

Index

- abstraction, 69–70, 163, 165–166, 185–186
 - Goldilocks level of, 90–93, 102–103
- adenosine triphosphate (ATP), 156–157
- Allan Hills meteorite (ALH84001), 183–184, 190, 214
- amino acids, 107–112, 197–198
 - chirality, 108
 - nonstandard, 111
- anomalies, 173, 179–181, 184–185, 191–194, 211–213, *See also* Kuhn, Thomas, scientific paradigms
- Archaea, *See* Domains of life
- Aristotle, 8–17, 24, 85–86, 118
 - on motion, 13, 85–86
 - on souls, 12–14
 - on the nature of life
 - self-nutrition, 8, 10–15
 - self-reproduction, 8, 10–15, 24
 - teleology, *See* causation
 - theory of material substance, 51
 - theory of terrestrial matter, 91
- artificial life (ALife), 40, 161–171
 - strong hard ALife, 164–166
 - strong soft ALife, 161–164
 - wet ALife, 167–170
- autocatalytic reaction networks, 26–27
- autopoiesis, 22–23, 162–164
- Bacteria, *See* Domains of life
- banded iron formations, 190
- Bedau, Mark, 42, 63, 77–78, 161
- Benner, Steve, 43, 63
- big data movement, 96–97
- biological individual, 143–154
 - biological autonomy, 144–146
 - Darwinian individual, 144–145, 148–149, 152
 - metabolic individual, 144
- Boden, Margaret, 163
- carbon, 113–115, 202
- carbon dioxide, 39, 127, 174–175
- causal-descriptive theories, 59
- causal theory of reference, 58
- causation, 12, 15
 - goal-directed self-causation, 9, 11–13, 15–16, 18–21, 27, 30, 145
- Cech, Thomas
 - discovery of ribozymes, 178–180
- Chang, Hasok, 86, 98–99, 101, *See also* Phlogiston
- Chao, Lin, 47
- computer metaphor, 20–21
- contingencies, 90–91, 120–123, 130–131
- Copernican revolution, 85–86
- correspondence rules, 66–67
- Crick, Francis, 200
 - central dogma of molecular biology, 179
- cultivation, 207–208
- Darwin, Charles
 - biological individuality, 144–145, 204
 - Darwinian algorithm, 162–164
 - theory of evolution, 18–21, 23–24, 40–43, 95, 133–134, 139–140
 - deductively closed axiom systems, 64–68, 72, 78
- definitions
 - function of, 64, 78, 80
 - ideal, 34, 48–50, 52, 73
 - lexical, 46–47
 - nonstandard, 63–64, 73–79
 - operational, 47–48, 80
 - stipulative, 52–54, 57
 - traditional, 63
 - definitions of life
 - evolutionary, 23–24, 40
 - chemical Darwinian, 23–24, 41–43, 60, 122–123, 126, 133
 - Darwinian, 41

- definitions of life (cont.)
 - metabolic
 - autopoietic, 22–23, 43–44, 49, 122
 - chemical-metabolic, 22, 24, 37–40, 123
 - thermodynamic, 22, 36–37
 - Descartes, René, 15, 86
 - descriptive theory, 53–59
 - cluster theory, 58–59
 - desert varnish, 212–213
 - disunity, 102, 132, 218
 - Domains of life, 119
 - Archaea, 116–117, 119–120, 134–135, 181–182, 205–206
 - Bacteria, 95–96, 115–117, 119–120, 134–135, 140–141, 146–147, 155–157, 167–168, 173–174, 181–183, 205–206, *See also* species concepts
 - Eukarya, 105, 115–120, 134–135, 142, 152–153, 203
 - prokaryote–eukaryote distinction, 115, 118–119, 181
 - Doolittle, Ford, 154
 - Duhem, Pierre, 98, 101
 - Dupré, John, 98
 - Dyson, Freeman, 122
 - Einstein, Albert
 - theory of relativity, 95, 97
 - electron transport chains (ETCs), 155–158
 - emergence, 28, 32
 - emergentism, 16–18, 27
 - end-Cretaceous mass extinction, 120–121
 - Eukarya, *See* Domains of life
 - exoplanets, 190–191
 - Gánti, Tibor, 43–44
 - Gibbs, Josiah, 92
 - Great Oxygenation Event, 117, 142
 - Haeckel, Ernst, 118
 - Herschel, William
 - discovery of Uranus, 177–178
 - horizontal gene transfer (HGT), 95, 133–138, 140–143, 202–204
 - Hume, David, 17, 30
 - idealization, 69, 90
 - inertia, 87
 - interpretation, 70–71
 - isomorphism, 71–72
 - Kant, Immanuel, 15–16
 - Kauffman, Stuart, 27, 37, 43, 124, 128
 - Kepler, Johannes
 - on inertia, 86
 - Kingdoms of life, 118–119
 - Kuhn, Thomas
 - scientific paradigms, 54–55, 101, 176–178
 - Lamarckian evolution, 139–143
 - Langton, Chris, 161
 - last universal common ancestor (LUCA), 135, *See also* $N = 1$ problem
 - lateral gene transfer, *See* horizontal gene transfer
 - Lavoisier, Antoine, 25, 50–51, 92
 - Lego Principle, 188–189
 - life
 - alternative origin of, 196–198
 - defining criteria, 173–174, 186–187, 193
 - functional characteristics of
 - genetic-based reproduction, 8–9, 14–15, 128–129
 - self-organization, 8, 14–15, 129
 - nature of, 127–130
 - tentative criteria, 176, 184–194
 - Linnæus, Carl, 118
 - Lipson, Hod, 165
 - Locke, John, 53–54
 - logical positivism, 65
 - logicomathematical structures, 72–73, 88
 - luminiferous aether, 94–95
 - Mars, *See also* Viking missions to Mars
 - life-detection missions, 180–181
 - mass, 86–88
 - mathematical theories, 64, 66–67, 71–72, 78
 - Mayr, Ernst, 136
 - metabolism, 122, 155–158, 172–173, 186–187, *See also* origins of life, metabolism-first
 - anabolism, 155–156
 - catabolism, 155
 - metagenomic methods, 208–211
 - microbes, 47, 105–106, 146–155, 201–215, *See also* Domains of life
 - alien, 47, 168, 172–176, 180–181, 187, 205–208, 210–211
 - biofilms, 149–153
 - holobionts, 148–149
 - rock-powered ecosystems, 156–158
 - microscopy, 206–207
 - models, 68–73, 89, 128–129
 - standard model, 71–72
 - modern evolutionary synthesis, 20
 - monism, 99–102, 129, *See also* pluralism
 - mutation, 140–142
 - $N = 1$ problem, 105–114, 117, 161, 169–170
 - nanobacteria, 214–215
 - nanobes, 213–215
 - natural kinds, 4, 34–35, 53–60, 64, 66–67, 73–74, 129
 - necessary and sufficient conditions, 4–5, 63–64, 67, 75–80
 - Newton, Isaac
 - theory of motion, 3, 5, 15–16, 54–55, 65–66, 70, 77, 83, 85–88, 90–91, 97, 143
 - nucleic acids, 107, 109–113, 125–126, 167, 198–200
 - XNA, 112

- On the Origin of Species*, *See* Darwin, Charles
- ontology, 83–85, 87–88, 96–97
 alternative ontologies, 93, 101
 inadequate ontologies, 87
 premature commitment to, 93
- Orgel, Leslie, 128
- origins of life, 33, 114–127, 135, 145, 158–159
 genes-first, 25, 122, 124, 128–129
 Lipid World, 124, 128
 metabolism-first, 26, 122–123, 128–129,
 198
- RNA World, 27–31, 106, 122, 124–129, 199–201,
 203
- pre-RNA World, 28, 125
- Small Molecule (SM) World, 26–29, 106, 122–124,
 126–128, 201
- paradigm, *See* Kuhn, Thomas, scientific paradigms
- persistence, 153–154
- phlogiston, 94, 98
- pluralism, 91, 96, 98–102, 129, 132, 160
 promiscuous realism, 98
Scientific Pluralism, 98, 100–102
 species pluralism, 137–138
- polymerase chain reaction (PCR), *See* metagenomic methods
- proteins, 107–109, 113, 159, 167, 179–180,
 197–199
- Putnam, Hilary, 76
 Twin-Earth thought experiment, 55–59
- quantum nonlocality, 18
- Ray, Thomas, 40
 Tierra, 162–163
- regeneration, 152–154
- replicas, 72
- Sagan, Carl, 36–37
- Saturn, 177–178
 life on Titan, 106, 113, 189
- scientific theories, 4–6, 63–81, 89
 exceptions to, 100
 pragmatic conception of, 79
 semantic conception of, 63, 68–73, 77–80, 84, 89
 syntactic conception of, 63–68, 84
- set theoretic structures, 69–71
- shadow biosphere, 195, 201–216
- silicon, 38, 113
- species concepts, 95, 135–139
 bacterial species problem, 96, 136–138
 biological species concept (BSC), 137
 phylogenetic species concept (PSC), 137
- theoretical definitions, 72–73, 77–80
- theoretical framework, *See* ontology
- theoretical identity statements, 52–54, 57, 73–76
- theoretical kinds, 66
- theoretical principles, 84
- theoretical terms, 66–67
- theory ladenness of observation, *See* Kuhn, Thomas,
 scientific paradigms
- tree of life, 135–136, 139
- unity, 101–102
- Venter, Craig
Synthia 3.0, 167–168
- Viking missions to Mars, 38–40, 172–176, 180
 gas chromatograph mass spectrometer (GCMS), 39,
 174–175, 210
- labeled release experiment (LR), 39, 172–176, 180,
 186–187, 192
- perchlorate, 175
- viruses, 145–146
 giant viruses, 182–183
- vitalism, 15–18
- water, 50–53, 56, 60–61, 74–76
- Weismann, August, 139–140
- Whittaker, R. H., 119
- Woese, Carl, 42, 181, 203–204