.005.

48. S. Pizzarello and L. B. Williams, “Ammonia in the Early Solar System: An Account from Carbonaceous Meteorites,” The Astrophysical Journal 749 (2012): 161–166, doi:10.1088/0004-637X/749/2/161.

49. Philippe Schmitt-Kopplin, Zelimir Gabelica, Regis D. Gougeon, Agnes Fekete , Basem Kanawati, Mourad Harir, Istvan Gebefuegi, Gerhard Eckel, and Norbert Hertkorn, "High Molecular Diversity of Extraterrestrial Organic Matter in Murchison Meteorite Revealed 40 Years After its Fall," Proceedings of the National Academy of Sciences of the USA 107 (2010): 2763–2768, doi:10.1073/pnas.0912157107; Michael P. Callahan, Karen E. Smith, H. James Cleaves II, Josef Ruzicka, Jennifer C. Stern, Daniel P. Glavin, Christopher H. House, and Jason P. Dworkin, "Carbonaceous Meteorites Contain a Wide Range of Extraterrestrial Nucleobases," Proceedings of the National Academy of Sciences of the USA 108 (2011): 13995–13998, doi:10.1073/pnas.1106493108.

50. Zachary R. Adam, "Temperature Oscillations Near Natural Nuclear Reactor Cores and the Potential for Prebiotic Oligomer Synthesis," Origins of Life and Evolution of Biospheres 46 (2016): 171–187, doi:10.1007/s11084-015-9478-6; Zachary R. Adam, Yayoi Hongo, H. James Cleaves II, Josef Ruzicka, Jennifer C. Stern, Daniel P. Glavin, Christopher H. House, and Jason P. Dworkin, "Estimating the Capacity for Production of Formamide by Radioactive Minerals on the Prebiotic Earth," Scientific Reports 8, no. 265 (2018), doi:10.1038/s41598-017- 18483-8.

51. Adam et al., "Estimating the Capacity for Production of Formamide."

52. Ruiqin Yi, Yayoi Hongo, Isao Yoda, Zachary R. Adam, and Albert C. Fahrenbach, "Radiolytic Synthesis of Cyanogen Chloride, Cyanimide, and Simple Sugar Precursors," Chemistry Select 3 (2018): 10169–10174, doi:10.1002/slct.201802242.

53. Adam et al., "Estimating the Capacity for Production of Formamide."

54. M. D. Hopkins and S. J. Mojzsis, "A Protracted Timeline for Lunar Bombardment from Mineral Chemistry, Ti Thermometry and U–Pb Geochronology of Apollo 14 Melt Breccia Zircons," Contributions to Mineralogy and Petrology 169, no. 30 (2015), doi:10.1007/ s00410-015- 1123-x.

55. C. F. Mileikowsky, A. Cucinotta, J. W. Wilson, Brett Gladman, Gerda Horneck, Lennart Lindegren, Jay Melosh, Hans Rickman, Mauri Valtonen, and J. Q. Zheng, "Natural Transfer of Viable Microbes in Space: from Mars to Earth and Earth to Mars," Icarus 145 (2000): 391– 427, doi:10.1006/icar.1999.6317; Wells, Armstrong, and Gonzalez, "Reseeding of Early Earth by Impacts of Returning Ejecta During the Late Heavy Bombardment."

فصل شانزدهم: کتاب‌های درسی هنوز پیدایش حیات را به‌درستی معرفی نمی‌کنند

1. Jonathan Wells, Icons of Evolution: Why Much of What We Teach abo Evolution Is Wrong (Washington, DC: Regnery Publishing, 2000).

2. Jonathan Wells, Zombie Science: More Icons of Evolution (Seattle: Discovery Institute Press, 2017).

3. Charles R. Darwin to J. D. Hooker, 1 February 1871, Darwin Correspondence Project, University of Cambridge, https://www.darwinproject.ac.uk/letter/DCP-LETT-7471.xml.

4. Alexander I. Oparin, The Origin of Life [Russian Proiskhozhdenie Zhizni, 1924], trans. Ann Synge, https://www.valencia.edu/~orilife/textos/The%20Origin%20of%20Life.pdf

5. Alexander I. Oparin, The Emergence of Life on the Earth [Russian

Vozniknovenie Zhizni no Zemle, 1936], trans. Sergius Morgulis (Mineola, NY: Dover Publications, 2003), 82.

6. Oparin, The Emergence of Life on the Earth, 104.

7. J. B. S. Haldane, Rationalist Annual 148 (1928): 3–10.

8. Harold C. Urey, "On the Early Chemical History of the Earth and the 6.Origin of Life," Proceedings of the National Academy of Sciences USA 38 (1952): 351–363, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1063561/pdf/pnas01577- 0073.pdf.

9. Jeffrey L. Bada and Antonio Lazcano, "Stanley Miller's 70th Birthday," Origins of Life and Evolution of the Biosphere 30 (2000): 107–112, doi:10.1023/A:1006746205180, http://evolvingcreation.com/wpcontent/ uploads/2012/08/Stanley-Miller-70thB-Day.pdf.

10. Bada and Lazcano, "Stanley Miller's 70th Birthday."

11. Stanley L. Miller, "A Production of Amino Acids under Possible Primitive Earth Conditions," Science 117 (1953): 528–529, doi:10.1126/science.117.3046.528, http://udel.edu/~mcdonald/miller1953.pdf.

12. James D. Watson and Francis H. C. Crick, "A Structure for Deoxyribose Nucleic Acid," Nature 171 (1953): 737–738, doi:10.1038/171737a0, http://annals.org/article.aspx?articleid=716280.

13. Francis W. Aston, "The Rarity of the Inert Gases on Earth," Nature 114 (1924): 786, doi:10.1038/114786a0.

14. Harrison S. Brown, "Rare Gases and the Formation of the Earth's Atmosphere," in The Atmospheres of the Earth and Planets, ed. Gerard P. Kuiper (Chicago: University of Chicago Press, 1949), 258–268.

15. Heinrich D. Holland, "Model for the Evolution of the Earth's Atmosphere," in Petrologic Studies: A Volume in Honor of A. F. Buddington, eds. Albert E.

J. Engel, Harold L. James, and Benjamin F. Leonard (New York: Geological Society of America, 1962), 447–449.

16. Heinrich D. Holland, The Chemical Evolution of the Atmosphere and Oceans (Princeton: Princeton University Press, 1984), 91.

17. Philip H. Abelson, "Chemical Events on the Primitive Earth," Proceedings of the National Academy of Sciences USA 55 (1966): 1365– 1366, https://www.pnas.org/content/pnas/55/6/1365.full.pdf.

18. Marcel Florkin, "Ideas and Experiments in the Field of Prebiological Chemical Evolution," Comprehensive Biochemistry 29B (1975): 241– 242.

19. Sidney W. Fox and Klaus Dose, Molecular Evolution and the Origin of Life, rev. ed. (New York: Marcel Dekker, 1977), 43.

20. Fox and Dose, Molecular Evolution and the Origin of Life, 74–76.

21. Gordon Schlesinger and Stanley L. Miller, "Prebiotic Synthesis in Atmospheres Containing CH4, CO, and CO2: I. Amino Acids," Journal of Molecular Evolution 19, no. 5 (1983): 376–382, doi:10.1007/BF02101642.

22. Schlesinger and Miller, "Prebiotic Synthesis," 381.

23. Schlesinger and Miller, "Prebiotic Synthesis," 381.

24. Schlesinger and Miller, "Prebiotic Synthesis," 376.

25. Robert Shapiro, Origins: A Skeptic's Guide to the Creation of Life on Earth (New York: Summit Books, 1986), 112.

26. Freeman Dyson, Origins of Life, 2nd ed. (Cambridge: Cambridge University Press, 1999), 33–34.

27. Feng Tian, Owen B. Toon, Alexander A. Pavlov, and H. De Sterk, "A Hydrogen-Rich Early Earth Atmosphere," Science 308 (2005): 1014– 1017, doi:10.1126/science.1106983.

28. David C. Catling, "Comment on 'A Hydrogen-Rich Early Earth Atmosphere,'" Science 311 (2006): author reply 38, doi:10.1126/science.1117827.

29. Kiyoshi Kuramoto, Takafumi Umemoto, and Masaki Ishiwatari, "Effective Hydrodynamic Hydrogen Escape from an Early Earth Atmosphere Inferred from High-Accuracy Numerical Simulation," Earth and Planetary Science Letters 375 (2013): 312–318, doi:10.1016/j.epsl.2013.05.050, https://www.ep.sci.hokudai.ac.jp/~keikei/preprint/Kuramoto- EPSL2013.pdf.

30. Adam P. Johnson, H. James Cleaves, Jason P. Dworkin, Daniel P. Glavin, Antonio Lazcano, and Jeffrey L. Bada, "The Miller Volcanic Spark Discharge Experiment," Science 322 (2008): 404, doi:10.1126/science.1161527, https://

pdfs.semanticscholar.org/8f93/00218893480182d6b7b6cba3fb25078d9e f.pdf

31. Robert Anderson, Stuart Gathman, James Hughes, Sveinbjörn Björnsson, Sigurgeir Jónasson, Duncan C. Blanchard, Charles B. Moore, Henry J. Survilas, and Bernard Vonnegut, "Electricity in Volcanic Clouds: Investigations Show That Lightning Can Result From Charge-Separation Processes in a Volcanic Crater," Science 148 (1965): 1179–1189, doi:10.1126/science.148.3674.1179.

32. Stephen R. McNutt and C. M. Davis, "Lightning Associated with the 1992 Eruptions of Crater Peak Mount Spurr Volcano, Alaska," Journal of Volcanology and Geothermal Research 102 (2000): 45, doi:10.1016/S0377-0273(00)00181-5.

33. Stanley L. Miller, "Production of Some Organic Compounds Under Possible Primitive Earth Conditions," Journal of the American Chemical Society 77 (1955): 2351–2361, doi:10.1021/ja01614a001.

34. Johnson et al., "The Miller Volcanic Spark Discharge Experiment."

35. Schlesinger and Miller, "Prebiotic Synthesis," 376.

36. H. James Cleaves, John H. Chalmers, Antonio Lazcano, Stanley L. Miller, and Jeffrey L. Bada, "A Reassessment of Prebiotic Organic Synthesis in Neutral Planetary Atmospheres," Origins of Life and Evolution of the Biosphere 38 (2008): 105–115, doi:10.1007/ s11084- 007-9120-3.

37. Cleaves et al., "A Reassessment of Prebiotic Organic Synthesis in Neutral Planetary Atmospheres."

38. Clemens Richert, "Prebiotic Chemistry and Human Intervention," Nature Communications 9 (2018): 5177, doi:10.1038/s41467-018-07219-5.

39. Eric T. Parker, Henderson James Cleaves, Jason P. Dworkin, Daniel P. Glavin, Michael Callahan, Andrew Aubrey, Antonio Lazcano, and Jeffery L. Bada, "Primordial Synthesis of Amines and Amino Acids in a 1958 Miller H2S-rich Spark Discharge Experiment," Proceedings of the National Academy of Sciences USA 108 (2011): 5526–5531, doi:10.1073/ pnas.1019191108.

40. Eric T. Parker, Manshui Zhou, Aaron S. Burton, Daniel P. Glavin, Jason P. Dworkin, Ramanarayanan Krishnamurthy, Facundo M. Fernández, and Jeffrey L. Bada, "A Plausible Simultaneous Synthesis of Amino Acids and Simple Peptides on the Primordial Earth," Angewandte Chemie 53 (2014): 8132–8136, doi:10.1002/anie.201403683.

41. Eric T. Parker, H. James Cleaves, Aaron S. Burton, Daniel P. Glavin, Jason P. Dworkin, M. Zhou, Jeffrey L. Bada, and Facundo M. Fernández, "Conducting Miller-Urey Experiments," Journal of Visualized Experiments 83 (2014): e51039, doi:10.3791/51039, https://www.jove.com/video/51039/conducting-miller-urey-experiments.

42. Scott Freeman, Kim Quillin, Lizabeth Allison, Michael Black, Greg Podgorski, Emily Taylor, and Jeff Carmichael, Biological Science, 6th ed. (Hoboken, NJ: Pearson Education, 2017), 71.

43. Freeman et al., Biological Science, 78.

44. Kenneth A. Mason, Jonathan B. Losos, Susan R. Singer, Peter H. Raven, and George B. Johnson, Biology, 11th ed. (New York: McGraw Hill Education, 2017), 516–517.

45. Mason et al., Biology, 517.

46. Neil A. Campbell, Lisa A. Urry, Michael L. Cain, Steven A. Wasserman, Peter V. Minorsky, and Jane B. Reece, Biology: A Global Approach, 11th ed. (New York: Pearson Education, 2018), 580.

47. "Organic Compound," Encyclopedia Britannica, accessed June 2019, https://www.britannica.com/science/organic-compound.

48. Campbell et al., Biology, 106.

49. Campbell et al., Biology, 580.

50. Miller, "Production of Some Organic Compounds."

51. Johnson et al., "Miller Volcanic Spark Discharge Experiment."

52. Sylvia S. Mader and Michael Windelspecht, Biology, 13th ed. (New York: McGraw Hill Education, 2019), 318.

53. Mader and Windelspecht, Biology, 318.

54. Kenneth R. Miller and Joseph S. Levine, Biology (Boston: Pearson Education, 2019), 660.

55. Miller and Levine, Biology, 660.

فصل هفدهم: شواهدی از طراحی‌هوشمندانه در پیدایش حیات

1. Harmke Kamminga, "Protoplasm and the Gene," in Clay Minerals and the Origin of Life, ed. A. G. Cairns-Smith and H. Hartman (Cambridge: Cambridge University Press, 1986), 1.

2. Alexander Oparin, Genesis and Evolutionary Development of Life (New York: Academic Press, 1968), 7.

3. F. Crick and J. Watson, "A Structure for Deoxyribose Nucleic Acid," Nature 171 (1953): 737–38; F. Crick and J. Watson, "Genetical Implications of the Structure of Deoxyribose Nucleic Acid," Nature 171 (1953): 964–67, esp. 964; T. D. Schneider, "Information Content of Individual Genetic Sequenc-

es," Journal of Theoretical Biology 189 (1997): 427–41; W. R. Loewenstein, The Touchstone of Life: Molecular Information, Cell Communication, and the Foundations of Life (New York: Oxford, 1999).

4. Bernd-Olaf Kuppers, Information and the Origin of Life (Cambridge: MIT Press, 1990), 170–72.

5. L. E. Kay, "Who Wrote the Book of Life? Information and the Transformation of Molecular Biology," Science in Context 8 (1994): 601–34; L. E. Kay, "Cybernetics, Information, Life: The Emergence of Scriptural Representations of Heredity," Configurations 5 (1999): 23–91; L. E. Kay, Who Wrote the Book of Life? (Stanford, CA: Stanford University Press, 2000), xv–xix.

۶- تنها حدس و گمان داروین در مورد منشا حیات در نامه‌ای منتشرنشده‌ای مطرح شده که به جوزف هوکر نوشته است. داروین در این نامه طرح‌های کلی ایده‌ی تکاملی شیمیایی را ترسیم کرده، یعنی این‌که حیات می‌توانست نخست از یک‌سری واکنش‌های شیمیایی شکل گرفته باشد. او نوشت:

> . . . اگر (و چه اگر بزرگی است) می‌توانستیم در یک حوضچه‌ی کوچک گرم با انواع نمک‌های آمونیاک و فسفر، – نور، گرما، الکتریسیته و غیره، تصور کنیم که یک ترکیب پروتیینی از نظر شیمیایی تشکیل شده است که آماده است تغییرات پیچیده‌تری را تجربه کند. . .

Darwin to Hooker, February 1, 1871, Darwin Correspondence Project, https://www.darwinproject.ac.uk/letter/DCPLETT-7471.xml. Darwin's original punctuation and abbreviations have been preserved.

7. E. Haeckel, The Wonders of Life, trans. J. McCabe (London: Watts, 1905), 111; T. H. Huxley, "On the Physical Basis of Life," Fortnightly Review 5 (1869): 129–45.

8. A. I. Oparin, The Origin of Life, trans. S. Morgulis (New York: Macmillan, 1938); S. C. Meyer, "Of Clues and Causes: A Methodological Interpretation of Origin of Life Studies" (PhD dissertation, Cambridge University, 1991).

9. J. C. Kendrew, in H. F. Judson, The Eighth Day of Creation (NY: Simon and Schuster, 1979), 562–63; J. C. Kendrew, G. Bodo, H. M. Dintzis, R. G. Parrish, and H. Wyckoff, "A Three-Dimensional Model of the Myoglobin Molecule Obtained by X-Ray Analysis," Nature 181 (1958): 662–66, esp. 664.

10. B. Alberts, D. Bray, J. Lewis, M. Raff, K. Roberts, and J. D. Watson, Molecular Biology of the Cell (New York: Garland, 1983), 111–12, 127– 31.

11. Judson, Eighth Day, 30.

12. Judson, Eighth Day, 95–96; E. Chargaff, Essays on Nucleic Acids (Amsterdam: Elsevier, 1963), 21.

13. Chargaff, Essays, 21.

14. Crick and Watson, “Structure.”

15. Crick and Watson, “Genetical Implications,” 965.

16. Judson, Eighth Day, 611.

17. Crick and Watson, “Structure”; Crick and Watson, “Genetical Implications.

18. Judson, Eighth Day, 245–46, 335–36.

19. Ibid., 470–89; J. H. Matthei and M. W. Nirenberg, “Characteristics and Stabilization of DNAase-Sensitive Protein Synthesis in E. coli Extracts,” Proceedings of the National Academy of Sciences, USA 47 (1961): 1580– 88; J. H. Matthei and M. W. Nirenberg, “The Dependence of Cell-Free Protein Synthesis in E. coli upon Naturally Occurring or Synthetic Polyribonucleotides,” Proceedings of the National Academy of Sciences, USA 47 (1961): 1588–1602.

20. Alberts et al., Molecular Biology, 106–8; S. L. Wolfe, Molecular and Cellular Biology (Belmont, CA: Wadsworth, 1993), 639–48.

۲۱- البته ما اکنون می‌دانیم که افزون بر فرآیند بیان ژن، آنزیم‌های خاص اغلب باید زنجیره‌های اسید آمینه را پس از ترجمه اصلاح کنند تا به توالی‌بندی دقیق لازم برای تاخوردگی صحیح به یک پروتیین عملکردی برسند. ممکن است زنجیره‌های اسید آمینه‌ای که بیان ژن تولید کرده نیز به ترتیب در شبکه‌ی آندوپلاسمی اصلاح شوند. در نهایت، ممکن است حتی زنجیره‌های اسید آمینه‌ای که به‌خوبی اصلاح شده‌اند، به «شِپرون‌های» پروتیینی از قبل موجود نیاز داشته باشند تا به آن‌ها کمک کند به پیکربندی سه‌بعدی کاربردی‌ای تبدیل شوند. تمام این عوامل، پیش‌بینی توالی نهایی پروتیین را تنها از روی توالی ژنی مربوطه‌ی آن ناممکن می‌کند.
See S. Sarkar, “Biological Information: A Skeptical Look at Some Central Dogmas of Molecular Biology,” in The Philosophy and History of Molecular Biology: New Perspectives, ed. S. Sarkar (Dordrecht, Netherlands: Boston Studies in Philosophy of Science, 1996), 196, 199–202.
با این حال، این غیر قابل پیش‌بینی بودن به‌هیچ‌وجه این ادعا را که DNA نشان‌دهنده‌ی «اختصاصی‌بودن توالی» است یا ادعای ایزومورفیک را مبنی بر این‌که DNA حاوی «اطلاعات اختصاصی‌شده» است، تضعیف نمی‌کند، همان‌طور که در بخش نخست نیز بحث شد. برای مثال، سارکر استدلال می‌کند که فقدان چنین قابلیت پیش‌بینی‌ای، مفهوم اطلاعات را از لحاظ نظری برای زیست‌شناسی مولکولی غیر ضروری می‌کند. در عوض، این غیر قابل پیش‌بینی بودن نشان می‌دهد که ویژگی خاص توالی‌های باز DNA شرط لازم برای رسیدن به تاخوردگی پروتیین مناسب است، گرچه شرط کافی نیست. یعنی DNA حاوی اطلاعات مشخصی است (قسمت I، بخش E) اما برای تعیین تاخوردگی پروتیین به‌تنهایی کافی نیست. در عوض، وجود هر دو فرآیند اصلاح پس از ترجمه و ویرایش ژنومی پیش از رونویسی (از طریق اگزونوکلئازها، اندونوکلئازها، اسپلایسئوزوم‌ها و دیگر آنزیم‌های ویرایش‌کننده) تنها بر نیاز به وجود دیگر مولکول‌های زیستی از قبل موجود و و غنی از اطلاعات برای پردازش اطلاعات ژنومی در سلول تاکید می‌کند. وجود

یک سیستم پردازش اطلاعات پیچیده و عملکردی یک‌پارچه نشان می‌دهد که اطلاعات روی مولکول DNA برای تولید پروتیین کافی نیست. این نشان نمی‌دهد که چنین اطلاعاتی برای تولید پروتیین‌ها غیر ضروری است، پس این ادعا را که DNA، اطلاعات ژنتیکی اختصاصی‌شده را ذخیره و منتقل می‌کند نیز بی‌اعتبار نمی‌کند.

22. C. Shannon, "A Mathematical Theory of Communication," Bell System Technical Journal 27 (1948): 379–423, 623–56.

23. F. Dretske, Knowledge and the Flow of Information (Cambridge: MIT Press, 1981), 6–10.

24. Ibid.; Shannon, "A Mathematical Theory."

25. B. Kuppers, "On the Prior Probability of the Existence of Life," in The Probabilistic Revolution, ed. Lorenz Kruger et al. (Cambridge: MIT Press, 1987), 355–69.

26. Schneider, "Information Content"; see also H. P. Yockey, Information Theory and Molecular Biology (Cambridge: Cambridge University Press, 1992), 246–58, for important refinements in the method of calculating the information-carrying capacity of proteins and DNA.

27. C. Shannon and W. Weaver, The Mathematical Theory of Communication (Urbana: University of Illinois Press, 1949), 8.

28. Schneider, "Information Content," 58–177; Yockey, Information Theory, 58–177.

29. Schneider, "Information Content"; Yockey, Information Theory; Sarkar, "Biological Information," 199–202, esp. 196; F. Crick, "On Protein Synthesis," Symposium for the Society of Experimental Biology 12 (1958): 138–63, esp. 144, 153.

30. Crick, "On Protein Synthesis," 144, 153.

۳۱- اگر به خاطر داشته باشید، برای مثال، تعیین کد ژنتیکی به هم‌بستگی مشاهده‌شده بین تغییرات در توالی‌های باز نوکلئوتیدی و تولید اسید آمینه در «سیستم‌های بدون سلول» بستگی داشت.
See Judson, Eighth Day, 470–87.

32. For a much more detailed discussion of specification, see W. A. Dembski, The Design Inference: Eliminating Chance through Small Probabilities (Cambridge: Cambridge University Press, 1998), 1–35, 136–74. The simplified discussion here draws in part on Stephen Meyer, "Yes, Intelligent Design Is Detectable by Science," Evolution News, April 24, 2018, https://evolutionnews.org/2018/04/yes-intelligent-design-isdetectable- by-science/.

33. J. Bowie and R. Sauer, "Identifying Determinants of Folding and Activity

for a Protein of Unknown Sequences: Tolerance to Amino Acid Substitution," Proceedings of the National Academy of Sciences, USA 86 (1989): 2152–56; J. Reidhaar-Olson and R. Sauer, "Functionally Acceptable Solutions in Two Alpha-Helical Regions of Lambda Repressor," Proteins, Structure, Function, and Genetics 7 (1990): 306– 10.

34. R. Dawkins, River out of Eden (New York: Basic Books, 1995), 11.

35. B. Gates, The Road Ahead (Boulder, CO: Blue Penguin, 1996), 228. L. E. Orgel, The Origins of Life (New York: John Wiley, 1973), 189.

36. Kay, "Who Wrote the Book of Life?" 611–12, 629; Kay, "Cybernetics";

37. Kay, Who Wrote the Book of Life? (For full details for Kay references, see note 5 above.)

38. Sarkar, "Biological Information," 199–202.

39. E. Schrödinger, What Is Life? and Mind and Matter (Cambridge: Cambridge University Press, 1967), 82; Alberts et al., Molecular Biology, 21; Crick and Watson, "A Structure"; Crick and Watson, "Genetical Implications"; Crick, "On Protein"; Judson, Eighth Day, 611; Orgel, Origins of Life, 189.

40. P. Davies, The Fifth Miracle (New York: Simon and Schuster, 1998), 120. Orgel, Origins of Life, 189.

41. Orgel, Origins of Life, 189.

42. Loewenstein, Touchstone; Davies, Fifth Miracle; Schneider, "Information Content"; C. Thaxton and W. Bradley, "Information and the Origin of Life," in The Creation Hypothesis: Scientific Evidence for an Intelligent Designer, ed. J. P. Moreland (Downers Grove, IL: InterVarsity Press, 1994), 173–210, esp. 190; S. Kauffman, The Origins of Order (Oxford: Oxford University Press, 1993), 287–340; Yockey, Information Theory, 178–293; Kuppers, Information and Origin, 170–72; F. Crick, Life Itself (New York: Simon and Schuster, 1981), 59–60, 88; J. Monod, Chance and Necessity (New York: Vintage Books, 1971), 97–98, 143; Orgel, Origins, 189; D. Kenyon and G. Steinman, Biochemical Predestination (New York: McGraw-Hill, 1969), 199–211, 263–66; Oparin, Genesis, 146–47; H. Quastler, The Emergence of Biological Organization (New Haven, CT: Yale University Press, 1964)

43. G. Wald, "The Origin of Life," Scientific American 191 (August 1954): 44–53; R. Shapiro, Origins: A Skeptic's Guide to the Creation of Life on Earth (New York: Summit Books, 1986), 121.

44. F. Crick, "The Origin of the Genetic Code," Journal of Molecular Biology 38 (1968): 367–79; H. Kamminga, "Studies in the History of Ideas on the Origin of Life from 1860" (PhD dissertation, Chelsea College, University of London, 1980), 303–4.

45. C. de Duve, “The Constraints of Chance,” Scientific American, Jan. 1996, 112; Crick, Life Itself, 89–93; Quastler, Emergence, 7.

46. H. J. Morowitz, Energy Flow in Biology (New York: Academic Press, 1968), 5–12; F. Hoyle and C. Wickramasinghe, Evolution from Space (London: J. M. Dent, 1981), 24–27; A. G. Cairns-Smith, The Life Puzzle (Edinburgh: Oliver and Boyd, 1971), 91–96; I. Prigogine, G. Nicolis, and A. Babloyantz, “Thermodynamics of Evolution,” Physics Today 23 (Nov. 1972); Yockey, Information Theory, 246–58; Yockey, “Self- Organization, Origin of Life Scenarios and Information Theory,” Journal of Theoretical Biology 91 (1981): 13–31; Bowie and Sauer, “Identifying Determinants”; Reidhaar-Olson et al., Proteins; Shapiro, Origins, 117–

47. Prigogine, “Thermodynamics of Evolution.”

48. Cairns-Smith, The Life Puzzle, 95.

49. John Reidhaar-Olson and Robert Sauer, “Functionally Acceptable Substitutions in Two Alpha-Helical Regions of Lambda Repressor,” in Proteins: Structure, Function, and Bioinformatics 7, no. 4 (1990): 306– 316; James Bowie and Robert Sauer, “Identifying the Determinants of Folding and Activity for a Protein of Unknown Structure,” Proceedings of the National Academy of Sciences USA 86 (1989): 2152–2156.

۵۰- جالب توجه است که آن‌ها در شرح نتایج خود اغلب نادربودن توالی‌های کاربردی در فضای دنباله را کم‌اهمیت جلوه می‌دهند و در عوض اغلب بر تحمل اسیدهای آمینه‌ی گوناگون که استفاده از آن‌ها در هر جایگاهی مجاز است تاکید می‌کنند. برای مثال، چکیده‌ی مقاله که رقم ۱ در ۱۰ ^{۶۳} را گزارش می‌کند، هیچ اشاره‌ای به اهمیت بالقوه‌ی آن نمی‌کند، در عوض بیان می‌کند که نتایج آن‌ها «سطح بالای تخریب را در اطلاعاتی که یک برابر پروتیین خاص را مشخص می‌کند، آشکار می‌کند».
Reidhaar-Olson and Sauer, “Functionally Acceptable Substitutions.”

51. Bowie and Sauer, “Identifying the Determinants of Folding”; Reidhaar- Olson and Sauer, “Functionally Acceptable Substitutions”; Cyrus Chothia, Israel Gelfand, and Alexander Kister, “Structural Determinants in the Sequences of Immunoglobulin Variable Acid Domain,” Journal of Molecular Biology 278 (1998), 457–479; Douglas Axe, “Extreme Functional Sensitivity to Conservative Amino Acid Changes on Enzyme Exteriors” J. Mol. Biol. 301 (2000), 585–595; Taylor, Sean V., Kai U. Walter, Peter Kast, and Donald Hilvert, “Searching Sequence Space for Protein Catalysts,” Proceedings of the National Academy of Sciences USA 98 (2001), 10596–10601.

52. See, for example, Max F. Perutz and Hermann Lehmann, “Molecular Pathology of Human Hemoglobin,” Nature 219 (1968), 902–909.

53. Douglas Axe, “Estimating the Prevalence of Protein Sequences Adopting

Functional Enzyme Folds" J. Mol. Biol. 341 (2004), 1295–1315.

54. For Dembski's treatment of probabilistic resources at the scale of the known universe, see Dembski's above-cited Design Inference, ch. 6.

۵۵- تعداد راه‌های ممکن برای ترکیب ذرات بنیادی (و در نتیجه تعداد رویدادهای ممکن ترکیبی) در واقع بسیار بیش‌تر از تعداد رویدادهای گوناگونی است که می‌توانسته در تاریخ جهان رخ دهد. چرا؟ زیرا وقوع هر رویداد منفرد مانع وقوع بسیاری از دیگر رویدادهای احتمالی در فضای ترکیبی بزرگ‌تر می‌شود. تعداد رویدادهای ترکیبی ممکن تعداد رویدادهای گوناگونی را نشان می‌دهد که ممکن است پیش از پدیدآمدن کیهان به‌گونه‌ای که واقعا از آن طریق پدید آمده است، رخ داده باشند. دمبسکی به‌درستی حداکثر تعداد رویدادهایی را که واقعا می‌توانند در هر تاریخ مشخصی از جهان رخ دهند به عنوان تعداد تعیین‌کننده‌ی منابع احتمالی جهان مشخص کرده است. این عدد تعیین می‌کند که جهان از طریق تصادف چند فرصت برای تحقق یک نتیجه‌ی خاص دارد. همان‌طور که دمبسکی توضیح می‌دهد، تعداد کل رویدادهای ترکیبی ممکن (یا ذرات بنیادی) در جهان، منابع احتمالی موجود را تعیین نمی‌کند بلکه تعداد فرصت‌ها برای «تفرد و جداکردن» رویدادهای واقعی هستند که منابع احتمالی موجود را تعیین می‌کنند.
See The Design Inference, ch. 6, and in that chapter p. 209 n.15.

۵۶- ذرات بنیادی شمارش‌شده در این محاسبه تنها شامل پروتون‌ها، نوترون‌ها و الکترون‌ها (فرمیون‌ها) می‌شوند؛ زیرا تنها این ذرات دارای چیزی هستند که فیزیک‌دانان آن را half-integral spin «اسپین نیمه‌انتگرال» می‌نامند و به آن‌ها اجازه می‌دهد ساختارهای مادی را تشکیل دهند. در این‌جا بوزون‌ها که نمی‌توانند ساختارهای مادی را تشکیل دهند و تنها انرژی را منتقل می‌کنند مد نظر نیستند و در این محاسبه شمارش نمی‌شوند. کوارک‌هایی که پروتون‌ها و نوترون‌ها از آن‌ها ساخته شده‌اند نیز در این‌جا محاسبه نمی‌شوند؛ زیرا کوارک‌ها لزوما درون این ذرات به هم متصل هستند. با این حال، حتی اگر کوارک‌ها شمارش شوند، تعداد کل ذرات بنیادی کم‌تر از یک مرتبه تغییر می‌کند؛ زیرا در هر پروتون یا نوترون تنها سه کوارک وجود دارد.

۵۷- از آن‌جا که حد بالایی برای سرعت نور وجود دارد، تنها آن بخش‌هایی از جهان که برای ما قابل مشاهده هستند می‌توانند بر رویدادهای روی زمین تاثیر بگذارند. بنابراین، جهان قابل مشاهده تنها بخشی از جهان هستی است که منابع احتمالی مربوط به توضیح رویدادهای روی زمین را دارد.

۵۸- برای اطمینان، دمبسکی عددی را که محاسبه کرده بود به 10^{150} گرد کرد، البته بدون هیچ توجیه فیزیکی یا ریاضی‌ای. از آن‌جا که نیازی به انجام این کار نبود، تصمیم گرفتم از عدد دقیق‌تر و بدون گردکردن به عنوان معیار واقعی منابع احتمالی جهان در ارزیابی‌هایم در مورد فرضیه‌ی شانس و تصادف استفاده کنم.

59. See discussion and references in Signature in the Cell, 217.

60. P. T. Mora, "Urge and Molecular Biology," Nature 199 (1963): 212–19.

61. Oparin, Genesis, 146–47.

62. C. de Duve, Blueprint for a Cell: The Nature and Origin of Life (Burlington, NC: Neil Patterson, 1991), 187.

63. T. Dobzhansky, "Discussion of G. Schramm's Paper," in The Origins of Prebiological Systems and of Their Molecular Matrices, ed. S. W. Fox (New York: Academic Press, 1965), 310; H. H. Pattee, "The Problem of Biological Hierarchy," in C. H. Waddington, ed., Organization, Stability, & Process [vol. 3 of Toward a Theoretical Biology] (Piscataway, NJ: Transaction, 1970), 123.

64. Richard Dawkins, The Blind Watchmaker: Why the Evidence Reveals a Universe Without Design (New York: Norton, 1987), 47–49; Kuppers, "On the Prior Probability."

65. Kuppers, "On the Prior Probability," 366.

66. Dawkins, Blind Watchmaker, 47–49; P. Nelson, "Anatomy of a Still-Born Analogy," Origins and Design 17, no. 3 (1996): 12.

67. Stephen C. Meyer, Signature in the Cell: DNA and the Evidence for Intelligent Design (San Francisco: HarperOne, 2009), 283–291.

68. C. de Duve, "The Beginnings of Life on Earth," American Scientist 83 (1995), 437.

69. Morowitz, Energy Flow, 5–12.

70. G. Steinman and M. N. Cole, "Synthesis of Biologically Pertinent Peptides Under Possible Primordial Conditions," Proceedings of the National Academy of Sciences USA 58 (1967): 735–41; G. Steinman, "Sequence Generation in Prebiological Peptide Synthesis," Archives of Biochemistry and Biophysics 121 (1967): 533–39; R. A. Kok, J. A. Taylor, and W. L. Bradley, "A Statistical Examination of Self-Ordering of Amino Acids in Proteins," Origins of Life and Evolution of the Biosphere 18 (1988): 135–42.

71. Meyer, Signature in the Cell, 229–270.

72. C. Thaxton, W. Bradley, and R. Olsen, The Mystery of Life's Origin: Reassessing Current Theories (Dallas: Lewis and Stanley, 1992), v–viii; D. Kenyon and G. Mills, "The RNA World: A Critique," Origins and Design 17, no. 1 (1996): 9–16; D. Kenyon and P. W. Davis, Of Pandas and People: The Central Question of Biological Origins (Dallas: Haughton, 1993); S. C. Meyer, "A Scopes Trial for the '90s," Wall Street Journal, Dec. 6, 1993, A14; Kok et al., "Statistical Examination."

73. Steinman and Cole, "Synthesis"; Steinman, "Sequence Generation."

74. Kok et al., "Statistical Examination"; B. J. Strait and G. T. Dewey, "The Shannon Information Entropy of Biologically Pertinent Peptides," Biophysical Journal 71 (1996): 148–155.

75. Kuppers, "On the Prior Probability," 64.

76. C. de Duve, "Beginnings of Life," 437.

77. R. Stalnaker, Inquiry (Cambridge: MIT Press, 1984), 85

۷۸- این در واقع جایی اتفاق می‌افتد که آدنین و تیمین به‌صورت شیمیایی در جفت باز مکمل در محور حامل اطلاعات مولکول DNA برهم‌کنش می‌کنند. اما در امتداد محور حامل پیام، هیچ پیوند شیمیایی یا پیوندهای افتراقی‌ای وجود ندارد که توالی را تعیین کند.

79. M. Polanyi, "Life's Irreducible Structure," Science 160 (1968): 1308–12, esp. 1309.

80. Yockey, "Self-Organization," 18.

81. H. P. Yockey, "A Calculation of the Probability of Spontaneous Biogenesis by Information Theory," Journal of Theoretical Biology 67 (1977): 377–98, esp. 380.

82. M. Eigen, Steps Toward Life (Oxford: Oxford University Press, 1992), 12.

83. Meyer, Signature in the Cell, 267–268, 284–286, 288–290.

84. R. Shapiro, "Prebiotic Cytosine Synthesis: A Critical Analysis and Implications for the Origin of Life," Proceedings of the National Academy of Sciences, USA 96 (1999): 4396– 4401; M. M. Waldrop, "Did Life Really Start Out in an RNA World?" Science 246 (1989): 1248–49.

85. R. Shapiro, "Prebiotic Ribose Synthesis: A Critical Analysis," Origins of Life and Evolution of the Biosphere 18 (1988): 71–85; Kenyon and Mills, "RNA World."

86. G. F. Joyce, "RNA Evolution and the Origins of Life," Nature 338 (1989): 217–24. Yuri I. Wolf and Eugene V. Koonin, "On the Origin of the Translation System and the Genetic Code in the RNA World by means of Natural Selection, Exaptation, and Subfunctionalization," Biology Direct 2 (2007): 1–25.

87. A. J. Hager, J. D. Polland Jr., and J. W. Szostak, "Ribozymes: Aiming at RNA Replication and Protein Synthesis," Chemistry and Biology 3 (1996): 717–25.

88. Johnston et al, "RNA-Catalyzed RNA Polymerization: Accurate and General RNATemplated Primer Extension," Science 292 (2001): 1319– 25.

۸۹- همچنین برای این‌که یک کاتالیزور RNA تک‌رشته‌ای خودهمانندسازی کند (تنها عملکردی که می‌تواند در محیط پیش‌زیستی انتخاب شود)، باید مولکول RNA کاتالیزوری دیگری را در مجاورت خود پیدا کند تا به عنوان یک الگو عمل کند؛ زیرا RNA تک رشته‌ای نمی‌تواند هم به عنوان آنزیم و هم به عنوان الگو عمل کند. بنابراین، حتی اگر یک توالی RNA که نخست

غیر اختصاصی است بعدا به‌طور تصادفی اهمیت عملکردی پیدا کند، تنها در صورتی می‌تواند عملکردی را انجام دهد که یک مولکول RNA دیگر –یعنی مولکولی با توالی بسیار خاص نسبت به مولکول اصلی– در مجاورت آن پدید آمده باشد. بنابراین، تلاش برای دورزدن نیاز به توالی‌یابی خاص در یک RNA کاتالیزوری اصلی، فقط مشکل اختصاصی‌بودن را به جای دیگری، یعنی به دنباله‌ی RNA دوم و لزوما بسیار خاص تغییر می‌دهد. به عبارت دیگر، افزون بر ویژگی مورد نیاز برای دادن قابلیت خودهمانندسازی به نخستین مولکول RNA، مولکول RNA دوم با یک توالی بسیار خاص –یکی با توالی اساسا مشابه اصلی– نیز باید ایجاد شود. با این حال، نظریه‌پردازان دنیای RNA منشا ویژگی لازم را در مولکول اصلی یا دوقلوی آن توضیح نمی‌دهند. جویس و اورگل[1] محاسبه کرده‌اند که در نظر گرفتن شانس معقول برای یافتن دو مولکول RNA یک‌سان با طول کافی برای انجام عملکردهای آنزیمی، مستلزم مجموعه‌ای متشکل از حدود ۱۰ ^۵۴^ مولکول RNA است. جرم چنین مجموعه‌ای بسیار بیش‌تر از جرم زمین است و این امر نشان‌دهنده‌ی غیر قابل قبول بودن منشا تصادفی یک سیستم همانندساز بدوی است. با این حال، نمی‌توان از انتخاب طبیعی برای توضیح منشا چنین همانندسازهای اولیه‌ای استفاده کرد؛ زیرا انتخاب طبیعی تنها زمانی اتفاق می‌افتد که خودهمانندسازی به وجود آمده باشد. افزون بر این، بازهای RNA نیز مانند بازهای DNA، پیوندهای خودسازمان‌دهی را که بتواند توالی خاص آن‌ها را توضیح دهد، نشان نمی‌دهند. به‌طور خلاصه باید گفت، اگر کسی پیشنهاد کند که اطلاعات ژنتیکی نخست در مولکول‌های RNA و یا DNA به وجود آمده است، همان نوع مشکلات شواهدی و نظری دوباره بروز خواهند کرد. اگر بخواهیم سناریو را با همانندسازهای RNA آغاز کنیم تا از این طریق مشکل توالی‌یابی را نادیده بگیریم، تنها مشکل به دنباله‌های خاصی منتقل شده که چنین همانندسازی‌ای را ممکن کرده‌اند.

90. Christian de Duve, Vital Dust: The Origin and Evolution of Life on Earth (New York: Basic Books, 1995), 23.

91. Matthew W. Powner, Béatrice Gerland, and John D. Sutherland, "Synthesis of Activated Pyrimidine Ribonucleotides in Prebiotically Plausible Conditions," Nature 459 (2009), 239–42.

92. Stephen Fletcher, Times Literary Supplement, Letters, 3 February, 2010.

93. Tracey A. Lincoln and Gerald F. Joyce, "Self-Sustained Replication of an RNA Enzyme," Science 323 (2009), 1229–32.

94. Quastler, Emergence, 16

95. Charles Sanders Peirce, Collected Papers, vol. II, edited by Charles Hartshorne and Paul Weiss (Cambridge, MA: Harvard University Press, 1932), 372–78.

نخستین‌بار فیلسوف و منطق‌دان آمریکایی، سی. اس. پیرس[2]، استدلال ربایشی یا استنتاج به

---

1. Joyce and Orgel
2. C. S. Peirce

بهترین توضیح را معرفی کرد. وی خاطرنشان کرد که برخلاف استدلال استقرایی که در آن یک قانون یا اصل جهانی بر اساس مشاهدات مکرر همان پدیده‌ها ایجاد می‌شود و بر خلاف استدلال قیاسی، که در آن یک واقعیت خاص با اعمال یک قانون یا قاعده‌ی کلی بر اساس واقعیت یا مورد خاص دیگری استنباط می‌شود، دانشمندان از سرنخ‌ها یا حقایق موجود در زمان حال برای استنتاج حقایق، رویدادها یا عللی که نادیده هستند و در گذشته رخ داده‌اند، استفاده می‌کنند. مثال زیر را در نظر بگیرید: اگر باران ببارد، خیابان‌ها خیس می‌شوند. خیابان‌ها خیس است. بنابراین، باران باریده است. این قیاس رویداد گذشته را تایید می‌کند (این‌که باران باریده است) اما منجر به مغالطه‌ای منطقی می‌شود که به عنوان تایید نتیجه شناخته می‌شود. با توجه به خیس‌بودن خیابان (و بدون شواهد اضافی برای تصمیم‌گیری در مورد این موضوع)، تنها می‌توان نتیجه گرفت که شاید باران باریده باشد. چرا؟ زیرا راه‌های ممکن دیگری وجود دارد که ممکن است خیابان از طریق آن‌ها خیس شده باشد. ممکن است باران باعث خیس‌شدن خیابان‌ها شده باشد. ممکن است ماشین‌شستن در خیابان باعث خیس‌شدن خیابان شده باشد یا ممکن است نشت آب از شیر آتش‌نشانی خیابان را خیس کرده باشد. استنباط گذشته از زمان حال می‌تواند دشوار باشد؛ زیرا علل احتمالی زیادی برای یک اثر خاص وجود دارد. با توجه به این شرایط، پیرس نمی‌دانست که چه‌گونه می‌توانیم همواره درباره‌ی گذشته استنباط‌های قابل اعتمادی انجام دهیم. برای مثال او اشاره کرد که هیچ‌کس در وجود ناپلئون شک ندارد. با این حال ما از استدلال ربایشی برای استنباط وجود ناپلئون استفاده می‌کنیم. یعنی وجود گذشته‌ی او را باید از آثار کنونی استنباط کنیم. اما علی‌رغم وابستگی ما به استدلال ربایشی برای این استنتاج، هیچ فرد عاقل یا تحصیل‌کرده‌ای شک ندارد که ناپلئون بناپارت واقعا زندگی کرده است. پیرس در توضیح این مشکل می‌گوید: «گرچه ما ناپلئون را ندیده‌ایم، اما نمی‌توانیم آن‌چه را دیده‌ایم بدون فرضیه‌ی وجود او توضیح دهیم». از نظر پیرس، یک فرضیه‌ی ربایشی خاص را می‌توان به‌طور منطقی (در عمل) باور کرد، به شرط آن‌که به‌گونه‌ای توضیح دهد که هیچ فرضیه‌ی دیگری نتواند توضیح دهد. به عبارت دیگر، استنتاج ابداعی در صورتی قدرتمند است که نشان‌دهنده‌ی بهترین یا تنها توضیح کافی در مورد نتایج مورد نظر است.

96. Stephen Jay Gould, “Evolution and the Triumph of Homology: or, Why History Matters,” American Scientist 74 (1986): 61.

97. Thomas Chamberlain, “The Method of Multiple Working Hypotheses,” Science (old series) 15 (1890): 92–96. Reprinted in Science 148 (1965): 754–759.

98. P. Lipton, Inference to the Best Explanation (New York: Routledge, 1991).

99. Charles Lyell, Principles of Geology: Being an Attempt to Explain the Former Changes of the Earth’s Surface, by Reference to Causes Now in Operation, three volumes (London: John Murray, 1830–1833).

100. V. Kavalovski, “The Vera Causa Principle: A Historico-Philosophical

Study of a Meta-Theoretical Concept from Newton through Darwin” (PhD dissertation, University of Chicago, 1974), 78–103.

101. E. Sober, Reconstructing the Past (Cambridge, MA: MIT Press, 1988), 4–5; M. Scriven, “Causes, Connections, and Conditions in History,” in Philosophical Analysis and History, ed. W. Dray (New York: Harper and Row, 1966), 238–64, esp. 249–50; Michael Scriven, “Explanation and Prediction in Evolutionary Theory,” Science 130 (1959): 477–82, especially 480.

102. Meyer, “Of Clues,” 96–108.

۱۰۳- البته، عبارت «مقادیر زیادی از اطلاعات اختصاصی‌شده» دوباره پرسشی کمّی ایجاد می‌کند و آن این است که: «سلول با حداقل پیچیدگی پیش از این‌که به طراحی دلالت کند، چه‌قدر باید اطلاعات یا پیچیدگی اختصاصی داشته باشد؟» اگر به خاطر داشته باشید، دمبسکی محدوده‌ی احتمال جهانی ۱ در $۱۰^{۱۵۰}$ را محاسبه کرده است که مربوط به منابع احتمالی جهان شناخته‌شده است. همچنین اگر به یاد داشته باشید، تابع لگاریتمی نشان می‌دهد رابطه‌ی احتمال و اطلاعات، رابطه‌ی معکوس است. بنابراین، محدوده‌ی احتمال جهانی ۱ در $۱۰^{۱۵۰}$ تقریبا به ۵۰۰ بیت اطلاعات ترجمه می‌شود. بنابراین، شانس به‌تنهایی توضیح کافی برای پیدایش نوظهور هر دنباله یا سیستم اختصاصی‌شده‌ای که حاوی بیش از ۵۰۰ بیت اطلاعات (مشخص) است، نیست. افزون بر این، از آن‌جا که سیستم‌هایی که با پیچیدگی مشخص می‌شوند در برابر توضیحات قوانین خودسازمان‌دهی مقاومت می‌کنند و از آن‌جا که به انتخاب طبیعی پیش‌زیستی استناد می‌شود اما منشا اطلاعات اختصاصی‌شده‌ی لازم برای پیدایش یک سیستم خودهمانندساز با حداقل پیچیدگی توضیح داده نمی‌شود، طراحی‌هوشمندانه به بهترین وجه منشا بیش از ۵۰۰ بیت اطلاعات مشخص مورد نیاز برای تولید نخستین سیستم زندگی با حداقل پیچیدگی را توضیح می‌دهد.

۱۰۴- ممکن است یک استثنای احتمالی برای این تعمیم در تکامل بیولوژیکی رخ دهد. اگر مکانیسم داروینی انتخاب طبیعی که روی تغییرات تصادفی عمل می‌کند، بتواند پیدایش کل حیات پیچیده را توضیح دهد، قطعا مکانیسمی وجود دارد که می‌تواند مقادیر زیادی اطلاعات تولید کند –البته با فرض این‌که مقدار زیادی از اطلاعات بیولوژیکی از قبل موجود در یک سیستم زنده‌ی خودهمانندساز وجود دارد. بنابراین، حتی اگر فرض کنیم مکانیسم انتخاب/تنوع می‌تواند تمام اطلاعات مورد نیاز برای تکامل کلان حیات پیچیده از حیات ساده‌تر را ایجاد کند، این مکانیسم برای توضیح منشا اطلاعات لازم در خصوص تولید حیات از مواد شیمیایی غیر زنده کافی نخواهد بود. همان‌طور که دیدیم، توسل به انتخاب طبیعی پیش‌زیستی تنها منشا اطلاعات اختصاصی‌شده را مطرح می‌کند. بنابراین، بر اساس تجربه، می‌توانیم تعمیم زیر را تایید کنیم: «برای تمام سیستم‌های غیر زیستی، حجم زیادی از پیچیدگی یا اطلاعات اختصاصی‌شده تنها از عاملیت ذهنی، فعالیت آگاهانه یا طراحی‌هوشمندانه منشا می‌گیرد.» به بیان دقیق‌تر، ممکن است تجربه حتی تعمیمی را که کم‌تر واجد شرایط است تایید کند (مانند «مقادیر زیادی از پیچیدگی اختصاصی‌شده همیشه از یک منبع هوشمند منشا می‌گیرد»)؛ زیرا این ادعا که انتخاب طبیعی می‌تواند بر روی جهش‌های تصادفی مقادیر زیادی اطلاعات ژنتیکی جدید تولید کند، به استدلال‌های نظری قابل بحث و

برون‌یابی از مشاهدات تغییرات خرد تکاملی در مقیاس کوچک بستگی دارد در حالی که خودِ اطلاعات بیولوژیکی توضیح داده نشده‌اند.
see Stephen. C. Meyer, “The Origin of Biological Information and the Higher Taxonomic Categories,” in Proceedings of the Biological Society of Washington 117 (2004): 213–239; Stephen C. Meyer, Darwin’s Doubt: The Explosive Origin of Animal Life and the Case for Intelligent Design, San Francisco: HarperOne, 2013

من در جای دیگری استدلال کرده‌ام که نه مکانیسم نوداروینی و نه هیچ مکانیسم طبیعی کنونی به اندازه‌ی کافی چه‌گونگی پیدایش اطلاعات مورد نیاز برای ساخت تاشدگی پروتیینی جدید و طرح‌های بدنی را که در انفجار کامبرین به وجود می‌آیند توضیح نداده‌اند. در هر صورت، تعمیم تجربی واجد شرایط‌تر (که در بالا در این یادداشت بیان شد) برای حمایت از استدلال ارایه‌شده در این‌جا کافی اس؛ زیرا این فصل تنها به دنبال معرفی طراحی‌هوشمندانه به عنوان بهترین توضیح برای منشا اطلاعات اختصاصی‌شده‌ی لازم برای پیدایش نخستین حیات است.

105. Meyer, “Of Clues,” 77–140.

106. K. Dose, “The Origin of Life: More Questions Than Answers,” Interdisciplinary Science Reviews 13 (1988): 348–56; Yockey, Information Theory, 259–93; Thaxton et al., Mystery, 42–172; Thaxton and Bradley, “Information and the Origin,” 193–97; Shapiro, Origins.

۱۰۷– تشخیص طراحی به‌طور معمول در علم و صنعت اتفاق می‌افتد. کشف تقلب، علم پزشکی قانونی و رمزنگاری همگی به کاربرد معیارهای احتمالی یا نظری اطلاعات طراحی‌هوشمندانه بستگی دارند.
See Dembski, Design Inference, 1–35.

بسیاری از افراد اعتراف می‌کنند که می‌توان به‌طور موجه از یک مصنوع یا رویداد غنی از اطلاعات، هوش انسانی را استنتاج کرد اما تنها به این دلیل که از قبل می‌دانیم ذهن انسان وجود دارد. آن‌ها استدلال می‌کنند از آن‌جا که ما نمی‌دانیم آیا عامل یا عوامل هوشمندی پیش از پیدایش انسان وجود داشته‌اند یا خیر، استنتاج به عمل یک عامل طراحی‌کننده که پیش از انسان‌ها وجود داشته، قابل توجیه نیست، حتی اگر معلول غنی از اطلاعاتی را مشاهده کنیم. اما باید توجه داشت که دانشمندان پروژه‌ی ستی SETI از قبل نمی‌دانند که آیا یک هوش فرازمینی وجود دارد یا خیر. با این حال، آن‌ها فرض می‌کنند که وجود مقدار زیادی از اطلاعات اختصاصی‌شده به‌طور قطع وجود یک عامل هوشمند را ثابت می‌کند. در واقع، ستی دقیقا به دنبال اثبات وجود سایر هوش‌ها در یک حوزه‌ی ناشناخته است. به همین ترتیب، انسان‌شناسان غالبا در تخمین‌های خود برای تعیین آغاز تاریخ یا تمدن بشری تجدیدنظر کرده‌اند؛ زیرا آن‌ها مصنوعات غنی از اطلاعاتی را کشف کرده‌اند که مربوط به زمان‌هایی است که پیش از تخمین‌های قبلی آن‌ها بوده است. بنابراین، وضعیت معرفت‌شناختی استنباط فعالیت یک هوش طراحی‌کننده از زمانی پیش از پیدایش انسان بر روی زمین، تفاوتی با دیگر استنتاج‌های طراحی ندارد که منتقدان پیش‌تر آن‌ها را مجاز دانسته‌اند.

See T. R. McDonough, The Search for Extraterrestrial Intelligence: Listening for Life in the Cosmos (New York: Wiley, 1987).

108. P. Lipton, Inference to the Best Explanation, 32–88.

109. Ibid.; S. C. Meyer, "The Scientific Status of Intelligent Design: The Methodological Equivalence of Naturalistic and Non-Naturalistic Origins Theories," in Science and Evidence for Design in the Universe, The Proceedings of the Wethersfield Institute, vol. 9 (San Francisco: Ignatius Press, 2000), 151–212; Meyer, "The Demarcation of Science and Religion," in The History of Science and Religion in the Western Tradition: An Encyclopedia, ed. G. B. Ferngren (New York: Garland, 2000), 17–23; E. Sober, The Philosophy of Biology (San Francisco: Westview Press, 1993); Meyer, "Of Clues," 77–140.

110. Quastler, Emergence, 16.

111. Oparin, Origin of Life, 28; M. Rothman, The Science Gap (Buffalo, NY: Prometheus, 1992), 65–92; K. Popper, Conjectures and Refutations: The Growth of Scientific Knowledge (London: Routledge and Kegan Paul, 1962), 35–37.

112. Meyer, "Of Clues," 77–140; Sober, Reconstructing the Past, 4–5; de Duve, "Beginnings of Life," 249–50.

113. R. Harré and E. H. Madden, Causal Powers (London: Basil Blackwell, 1975).

114. M. Ruse, "McLean v. Arkansas: Witness Testimony Sheet," in But Is It Science? ed. M. Ruse (Amherst, NY: Prometheus Books, 1988), 103; Meyer, "Scientific Status"; Meyer, "Demarcation."

115. Meyer, "Scientific Status"; Meyer, "Demarcation"; L. Laudan, "The Demise of the Demarcation Problem," in Ruse, But Is It Science? 337–50; L. Laudan, "Science at the Bar—Causes for Concern," in Ruse, But Is It Science? 351–55; A. Plantinga, "Methodological Naturalism?" Origins and Design 18, no. 1 (1986): 18–26; A. Plantinga, "Methodological Naturalism?" Origins and Design 18, no. 2 (1986): 22–34.

116. Bridgman, Reflections of a Physicist, 2nd ed. (New York: Philosophical Library, 1955), 535.