



THE LARGE-SCALE STRUCTURE OF INDUCTIVE INFERENCE

John D. Norton

ISBN 978-1-77385-541-7

THIS BOOK IS AN OPEN ACCESS E-BOOK. It is an electronic version of a book that can be purchased in physical form through any bookseller or on-line retailer, or from our distributors. Please support this open access publication by requesting that your university purchase a print copy of this book, or by purchasing a copy yourself. If you have any questions, please contact us at ucpress@ucalgary.ca

Cover Art: The artwork on the cover of this book is not open access and falls under traditional copyright provisions; it cannot be reproduced in any way without written permission of the artists and their agents. The cover can be displayed as a complete cover image for the purposes of publicizing this work, but the artwork cannot be extracted from the context of the cover of this specific work without breaching the artist's copyright.

COPYRIGHT NOTICE: This open-access work is published under a Creative Commons licence. This means that you are free to copy, distribute, display or perform the work as long as you clearly attribute the work to its authors and publisher, that you do not use this work for any commercial gain in any form, and that you in no way alter, transform, or build on the work outside of its use in normal academic scholarship without our express permission. If you want to reuse or distribute the work, you must inform its new audience of the licence terms of this work. For more information, see details of the Creative Commons licence at: http://creativecommons.org/licenses/by-nc-nd/4.0/

UNDER THE CREATIVE COMMONS LICENCE YOU MAY:

- read and store this document free of charge;
- distribute it for personal use free of charge;
- print sections of the work for personal use;
- read or perform parts of the work in a context where no financial transactions take place.

UNDER THE CREATIVE COMMONS LICENCE YOU MAY NOT:

- gain financially from the work in any way;
- sell the work or seek monies in relation to the distribution of the work:
- use the work in any commercial activity of any kind;
- profit a third party indirectly via use or distribution of the work:
- distribute in or through a commercial body (with the exception of academic usage within educational institutions such as schools and universities);
- reproduce, distribute, or store the cover image outside of its function as a cover of this work:
- alter or build on the work outside of normal academic scholarship.



Acknowledgement: We acknowledge the wording around open access used by Australian publisher, **re.press**, and thank them for giving us permission to adapt their wording to our policy http://www.re-press.org

Afterword

In this volume, I have sought to describe the large-scale structure of the inductive inferences and the inductive relations of support in science. Although I am satisfied that the many chapters devoted to this task have made considerable progress in delineating that structure, I am sure that there is much more to be done. The research that led to this volume has been research in the history and philosophy of science. As I noted in the introduction, that research involves a continuing exchange between the philosophy of science and the history of science. One component of the exchange needs to be emphasized. I have found that a major source of theses in the philosophy of science lies in the study of the history of science. That history recounts the many examples of scientists who grappled with inductive problems of great difficulty and overcame them with inductive maneuvers of still greater ingenuity. Time spent studying the history is philosophically fertile in a way that armchair reflection is not. Armchair reflection can only return what each of us can think up ourselves. A study of the history of science can draw from the ingenuity of generations of the cleverest minds at their moments of greatest achievements. It provides an endlessly fertile repository of inductive ideas in the philosophy of science for those willing to explore it. This volume explores only a tiny portion of this repository. Much remains to be found. My hope is that this volume will encourage others to enter this repository and see what marvels they can find.

Index

Page numbers followed by f, t, and n denote figures, tables, and notes, respectively.

a priori propositions, Kantian synthetic, 92 abduction, abductive inference, 35, 196, 211. See also inference to the best explanation "acceptance system," notion of, 152 Aczel, Peter, 113 age, radiocarbon, 289-95 Agricola, Georgius, 368, 369, 371, 376-77, 382 Airy, George B., 342n12, 343f alkali and alkaline earth metals, spectra of, 275 Almagest (Ptolemy), 253, 348, 349 alums, gallium, in Mitscherlich's law of isomorphism, 311 ammonia, Dalton's formula, 301 Ampère, hypothesis of, 307, 323 ampliation, ampliative inference, 16, 20-21, 186; forms of, 16, 179, 195, 196; nondemonstrative, 195n9; notion of, 194-95; Salmon's analysis, 183, 195n9, 214 analogical inferences, 30-31, 32 analogy(ies): arches, 66-69; architectural, 66; as argument form, 32, 139, 140; bare formal schema, 29, 31; to dome, 69; facts of, 32, 33; as form of inference, 30-31; material approach to, 31-32; reasoning by, 28; twodimensional model, 30-31; vaulted ceilings, 69-72; to waves propagating, 140n14 Andromeda nebula, 234, 236, 237, 244 Anglo-Persian Oil Company, 378 angular momentum, determining stable electron orbits, 282, 285 Anti-Foundation Axiom, in set theory, 113 aphelion of planets, in exactness of inverse square law of gravity, 265-66

apogee, perigee of objects in Ptolemaic astronomy (Moon, Sun, Mercury, Venus, Jupiter, Saturn) 350-51 archaeological dating, 294. See also radiocarbon dating, mutually supporting evidence in arch(es), 66-69, 74-75; illustration, 67-69; for Moon test, 262f, 267f, 316f, 321f Archimedes, 337, 339 Arditti, Fred D., 403-4 Aristarchus of Samos, 335-39, 346 Aristotle, 28, 105, 354 Arnold, James R., 291, 294 Aronson, David R., 405, 407 Arp, Halton, 73, 130-33 articulation model, of analogy, 31 artifacts, dating of, 68, 103-4, 115. See also radiocarbon dating, mutually supporting evidence in astrology, 346n16, 366, 403 astronomers, 12, 34, 36, 76, 109, 265; ancient, 331, 333, 341; Arp, 130-33; astrophysicists and, 130; Bahcall, 130-33; Curtis, 234; naked-eye methods, 339; Shapley, 234. See also Hubble, Edwin astronomy, 253n22, 332; anomalies, 34, 128; basic problem of, 331; Brahe's, 42-43; curvefitting problem, 263; geocentric, 348; Greek, 34, 332; heliocentric, 77, 332, 346, 353, 354, 358, 359; histories of, 345; introduction of telescopes to, 331; Kepler in, 346, 359; Simon Newcomb, leading authority in, 344; literature, 331-32; naked eye, 12, 76; observational and theoretical, 70; parallax in, 12, 76; physical, 62; Ptolemaic, 43, 164, 348; relative positions of Sun, Moon, and planets, 137. See also Copernican astronomy Atherino, Rodrigo, 405, 412 atomic heat capacity, in Dulong and Petit's law

of specific heats, 309

atomic spectra, mutually supporting evidence in: Bohr's theory of atom, 280-82; discovery of regularities in emission spectra, 271-75; overview, 269-71, 276-79; quantum theory, 282-86; Ritz's combination principle, 275-76, 279-80, 282-86. See also quantum theory; Ritz's combination principle atomic weights, determination of: Avogadro's hypothesis, 326-27; circularity and, 301-4, 306-11; Dalton's atomic theory, 299-301; Dulong and Petit's law, 308-10, 318-21; failed hypothesis of simplicity, 304-5; heat capacity, 309; kinetic theory of gases, 321-26; Mitscherlich's law of isomorphism, 310-11; mutual support of, 313-21; overview, 297-99; vaulted inductive structure, 311-13. See also Avogadro's hypothesis; circularities; Dulong and Petit, law of atom(s): Bohr's atomic theory, 11, 78, 270-71, 274, 275, 279n6, 280-82, 283, 284-85; nitrogen, 291, 300. See also Bohr's theory of atom; hydrogen; oxygen; quantum theory; Ritz's combination principle Avogadro, Amedeo. See Avogadro's hypothesis Avogadro's hypothesis, 12, 298, 311, 312-13, 315-17, 326-27; appeal of, 326; Cannizzaro and, 71, 299, 307-8, 311, 312, 313, 314, 315, 318-21, 323, 324, 326, 327; in chemistry and kinetic theory of gases, 321-26; circularity,

318–26 Axiom of Foundation, Zermelo-Fraenkel, 113 Aymar, Jacques, 377 azimuthal quantum number, 285 "azote" (nitrogen), in Dalton's system, 300

breaking, 306–8; Dulong and Petit, law of, 68–69, 71, 77, 299, 312, 318–21, 326–27; by

equipartition theorem, 299; hydrogen gas,

317; Maxwell on, 325; mutual support of,

Bacon, Francis, 23, 182, 186, 195
Bahcall, John, 130–33
Balmer, J.J., 72, 82, 269, 272–73, 274, 276, 277–78, 282
bare formal schema, for analogical inference, 29
Barin-Gould, Sabine, 377
barium chloride, same crystallographic structure as radium chloride, 24, 25, 27
Barrett, William F., 368, 373, 374, 377, 381
Bartha, Paul, 30, 31
Barwise, Jon, 113
Bassetti, W.H.C., 390, 391–92, 401, 402, 405

Bayes, Thomas, 179, 185, 186 Bayesian analysis: of coherentism, 164-70; failure of generality, 47-49; Laplace's analysis and, 46-47, 48-49; Laplace's rule of succession, 45-46; within material theory of induction, 51-52; principal goal of, 163-64; probabilities, inapplicable, 49-51; problem, 44-45 Bayesian approach: for matching DNA samples, 44; subjective, 51n24 Bayesian epistemology, 168 Bayesian inverse approach, 187 Bayesianism, 215 Bayesian literature on coherentism, 144 Bayesian philosophy of science, 168 Bayesian probabilistic representations, 166 Bayesian system, 140, 145 Bayesian vindication of inference, 205 Bayes' theorem, 2, 44; application of, 140, 164, 166; prior probabilities and, 2-3, 140 Becker, Adam, 93 beliefs, 16, 20, 160, 175, 183, 190, 213, 222, 368, 383; cognitively spontaneous, 154; for coherentism, 7, 144, 145-47, 151, 153, 154, 155, 159, 162, 163, 164-65; in dowsing, 377; epistemology of, 159, 171, 179-80, 198-200, 219, 220, 223; foundationalist conception, 146; inferential relations among, 150; justification for, 7, 153, 159, 161, 191, 200, 202, 203; "local" and "global" levels of justification, 147-48; propositions vs., 155-58; system of, 150, 164-65; web of, 3 Bell, Eric Temple, 93n14 benign circularity, examples of, 112, 113 Berry, Arthur, 102, 341 "big bang" hypothesis, big bang cosmology, 78, 129-30, 157 Bird, Alexander, 218n18 bismuth, melting point illustrates material theory, 222 Bohr, Niels. See Bohr's theory of atom Bohr's theory of atom, 270-71, 279n6, 280-82; attribution of spectra to helium, 275; consequence of, 78; evidential support, 271; outcome of, 274; quantum theory, 11, 78, 270, 271, 282, 283, 285; Ritz's combination principle, 281, 282, 283, 284-85 Bokulich, Alisa, 290 Boltzmann's constant, 322 Bondi, Hermann, 78 BonJour, Laurence, 145, 146, 151, 159; beliefs vs. propositions, 155-56, 157, 158;

Bachelier, Louis, 393

coherence vs. inductive support, 150; coherentism, problems of, 160, 161-62; coherentism vs. foundationalism, 153; "doxastic presumption," 157; "input objection"/"isolation objection," 153; literature in epistemology of belief, 158; "local" and "global" levels of justification, 147-48 Born, Max, 283 Bovens, Luc, 145, 163 Boyd, Nora, 73, 123 Boyle, Robert, 300, 370, 371, 376 Boys, Charles, 373 Brackett, Frederick S., 72, 82, 272, 273, 277, 278, 286 Bradley, F.H., 189 Brahe, Tycho, 42-43 Brightest Star Magnitude hypothesis, 232, 237-38, 244 bromine, in Cannizzaro's analysis, 72, 314t, 319 Brownian motion, example of random walk, Buffett, Warren, 389, 405-6, 409 Bundesministerium für Forschung und Technologie, 379 Burali-Forti contradiction, 102

Cadman, John, Sir, 378 calibration, need for in radiocarbon dating, 291-93 calibration curves, in radiocarbon dating, 11, 104, 292, 293f, 294 Cancer, nebula cluster, 239n11 Cannizzaro, Stanislao: atomic weights and molecular formulae, 311, 312, 313, 314, 315; Avogadro's hypothesis and, 71, 299, 318-21, 323, 324, 326, 327; canonical formulation by, 307-8; gas density data, 314t; Mitscherlich's law, 311; Pavesi and, 312; results, 11-12, 71-72; specific heat calculations for elements, carbon, 297; atmospheric, levels of, 11; atom of, 297; charcoal (carbon), 300; chemically

carbon-based fossil fuels, affect on radiocarbon dating, 291 carbonic acid, in Dalton's chemistry, 300 carbonic oxide, in Dalton's chemistry, 300 Carpenter, William, 380, 381n7 Casimir effect, in reactionless drives, 87

identical isotopes, 38; dating, 11, 115,

mutually supporting evidence in

289, 290-91. See also radiocarbon dating,

Cassini and Richer's measurement, of parallax of Mars, 341 Cassirer, Ernst, 190n6 cataclysm, effect on predicting sunrise, 48 cathode rays, Thomson's, 127 causality, principle of, 92 Cavendish-type experiments, 69n2 celestial bodies: configuration of, 332; construction for, 349; distances to, determining, 75-76, 115, 332, 333, 345, 346, 350, 351, 354; Earth and, 62; geocentric configuration of, 353; motions of, 34, 348; perturbations from, 268, 284n9; plausible distance ordering for, 76; in Ptolemy's system, 349, 350, 353 celestial forces, 258, 259; identity of, 67-68; lunar, 81, 260, 261, 262, 263 celestial mechanics, Newton's, 82, 94, 359 celestial objects, 236, 339, 340 centering, as scaffold for arch, 74-75 central limit theorem of probability theory, 393-94, 396, 397, 398 Cepheid variable stars, 234, 237, 244 Cesàro sum, 112 Chalmers, Alan, 299, 312 charcoal (carbon), in Dalton's chemistry, 300 chartists, in stock market prediction, 390-92 charts, 391, 395, 402; fabricated, 403, 404; of signals, 390 chemical transformations, in conservation of energy, 207 chlorine, in Cannizzaro's analysis, 72, 313, 314t, 315, 317-18, 320

Christoffel symbols, in general relativity, 34 circles, logical, fear of, 99-100

circularities: atomic weights and molecular formulae, 298, 299, 301-4, 310; Avogadro's hypothesis and, 306-8; benign, 161, 177; breaking, 77, 306-11; for coherentism, 155; concern about, 161; cost of, 205; Dalton and, 298, 299, 306, 326; determinate, 110-15; Dulong and Petit's law of specific heats, 308-10; failure, 177; fear of circles, 99-100; formulation, 190-95; Hume's, 184-85, 187-88, 189, 190, 191, 194-95; indeterminate circularities, 105-10; in inductive relations, 6, 7, 71; in interdependencies, 160-61; of justification, 160-61; of material theory, 180; Mill's dismissal of, 188; Mitscherlich's law of isomorphism, 310-11; of problem of induction, 175, 176, 177, 179, 180, 184-85, 187-88, 189, 190-95, 196, 197, 204, 205, 210-12;

circularities (continued) inductive, 124-25. See also dowsing, regresses and, 196, 197, 204; of rule of instabilities of evidential competition: inductive inference, 179; of Russell's and inductive logics, competition Reichenbach's analyses, 196; self-defeating, conditional probability of propositions, 17–18 confirmation, hypothetico-deductive, 78–79 177; self-supporting inductive structures, confirmation theory, 16 90; threat of, 160; version, 179; vicious circularity, 100-105, 161, 177, 197, 210 confounding effects, in experimental tests of reactionless drives, 87 class O stars, in Harvard spectral classification system, 66 conjecture(s): Plato's, 346; underdetermination, Clausius, Rudolf, 106, 321, 323-25 120, 121, 122, 134-37 connective-based deductive inferences, 21 Clustering of Nebular Luminosity hypothesis, 232, 233, 238-39, 244, 245, 246 conservation of angular momentum, in coal, in carbon dating, 290 electron orbitals, 285 COBE satellite, 129 conservation of energy, 86, 87, 206, 208-9, 210, "cognitively spontaneous beliefs," in coherentist conservation of forces, 86, 87, 206, 208-9, 210 epistemology, 154 coherence: of coherentism, probabilistic conservation of heat, 208 notions, 164; notion of, 144, 150, 164 conservation of mass, 208-9, 210 coherentism: Bayesian analysis of, 164-70; conservation of momentum, 86, 87, 209, 210, 285 Cook, Captain, 342 Bayesian literature on, 144; beliefs vs. propositions, 155-58; circularities for, Cookworthy, William, 384 147-59; core claim of, 145; dissimilarities, Copernican astronomy, 343-44; geometry 147-59; in epistemology, 95, 143, 144, of, 42; heliocentric, 43, 341, 346, 353, 358; 147-48, 154, 158, 159, 164, 165; examples, Newton's mechanics and, 77; Ptolemaic and, 158-59; formalization, premature, 164-67; 164 Copernican hypothesis, 12, 77, 332, 353-59, 361; foundationalism vs., 153-55; foundationalist conception, 146; holism vs. localism, 147-50; securing, 358-59 inductive support vs., 150-53; Lehrer on, Copernican system, 43-44; appeal to simplicity, 145-46, 151, 152, 153, 155; overview, 143-44; 39; coherence of, 164; geometric advantages of, 43; heliocentric system, 35, 42, 43, 137; probabilistic accounts, 163-64; probabilistic framework, not sufficiently general, 167-70; motion of Earth, hypothesis of, 34; Ptolemaic problems of, 160-62; similarities, 146-47; and, 164, 358-59; Tychonic system and, theories of epistemic justification, 145-46. 137-38; Venus in, 354, 355, 356f, 357f, See also BonJour, Laurence 358-59; virtues of, 36 corpuscles, in matter theory, 133, 139, 140, 370 coherentists, 7 coins, tossing of, 19, 49, 403 corruption of biology, Lysenko's mid-twentieth-Coma, nebula cluster, 239n11 century, 122 combination principle, Ritz's, 72, 78, 269, 273, cosmic rays, role in carbon dating, 291 275-76, 279; applications of, 270; Balmer cosmological principle, perfect, 78 series, 277, 278; Bohr's theory and, 281-82; cosmologists, 159; steady state, 78 direct explanation of, 271; heuristic guidance cosmology(ies), 131, 132; big bang, 129-30, of, 279; inferences of support, 82; Paschen 157; geocentric, Ptolemy's, 12, 35, 36, 76; series, 277, 278; physical basis of, 281, heliocentric, 359; modern, 72, 73, 231, 282f; quantum theory, support for, 69, 271, 236, 248; relativistic, 86, 103; scales, 122; 282-86; supporting, 279-80; warranting standard, 70, 132; steady state, 78, 129-30, authority of, 10-11 157; universe, 131, 132 comets, 40-42 Coulomb, Charles, 372 Commentariolus (Copernicus), 354 credences, in coherentist epistemology, 168, 169 "comparative reasonableness," notion of, 152n6 Creighton, James E., 187 competing theories, incompatible factual Cretans, Epimenides in liar sentence, 102 claims of, 123-24 Crick, Francis, 84 competition: detailed examination of, 125; crystal healing, example of pseudoscience, 366

empirically decidable, 123-24; unstable

crystallographic forms: barium chloride, 24, 25, 27; "cubic" system, 27; dimorphism, 27; enumerative induction, 27-28; gallium and potassium, sulfates of, 311; gazing, 210-11; Haüy's principle, 27, 28, 79, 80; Mitscherlich's law of isomorphism, 310-11; monoclinic system, 27; polymorphism, 27, 80; radium chloride, properties of, 24, 26-27, 79, 80; regular system, 28; snowflakes, 26-27 crystals, research in mineralogy on, 26 Curie, Marie, 24, 25-26, 27, 28, 79-80 Curie, Pierre, 24 Curtis, Heber, 234 curve fitting: polynomials in, 42; procedures, 41; simplicity in, 39, 40 curves, 40-42; calibration, 11, 104, 292, 293f, 294; fractal, 395-96

Dalton's atomic theory, 11, 12, 77, 109, 115, 297, 298, 299–301, 303, 311, 318; atomic elements and their compounds, 302f; circularity and, 71, 301, 306; Dulong and Petit's law of specific heats, 308; hypothesis of simplicity, 304, 305; of incompatibility, 326; Lavoisier and, 300–301; model of gases, 306n5; New System of Chemical Philosophy (Dalton), 71, 299, 308

Damon, Paul E., 294 Darwin, Charles, 38, 122, 125-26 data, tidal, curve fitting, 42 dating(s): of artifacts, 68, 103-4, 289; carbon, 11, 68, 103-4. See also radiocarbon dating, mutually supporting evidence in deductive argument schema, 17 deductive inferences, 180; connective-based, 21; example, 22; formal schema of, 20; general schema for, 22; in inductive structures, 79-83; warrant for, 19, 22 deductive logic, 198 deductive support, 81-83 de Grefte, Job, 200n13, 203, 221 De magnete (Gilbert), 369 demons, deceiving, 21 "demonstrative inductions," 80 Descartes, Rene, 370, 371-72 de Sitter's analysis of double stars for special relativity, 84

determinate circularities: among relations of inductive support, 114–15; elementary examples, 110–12; extreme example, 112–13; intermediate examples, 113–14

determinism, principle of, 188

Dialogue Concerning the Two Chief World Systems (Galileo), 36
Dicaearchus' estimate of the Earth's circumference, 337
dimorphism of crystalline forms, 27
"direct inference," 223
discovery of inductive relations of support, hypotheses in: hypotheses, illustrations of, 75–78; hypothetico-deductive confirmation, 78–79; problem of, 73–75
distributed justifications of inductive inference.

distributed justifications of inductive inference, local vs., 178

distributed vindication of inductive inference, 86–87

diverging inductive logics, 382–83 Dodd, David, 389, 403, 404, 405, 406 domains: inductive inferences from, 19–20; inhospitable/hospitable, 21, 22; probabilistic, 168; warranting facts, 1, 19, 20, 168

domain-specific inductive logics, uniqueness of: challenges, 119–21; competing systems of relations, 123–24; formal accounts, 139–41; illustrations of instability, 125–33; mature sciences, 122; observationally equivalent theories, 137–39; unconceived alternatives, 133–34; underdetermination thesis, 134–37; unstable inductive competition, 124–25

domes, analogy for inductive relations, 69, 74 Douven, Igor, 211–12

Dow, Charles, 390

Dow Jones Industrial Average, 390, 401 dowsing: mechanism of, 13; physical theory of, 374; practice of, 13; skeptics and, 121, 125, 367, 368, 382, 387

dowsing, instabilities of evidential competition: diverging inductive logics, 382–83; effluvial theory of, 369–71, 372; geology, dispute over, 375–76; ideo-motor principle, 367, 380–81; overview, 365–68; phenomena, dispute over, 376–80; phenomenon established, 368–69; processes, disputes over theory of, 369–74; proponents of, 13, 121, 125, 367, 368, 369, 371, 372, 373, 382; resistance by skeptics, 371–72; theory, collapse of, 372–74

"doxastic presumption" in coherentist epistemology, 157

Dreyer, J.L.E., 336n4, 346n16

Du fondement de l'induction (Lechalier), 189

Dulong and Petit, law of: Avogadro's hypothesis and, 68–69, 71, 77, 299, 312, 326–27; mutual support of, 318–21; specific heats, 299, 308–10, 326–27

Earman, John, 185 Earth, 62, 240, 355, 358; ancient, 70; cataclysmic collisions with, 48, 51; Copernican system and, 34, 42-43, 137-38, 353, 354, 355; distance from, 346, 350; evidential circle, breaking, 335-39; formation of, 136; gravitational forces of, 138; inverse square of distance as, 81; magnetism of, 370; Mars and, 341, 344; Moon and, 10, 25, 32, 33, 67, 81, 259, 335-39, 341-42, 350; motion of, 34, 43, 138; parallax, measurements of, 253n22, 339, 340; perigee of, 350; Ptolemy's system, 42-43, 350, 351, 359; radius of, 339, 340, 351; relative positions of, 137–38; Sun and, 32, 42-43, 335-39, 341-42, 343; sunrises and, 48; surface of, 259; velocities of nebulae relative to, 234; Venus and, 77, 341-42, 344, 350, 355 Earth-Sun distance, 358, 359; accurate estimates of, 77; Aristarchus and, 335-39;

Earth-Sun distance, 358, 359; accurate estimates of, 77; Aristarchus and, 335–39; Copernican system, 137–38, 341; estimation, 341, 343–44; by geometric triangulations, 77; parallactic measurements of, 76; parallax of Mars, 341; parsec, 253n22; Tychonic systems, 137–38

eclipses: "annular," 334; local conditions, 122; lunar, 331, 340, 341; Moon, 334, 335, 337, 339, 350; solar, 331, 340, 341, 344; of Sun, 334, 340 Edwards, Robert D., 390, 391-92, 401, 402, 405 efficient market hypothesis, 394-95, 405 effluvial theory of dowsing, 369-71, 372 Einstein, Albert, 94n15, 159, 208, 210, 327; anomalous motion of Mercury, 127-28; conversion to mathematical Platonism, 348; general theory of relativity, 34-35, 85-86; gravitational field equations, 114; indeterminacy-producing circularities, 107, 108; principle of relativity, 139; random walk hypothesis, 393; relativistic cosmology, 103; static universe, 132; vicious circularity, 103, 104, 105

electrical processes in conservation of energy, 207

electricity, phenomena of in accounts of dowsing, 369–70

electrons: atoms and, 65; Bohr's atomic theory, 11, 279n6, 280, 281, 282, 283; defined, 127; neutrinos, 85; Ritz combination principle and, 271, 283, 285

Elements of Chemistry (Lavoisier), 38, 300 Elements of Logic (Whately), 105, 186–87

Elliot wave theory, in stock market prediction, 390n3

elliptical orbits: inverse square law and, 257, 263–65, 267f, 284n9; Kepler's, 284n9; of planets, 10, 68, 82, 257, 263–65, 266, 267, 284n9; warranting facts, 68

Ellis, Arthur J., 380

EmDrive, example of dubious reactionless drive, 86–87, 206

emission spectra, discovery of regularities in, 271-75

empirically decidable competition within sciences, 123-24

empirically equivalent theories, 137–39 empiricism, 123–24

Empiricus, Sextus, 181

145-46

Encyclopaedia Britannica, 298, 325

Encyclopedia Galactica, 74

energy, conservation of, 86, 87, 206, 208–9, 210, 285

Enquiry (Hume), 185, 188n5, 190, 193 Enright, James T., 379

enthymemes, inductive inferences as, 222 enumerative induction, 16, 17, 18, 23–28, 180; credible, 25; failure of formal analysis, 24–25; form of inductive generalization, 34; Marie Curie and, 24; material analysis, 25–28; rule of, 175; simple schema for, 29, 62;

task of accounting, 182; warrant for, 196 Epimenides, in liar sentence, 102 epistemic justification, coherentist theories of,

epistemology: Bayesian, 168; of beliefs, 159, 171, 179–80, 198–200, 219, 220, 223; coherentism in, 95, 143, 144, 147–48, 154, 158, 159, 164, 165; foundationalism in, 144, 146; literature on, 158, 171, 200; logic *vs.*, 219–23; nonskeptical, 147–48; problem of induction, 198–203; psychology and, 156n12; serviceable, 154; universal applicability in, 170

Eratosthenes measurement of the Earth's size,

Erkenntnis (Reichenbach), 191–92, 196n10 Philosophical Essay on Probabilities (Laplace), 186

Etchemendy, John, 113
ether, as electron theory, 127
ether-based electrodynamics, Lorentz, 84, 104,
139
ether wave theory of electrons, 127

ether wave theory of electrons, 127 Euclidean geometry, 94, 122 Euclidean space, 108
evidence: evidential support, relations of,
293–95; Hubble's, 248–49; observed, 257–58.
See also atomic spectra, mutually supporting
evidence in; dowsing, instabilities of
evidential competition

evidential circles: breaking, 335–39; distances and sizes of the Moon and Sun, 333–35 evolution, biological, 3–4, 70 Experience and Prediction (Reichenbach), 192 Explanation of the Copernican Hypothesis and

Spheres (Moxon), 353 extragalactic nebulae, 64n1, 231, 232, 234, 235, 241f

failed hypothesis of simplicity, 304–5 failure of generality, in probabilistic analysis, 47–49

Fama, Eugene F., 393, 394–95
Faraday, Michael, 208, 323–24, 381
Fernandes, Cristiano, 405
financial astrology, 403
Fizeau, measurement of speed of light, 133
Forbes, George, 342n12
force(s): celestial, 67–68, 81, 258, 259, 260, 2

force(s): celestial, 67–68, 81, 258, 259, 260, 261, 262, 263; conservation of, 86, 87, 206, 208–9, 210; gravitational, 29, 65, 67, 68, 88n12, 138, 258, 259, 260; terrestrial, 67–68; universal, defined, 108

formal accounts of inductive inference, 139–41 formal analysis, failure of, 24–25 formal approach to analogy, development of, 30 fossil(s): carbon-based fossil fuels, 291;

competing account of, 126; origin of, 136; record, 136

Foucault, measurement of speed of light, 133 foundationalism: alternative to, 161–62, 171; coherentism *vs.*, 153–55; in epistemology, 144, 146

Foundations of Scientific Inference (Salmon),

foundherentism, 154 founding hypothesis, theories of the stock market, 388, 389, 396, 401, 404, 406, 408 Fourier analysis, theory of, 42 Fowler, Alfred, 271, 273 fractal(s): analysis, random walk theory and

fractal(s): analysis, random walk theory and, 400; converge, 398–99; curves, 395–96; Mandelbrot's, 395–98, 405

Franklin, James, 154n7 Franklin, T. Bedford, 373–74 Freire, Rosane Riera, 405 Frost, Alfred J., 390n3 Fumerton, Richard A., 200n14 fundamental analysis, stock market, 389–90, 400–401

galaxies, 231n2, 234, 249; energetic nuclei of, 133; expansion of, 78; Hubble's discovery of recession of, 103; Hubble's "extragalactic nebulae," 64n1; origin of galactic red shifts, Arp and Bahcall on, 73, 130–33; velocity of recession of, 132

Galilei, Galileo: Dialogue Concerning the Two Chief World Systems (Galileo), 36; Letters on Sunspots, 359; mountains on moon, 32–33; Siderius nuncius — the Starry Messenger (Galileo), 32; warranting fact, 80 gallium alum, in law of isomorphism, 311 garlic, supposed power over magnets, 369 gas(es): Dalton's model of, 306n5; densities of, 313, 314t; hydrochloric acid, 317–18; hydrogen, 71–72, 307, 313, 315; ideal gas law, 47n21; kinetic theory of, 12, 69, 299, 306n5, 321–26, 327; mass density of, 317–18; oxygen, 71, 300n1, 307

Gaussian random walk theory, stock market,

Gay-Lussac, Joseph-Louis, 306, 308, 322n13, 325n15, 327

generality, failure of in probabilistic analysis, 47–49

generalizations, 10, 27, 80, 182, 188, 217, 397; about nebulae, 64; hierarchy of, 65–66; Hubble's, 64, 231, 232, 242; inductive, 16, 28, 34–35; instances of, 186; notion of, 62–63; Ritz combination principle, 270, 279, 280; simple, 231, 232; version of, 195; warrant, 280 geocentric system: Ptolemaic, 35, 36, 42–44, 76, 353; Tychonic, 137

geology, dispute over with dowsing, 375–76 geometrical triangulations, determining celestial distances, 12, 76, 77, 344

geometry, 76, 107, 236, 350–51, 355; of Aristarchus' figure, 338; construction, 33, 346, 348, 350; Copernican astronomy, 42, 43; curved space-time, 65; Eucidean, 86, 94, 108, 122; Heath's analysis, 337; relativity of, 108; simple, 12, 76, 333, 334; of space, 92, 108 Gesammelte Werke (Collected Works) (Ritz),

275–76 Gibbs, R.C., 285–86 Gilbert, William, 369, 372 Gold, Thomas, 78 Goldbach's conjecture, 154n7
Goldman, Alvin I., 156n12, 202
Goldstein, Bernard R., 349–50
Graham, Benjamin, 389, 403, 404, 405, 406
Grandi's series, 112
gravity, 145, 223, 372; force of, 29, 65, 67, 68, 88n12, 138, 258, 259, 260; Hume's challenge, 193; Mill's dismissal of circularity, 188; motions of bodies under, 207, 208; terrestrial, 10, 81, 258, 260, 261, 262, 263; theories of, 369. See also inverse square law of gravity, Newton's; universal gravitation, Newton on Gregory, John W., 378, 381
Gross, Henry, 376

Haack, Susan, 154 halogens, in Cannizzaro's analysis, 72, 315-16, Hansen, George P., 378 Harman, Gilbert H., 182, 196, 205 Harmonices mundi (Kepler), 347, 360 harmonic hypotheses, Pythagorean and Platonic, 75, 86, 332, 345-48 Hartmann, Stephan, 145, 163 Harvard spectral classification system for stars, Hasanhodzic, Jasmina, 404 Haüy, René Juste, 27, 28, 80 heat, transformations of in conservation of energy, 207 heat capacity, atomic, 308, 309, 310, 319-20, 327 Heath, Thomas, 335, 337-38, 339n7 heliocentric astronomy of Newton's time, 77 heliocentric system: Copernicus, 35, 36, 42, 43, 77, 137, 332, 341, 346, 353-55, 358; Newton, 77, 332, 359; solar system distance measurements, 77 helium, spectra of, 274, 275 Helmholtz, Hermann, 206, 207-8 Henderson, Leah, 224 Hertz, Heinrich, 93, 372 Hesse, Mary B., 30, 31 hierarchical conception of inductive support, tower, 62-63 hierarchy of generalizations, 65-66

Hilbert space formulation of quantum theory,

historical-anthropological objection to the

holism vs. localism in coherentist epistemology,

Hipparchus, 339, 340, 344n13, 346

material dissolution, 220

horizontal parallax in determining celestial distances, 339-40 horror circulorum, 99, 100, 103, 112, 113 H propositions in artefact dating by history, 68, 290, 293, 294, 295 Hubble, Edwin: circularity and, 109-10, 115; constant, 240; distances to nebulae, 236-42; generalization, 64-65; Hubble-Lemaître law, 231n3; Humason and, 236n8, 239, 240n12, 242-43, 248; hypotheses, 242-44; investigations, background to, 234-36; law, 10, 231; light from galaxies, 130-31; notion of consistency, 233; The Realm of the Nebulae, 234, 252; recession of galaxies, 103; twenty-two nebulae, 77-78, 232-33; velocities, nebular, 236-42. See also recession of nebulae Huemer, Michael, 163, 166 Humason, Milton L., 236n8, 239, 240n12, 242-43, 248 Hume, David, 45, 47, 198; circularities, 184-85, 187-88, 189, 190-95; critique of inductive inference, 182-85, 186-90, 191, 195; Enquiry (Hume), 185, 188n5, 190, 193; inductive inferences and, 179; in nineteenth century, 186-90; Principle of Uniformity of Nature, 213; problem, 200, 212, 213, 215, 223; Reichenbach and, 190-95; skepticism, 185, 186, 213, 214; Treatise (Hume), 183n3, 185 hydrobromic acid, 315 hydrochloric acid, 313, 314t, 315, 317-18 hydrogen, 300, 314t; atomic weight, 315, 319; atom of, 11, 65-66, 71-72, 280, 281, 283-84, 297, 301, 303, 306, 307, 315; chemistry of, 65; chlorine and, 313; diatomic composition of, 317-18; gas, 71-72, 307, 313, 315, 317; molecular formulae of, 316; molecule, phenomenological theory of, 65-66; monatomic constitution for, 317; Ritz combination principle, 279, 281, 284; spectrum, 10, 82, 269, 270, 271-75, 276, 279, 281, 284, 285; volumes of, 306, 307, 317 hydro-halogenic acids, in Cannizzaro's analysis, 317 hydroiodic acid, in Cannizzaro's analysis, 315 hyperbolas, planetary motion, 68, 69n2 hyperset theory, 113 hypotheses, in determining distances in planetary system: Aristarchus of Samos, 335-39, 346; Copernican hypothesis, 353-59;

Holmes, T.V., 373, 375

Hooke, Robert, 353

147 - 50

evidential circle, distances and sizes of the Moon and Sun, 333–35; need for, 344–45; order, 350, 354; overview, 331–33; packing, 350, 353n20, 354; parallax, measurements of, 339–41; parallax of mars, 341; Ptolemy's *Planetary Hypotheses*, 348–53; Pythagorean and Platonic harmonies, 345–48; relations of support, crossing of, 359–61; transits of Venus, 341–44

hypotheses in discovery of inductive relations of support: discovery problem, 73–75; hypothetico-deductive confirmation, 78–79; illustrations of, 75–78; warranting, 74

hypothesis: "big bang" hypothesis, 78; Brightest Star Magnitude, 232, 237–38, 244; Clustering of Nebular Luminosity hypothesis, 232, 233, 238–39, 244, 245, 246; defined, 354; efficient market, 394–95, 405; failed, of simplicity, 304–5; founding, 388, 389, 396, 401, 404, 406, 408; of fractal finance, 396; perfect cosmological principle, 78; "primeval fireball," 78; Ptolemy, 332, 348–53, 354, 358; of random walk, 393; of technical analysis, 392; warranting fact, 74, 218. See also Avogadro's hypothesis; Copernican hypothesis

hypothetical induction, 16, 34–36 hypothetico-deductive confirmation, 78–79, 135

ideal gas law, 47n21 ideo-motor principle, applied to dowsing, 367, 380–81

imprecise probability, 50–51 indeterminacies, arising from circularities, 212 indeterminacy-producing circularities, 107–8 indeterminate circularities: begging question,

105–6; producing conventions, 107–8; in relations of inductive support, 108–10

induction(s): closure, 88–90; demonstrative, 80; hypothetical, 16, 34–36; logic of, 198–99; principle of, 191, 192, 195, 196–97; universal logic of, 91. *See also* enumerative induction; material theory of induction; problem of induction

inductive anxieties, 178–79, 180–82, 186 inductive competition, unstable, 124–25 inductive debt, 74

inductive evidence, concept of, 199 inductive generalization, 16; analogy as form of, 28; forms of, 34–35

inductive inferences: applicable rules or schemas for, 204; background facts, 20; challenges for, 17-20; claims and arguments, 4-9; formal accounts of, 139-41; formal approaches to, 29; forms of, 34, 44; Harman's schema of, 196; Hume's critique of, 182-85; hypothetico-deductive approach to, 3; justification for, 178, 196, 215-16; literature on, 9; locality of, 21; local vs. distributed justifications of, 178; logic of, 175, 198-99; material character of, 162; in mathematics, 154; in mature science, 178; nature of, 136; overview, 16-17; in philosophical literature, 9-10; principal accounts of, 17; rules of, 175, 176, 214-15; schemas of, 22-23, 202, 205, 212; simplicity as surrogate, 39-40; treatment of, 189; universal calculus of, 2; warrant/ warranting facts of, 6, 19-20, 21, 33, 50, 60, 74, 79, 162, 176, 177, 178, 204, 218, 408 inductive instability. See dowsing, instabilities

of evidential competition inductive logics, 175, 198–99, 219–20; diverging, 382–83. *See also* domain-specific

inductive logics, uniqueness of inductive logics, competition: competition among systems, 399–407; efficient market hypothesis, 394–95; fundamental analysis, 389–90, 400–401; Mandelbrot's fractals, 395–98; overview, 387–99; random walkers and fractals converge, 398–99; random walks, 392–94, 405–7; technical analysis

inductively self-supporting structures: closure, 88–90; mature sciences, 90–91

("chartists"), 390-92, 402-5

inductive relations of support, hypotheses in discovery of: discovery problem, 73–75; hypotheses, illustrations of, 75–78; hypothetico-deductive confirmation, 78–79 inductive rigidity, of mature science, 83–86, 91 inductive structure of atomic weights and molecular formulae, vaulted, 311–13

inductive structures, deductive inferences in: feature of, 79–81; locally deductive but globally inductive, support, 81–83

inductive support: natural hierarchical structure for, 232; regresses of, 208, 209, 218; strengths of, 168

inductive support, nonempirical components: ineffable conditions, 94; Kantian synthetic, priori proposition, 92; mathematical structure, 92–94; principle of causality, 92; universal logic of induction, 91 inductive support, nonhierarchical relations of: arch, 66-69; firm ground of experience, 72–73; hierarchical conception, tower, 62–63; hierarchy of generalizations, 65-66; lack of respect, 64-65; vaulted ceilings, 69-72 inductive support, relations of, 136, 141;

coherence vs., 150-53; determinate circularities, 114-15; differences of, 149; entangled relations of, 81-83; indeterminate circularities, 108-10; large-scale structure of material relations, 143, 144, 146, 147, 148-49; for mature science, 104, 177, 206, 210; single, global property of, 162; strength of, 150; uniqueness of, 119, 120, 121

ineffable non-empirical conditions, 94 inertial motion, 32, 137-38, 259

inference(s): abductive, 196; ampliative, notion of, 16, 194-95, 195n9, 196; direct, 223; logical notion of, 16-17; nondemonstrative, 194-95; rule of, 211-12; summarized, 260-63

inference to the best explanation, 35, 40, 73, 125, 140, 151, 175, 182, 196, 205, 225. See also abductive inference.

Inference to Worst Explanation (IWE), 211–12 "infinite regression," concept of, 197

"input objection," to coherentist epistemology, 153

instability(ies): Arp and Bahcall on origin of galactic red shifts, 130-33; big bang and steady state cosmology, 129-30; of competing systems, 407-11; Einstein and anomalous motion of Mercury, 127-28; illustrations of, 125-33; Lyell's Principles of Geology, 126; more illustrations, 133; Origin of Species (Darwin), 125-26; Thomson's cathode rays, 127. See also dowsing, instabilities of evidential competition; inductive logics, competition

An Introductory Logic (Creighton), 187 intuitive principle of abstraction, in set theory, 102n1

inverse probabilities, Bayes' work on, 185, 186 inverse square law of gravity, Newton's, 10, 64, 257, 259; adjustment to exponent in, 128; Cavendish-type experiments, 69n2; celestial and terrestrial forces, 67-68, 260, 261, 262, 263; elliptical orbits and, 257, 263-65, 267f, 284n9; exactness of, 82, 265-67; Kepler's third law, 284n9, 332-33, 360; propositions of, 257; universal gravitation and, 81 iodine, in Cannizzaro's analysis, 72, 314t, 315,

"isolation objection," to coherentist epistemology, 153 isomorphism, Mitscherlich's law of, 299, 310-11

Jackson, Alexander, 223 Jevons, W. Stanley, 187 John Magee, Inc., 402 Joule, James, 206 Journal of the Society for Psychical Research (Hansen), 378 Joyce, George Hayward, 29, 31

Jupiter, 351, 355, 359, 361; apogee of, 351n19; center of, 258; distance from Earth, 350; moons, 258, 360; motion, 265, 349, 350; relative distance, 345

justification(s): for beliefs, 7, 147-48, 153, 159, 161, 191, 200, 202, 203; circularities of, 160-61; deductive and inductive, 193; epistemic, coherentist theories of, 145-46; for inductive inferences, 178, 196, 215-16; in material theory, regress, 216; problem of induction in material theory, 215-16; for reasoning, 200; regress of, 216

Kant, Immanuel, 179, 185, 189 Kantian synthetic, a priori proposition, 92 Karlsruhe Congress (1860), 311, 312 Kelly, Tom, 216-20 Kepler, Johannes, 94, 352-53, 355; drawing of Ptolemaic system, 352f; elliptical orbits of planets, 284n9; Harmonices mundi, 347, 360; hypothesis, 346-47; Kepler's second law, 263; Kepler's third law, 77n3, 332-33, 359, 360-61; Mysterium cosmographicum, 346, 353 kinetic theory of gases, in relation to Avogardro's hypothesis, 12, 69, 299, 306n5, 321-26, 327 Kirchner, Athanasius, 380 Kirwan, Richard, 100-101, 102, 186 Koch snowflake, 395-96 Korman, Daniel Z., 223 Krönig, August, 321, 324-25 k term, for recession of the nebulae, 235 Kuhn, Thomas S., 123

Lachelier, Jean, 189 Lafleur, Trevor, 87 Laplace's analysis of rule of succession, 46-47, 48 - 49,50Laplace's rule of succession, 16, 45-46, 47-48, 52-54, 169, 186

large-scale structure, claims: deductive inferences in inductive structures, 79-83; inductively self-supporting structures, 88-91; inductive relations of support, hypotheses in discovery of, 73-79; of inductive support, nonempirical components, 91-94; maturity of science, 83-87; nonhierarchical relations of inductive support, 62-73; overview, 59-62 Latimer, Charles, 372, 375, 377 Laudan, Larry, 135 Lavoisier, Antoine, 38, 122, 133, 208-9, 299, 300-301 Leavitt, Henrietta, 237 Lehrer, Keith, 145-46, 151, 152, 153, 155 Leibniz, Gottfried Wilhelm, 165 Lenard, Philipp, 127, 275n4 Leo, nebula cluster, 239n11 Leplin, Jarrett, 135 Letters on Sunspots (Galileo), 359 Lévy, Paul, 397 Lewis, C. I., 165 Libby, Willard F., 291, 294 Libby, William, 290 light: analogies of, 139-40; color of, 139; polarization, 140; properties of, 139 linearity of nebular recession, evidence for, 248-49 Livengood, Jonathan, 223 Lo, Andrew W., 399, 404 localism, holism vs., in coherentist epistemology, 147-50 local vs. distributed justifications of inductive inference, 178 Logic of Scientific Discovery (Popper), 196 logic(s), inductive, 175, 198-99, 219-20; epistemology vs., 219-23; multiple systems of, 388-99. See also domain-specific inductive logics, uniqueness of; inductive logics, competition Logik der Forschung (Popper), 196-97 Lorentz ether-based electrodynamics, 84, 104, 139, 372 Lorenzoni, Giuliano, 405 luminosity(ies): class O star, 66; Clustering of Nebular Luminosity hypothesis, 232, 233, 238-39, 244, 245, 246; intrinsic, 132-33; magnitude and, 252-54; nebulae, 232-33, 234, 236-37, 243t, 244, 245, 246, 252-54 Lyell's principles of geology, 122, 126 Lyman, Theodore, 72, 272, 273, 277 Lysenkoism, 122

Maby, J. Cecil, 373-74 Macaulay, Frederick R., 403 MacKinlay, A. Craig, 399 Magee, John, 390, 391-92, 401, 402, 405 Magellenic Clouds, 237 magnetism, phenomena of, in dowsing, 369-70 magnitude(s): luminosity and, 252-54; of nebulae, 65, 78, 107, 110, 234, 237, 238, 239-40, 244, 245, 246, 252-54 Major Achievements of Science (McKenzie), 231-32 Malkiel, Burton, 394, 399, 400-401, 403, 404, 405 Mandelbrot, Benoit, 395-98, 399, 401, 403, 405 Manual of Logic (Munro), 186 March, Paul, 87 market hypothesis, efficient, 394-95, 405 Mars, 332, 349, 350, 351, 355, 359; distance to, 76, 344; Earth and, 341, 344; parallactic measurement of distance to, 76; parallax of, 332, 341, 358; relative distance, 345 mass, conservation of, relation to conservation of energy, 208-9, 210 material analysis of instances of enumerative induction, 25-28 material dissolution: critical responses to, 216-24; logic vs. epistemology, 219-23; more treatments, 223-24; particulars to generalities, 216-19; of problem of induction, 176, 178, 180, 204, 216-24 material theory of induction: analogy, 28-33; Bayesian analysis, 44-52; case for, 20-22; claims of, 4-9; enumerative induction, 23–28; guiding rule of, 74; hypothetical induction, 34-35; illustration, 22-23; inductive inference, 16-18; Laplace's rule of succession, 16, 45-46, 47-48, 52-54; overview, 15-16; principal consequence of, 202; problem for, 176; problem of induction, justification, 215-16; Ptolemy and Copernicus, 42-44; regresses, 206-9; requirements of, 136; simplicity, 37-44; solution in three slogans, 18-20; twodimensional model, 30-31; vicious circles in, 103-5; warrants in, 206. See also analogy(ies); circularities; coherentism; regresses Mathematical Principles of Natural Philosophy (Newton), 257 mathematics, 47, 101; in formulating physical theories, 61-62; of group theory, 28; inductive inferences in, 154; large-scale structure of inductive support, component, 92-94

Matter and Motion (Maxwell), 263 mature sciences: claims of, 6-7; distributed vindication, 86-87; inductive inferences in. 178; inductive rigidity, 83-86, 91; inductive support, relations of, 104, 177, 206, 210; propositions of, 6; self-supporting inductive structures, 90-91; support relations in, 70; uniqueness of, 7, 122 Maxwell, James Clerk, 359n26, 361; Avogadro's hypothesis and, 321-22, 325-26; electrodynamics, 84, 113, 208, 372; elliptical motions of planets, 263, 264, 266; equations, 113, 114; kinetic theory of gases, 321-22, 325; law of Gay-Lussac, 322n13; Lorentz and, 84, 104: Matter and Motion, 263 Maxwell's equations, 113-14 Mayer, Julius, 206 McCullough, W. Andrew, 403-4 McDermott, Richard, 402, 405 McKenzie, A.E.E., 231-32 megaparsec, 253n22 Meinzer, Oscar E., 379, 384-85 Meldrum, Andrew, 326 Mendeleev, Dmitri, 122, 297, 298f, 312 mercury, 38, 300; atomic weights, 314t, 319, 320; chlorides, 321; halides of, 320 Mercury, 159, 350, 358-59; anomalous motion, Einstein and, 35, 127-28; apogee of, 351; Copernican construction for, 355; distance from Earth, 350; epicycles of, 358; perigee of, 351; perihelion motion of, 34, 158; relative distance, 345 metrical and stress-energy tensors, 34 Meyer, Lothar, 312, 324 Milky Way, 231n2, 234, 248 Mill, John Stuart, 62, 105n3, 106, 189-90, 193; dismissal of circularity, 188; principle of uniformity of nature, 21, 215; System of Logic, 181-82, 187, 188 Minkowski, Hermann, 209 Mitchell, Sam, 136-37 Mitscherlich's law of isomorphism, 299, 310-11 modus ponens, schema, 20 molecular formula, atomic weights and: circularity, 301-4; mutual support of, 313-18; vaulted inductive structure of, 311–13; water, 11, 71, 109, 297, 301, 303-4, 305, 317 momentum, conservation of, in relation to

Moon, 62, 75-76, 236, 331; apogee of, 351; celestial force on, 260, 261, 262, 263; celestial-gravitational force on, 68; distances and sizes of, 333-35; distance to, 12, 75-76, 109, 338, 344, 345, 346, 350, 358; Earth and, 10, 25, 32, 33, 67, 81, 259, 335–39, 341–42, 350; eclipse of, 337, 339; full, 333, 335; illusion, 333n2; Jupiter's, 258, 360; at lunar dichotomy, 336f; Mercury to, 350; motions of, 105; mountains on, 32-33; parallax of, 341-42, 344n13, 344n14; principal lunar semidiurnal M2, 42; Ptolemy's analysis, 348, 350; relative positions of, 137; of Saturn, 360; Sun and, 109, 137, 333-39; terrestrial bodies and, 81, 260, 261, 262, 263; test, 10, 67, 81-82, 257, 258-60, 262; Venus and, 342, 359 "moral reasoning," distinguished from "demonstrative" by Hume, 184-85 Moxon, Joseph, 353 Muir, Pattison, 311 multiple systems of inductive logic: efficient market hypothesis, 394-95; fundamental analysis, 389-90; Mandelbrot's fractals, 395-98; overview, 388-89; random walkers and fractals converge, 398-99; random walks, 392-94; technical analysis ("chartists"), 390-92 Munro, H.H., 101, 186 muriatic acid gas, in Cannizzaro's analysis, 317-18 Murphy, Peter, 153-54, 161 mutually supporting evidence. See atomic spectra, mutually supporting evidence in; radiocarbon dating, mutually supporting evidence in mutual support: of atomic weights and molecular formulae, 313-18; of Avogadro's hypothesis and law of Dulong and Petit, 318-21; of Avogadro's hypothesis in chemistry and kinetic theory of gases, 321-26; relations

Narratio prima (Rheticus), 354
NASA Johnson Space Center, 87
NASA's COBE satellite, 129
natural laws, in Popper's form of the problem of induction, 197
nature: mathematical character of, 92–94;
simplicity and, 38

of, 69, 267, 269, 270, 282, 317, 321, 326

Mysterium cosmographicum (Kepler), 346, 353

Nature, 84, 273, 275, 373-74

drives, 86, 87, 209, 210

Montucla, Jean-Étienne, 377

perpetual motion machines, reactionless

nebulae, 64-65, 77-78; determination of distances, 236-40; extragalactic, 64n1, 231, 232, 234, 235; forty-six, 64, 77, 109, 115, 232, 236, 240; generalities to particulars, 245-47; linearity, evidence for, 248-49; luminosities, 232-33, 234, 236-37, 243t, 244, 245, 246, 252-54; magnitudes of, 65, 78, 107, 110, 234, 237, 238, 239-40, 244, 245, 246, 252-54; motions of, 234-36; particulars to generalities, 240-42; recession of, 109-10; twenty-four, 64, 78, 232, 233-34, 240, 242, 244, 246; velocities of, 234-35. See also recession of nebulae Neptune, discovery of, 128 Nernst, Walter, 327 neutrinos, discovery of non-zero rest mass, Newcomb, Simon, 342n12, 344 New Scientist article, on the "EmDrive," 86 New System of Chemical Philosophy (Dalton), 71, 299, 308 Newton, Isaac, 10, 12, 31, 39, 65, 105, 186; elliptical orbits of planets, 68, 263-65; gravitational effects, 109, 128, 138n11, 158-59; heliocentric astronomy of Newton's time, 77; law of motion, 87, 223; Mathematical Principles of Natural Philosophy, 257; mechanics, 82, 94, 104, 208, 332, 359, 360, 361; Moon test, 10, 67, 81-82, 257, 258-60; perturbations in Jupiter's motion, 265n1; Principia, 37, 94, 258, 260, 263, 264, 265, 359, 360, 372; seventeenth-century mechanics, 85, 122; Tychonic system and, 137-38. See also inverse square law of gravity, Newton's; universal gravitation, Newton on New York Times article, 234n5 NGC 7619, nebula, 248 nitrogen atoms: in radiocarbon dating, 291; in Dalton's chemistry, 300 nondemonstrative inference, 194-95 nonhierarchical relations of inductive support: arch, 66-69; firm ground of experience, 72–73; hierarchical conception, tower, 62–63; hierarchy of generalizations, 65-66; lack of respect, 64-65; vaulted ceilings, 69-72 A Non-Random Walk down Wall Street, 399

observationally equivalent theories, 137–39 Ockham's razor, 37, 39 Okasha, Samir, 180, 212–15 Olsson, Erik J., 145–46, 163, 165, 166 On the Revolutions of the Heavenly Spheres (Copernicus), 36, 353

OPERA Collaboration, faster than light neutrinos, 85
order hypothesis, Ptolemy's analysis, 350, 354
Origin of Species (Darwin), 125–26
Osiander, 34, 353, 354
Outlines of Theoretical Chemistry (Meyer), 324
oxygen: atomic weight of, 303, 310, 319; atoms of, 11, 71, 297, 300, 301, 303, 306–7, 314t; component densities, 315; diatomic composition of, 71, 317; gases, 71, 300n1, 307; theory, 133, 208–9; volume of, 306–7
Ozanam, Jacques, 377

packing hypothesis, Ptolemy's analysis, 350,

353n20, 354 Papineau, David, 203 parabolas, planetary motion, 68 Paracelsus, 300, 376 parallactic measurement of celestial distance. parallax: in astronomy, 12, 76; Cepheid variable stars, measurements, 237; horizontal, 340; of Mars, 332, 341, 358; measurements of, 253n22, 331-32, 339-41, 344; of Moon, 341-42, 344n13, 344n14; of Sun, 341, 342; of Venus, 342 parapsychology, 366 Paretian distribution, 397-98 parsec, 253n22 parsimony, principles of, in inductive inference, 37 - 39particle interactions, laws of, 19 Paschen series, 72, 82, 272, 273, 276, 277-78 Pavesi, Angelo, 312 Peden, William, 223 Pegasus, nebula cluster, 239n11 Penzias and Wilson's discovery, 78, 129 perfect cosmological principle, hypothesis of, perigee: apogee and, bodies in Ptolemaic astronomy (Moon, Mercury, Venus, Sun, Mars, Jupiter, Saturn) 351 perihelion motion of Mercury, 34, 158-59, 266 Perseus, nebula cluster, 239n11 Petit, Dulong and: Avogadro's hypothesis and, 68-69, 71, 77, 299, 312, 326-27; law of specific heats, 299, 308-10, 326-27; mutual support of, 318-21 petitio principii, 100, 105-6 Pfund, August, 72, 82, 272, 273, 277, 278, 286

phenomenological theory of hydrogen molecule, 65-66 phlogiston theory, competition with oxygen theory, 133 phosphorus, in Lavoisier's Elements, 300 The Physics of the Divining Rod (Maby and Franklin), 373-74 Pisces, nebula cluster, 239n11 Pizzinga, Adrian, 405 Planck formula, energy in black body radiation, Planetary Hypotheses (Ptolemy), 332, 348-53 planets, 25, 42-43, 62, 82, 360, 361; aphelion of, 265-66; celestial force, 258; distances to, 12, 76, 77, 333, 339, 344, 345, 357f, 358; elliptical orbits of, 10, 68, 82, 257, 263-65, 266, 267, 284n9; epicycle-deferent construction for, 164; inverse square law, 263-68; motions of, 34, 35, 43, 65, 105, 128, 164, 213, 266, 359; Neptune, 128; observed positions of, 68, 82, 263, 264, 265, 266, 267; orbital sizes for, 94, 136; relative positions of, 137; Uranus, 128, 361; Vulcan, 128. See also Copernican astronomy; Copernican hypothesis; Copernican system; hypotheses, in determining distances in planetary system; Jupiter; Mars; Ptolemy; Saturn; Venus Plato, 76, 86, 94n15, 106, 332, 345-48 Platonic harmonies, Pythagorean and, 76, 86, 332, 345-48 polymorphism, of crystalline forms, 27, 80 polynomials, in curve fitting, 40, 41, 42 Popper, Karl, 179, 181n2, 196-97, 215, 222 potassium alum/potash alum, in Mitscherlich's Law of Isomorphism, 311 Prechter, Robert R., 390n3 Price, Richard, 45, 185-86 "primeval fireball" hypothesis, cosmology, 78 Principia Mathematica (Whitehead), 102 Principia (Newton), 37, 94, 258, 260, 263, 264, 265, 359, 360, 372 principle of causality, 92 principle of combination. See Ritz's combination principle principle of induction, 191, 192, 195, 196-97 principle of relativity, Einstein's, 139 principle of selection, in atomic spectra, 285 Principles of Geology (Lyell), 126 Principles of Logic (Bradley), 189 principles of parsimony, in inductive inference, Principles of Philosophy (Descartes), 370

Principles of Science (Jevons), 187 probabilistic accounts of coherence, 163-64 probabilistic distribution, of price changes, stock market, 396-97 probabilistic framework, coherentism and, 167-70 probabilistic notion, coherence of coherentism, probability theory, central limit theorem of, 393-94, 396, 397, 398 problem of induction: circularities, 190-95, 210-12; critical responses to material dissolution, 216-24; epistemology and, 198-99, 200-203; failed attempts, 177, 180; inductive anxieties, 178-79, 180-82, 186; local vs. distributed justifications of inductive inference, 178; logic of induction, epistemology of belief and, 198-99; material dissolution of, 176, 178, 180, 204, 216-24; in material theory, justification, 215-16; for material theory of induction, 176; overview, 178-80; regresses, 204-9; formulation, 195-97; Sober and Okasha, 212-15; traditional, 175-76; twentieth century, 190-97; version of, 183. See also circularities; epistemology; Hume, David; regresses Problems of Philosophy (Russell), 190 "proportional syllogisms," 223 propositions, beliefs vs., 155-58 Pryce, William, 370, 371, 372, 376, 383, 384 pseudosciences, 13, 366 Psychical Research (Barrett), 374 psychic surgery, 366 Ptolemy, 12, 76, 354, 355, 359, 361; Almagest, 253, 348, 349; astronomy, 43, 164, 348; Copernican astronomy and, 164; epicycle for Venus, 349f; geocentric system, 35, 36, 42-44, 76, 353; Hipparchus and, 339, 340; hypothesis, 332, 348-53, 354, 358; Moon eclipse technique, 339; packing hypothesis, 350, 353n20, 354; Planetary Hypotheses, 332, 348 - 53Pythagoras' theorem, 355

quantum theory, 3, 122; Bohr's atomic theory and, 11, 78, 270, 271, 282; Casimir effect, 87; coherence of, 149, 150; discontinuity, 80–81; discovery of, 188; Dulong and Petit's law of specific heats, 299; field theory, 85, 149; forms of, 150; Hilbert space formulation

Pythagorean/Platonic proposals, 76, 86, 332,

345 - 48

of, 209; hydrogen, treatment of, 65–66; of individual atoms, 65; measurement, 149–50; mechanics, 65, 149; Ritz's combination principle and, 11, 69, 271, 280, 282–86; support for, 11, 69, 149–50 quasars, 132–33 quasi-ordering, as assessment of coherence, 163 Quine, Willard Van Orman, 3, 136

radiocarbon age, 292
radiocarbon dating, mutually supporting
evidence in: of artifacts, 68, 103–4, 115; ¹⁴C
in atmosphere, 290–91; need for calibration,
291–93; overview, 289–90; relations of
evidential support, 293–95
radiocarbon methods, 11
radium chloride: crystalline properties of, 24,
26, 27–28; crystals of, 80; samples of, 79

Ramsay, William, 311 Randi, James, 378–79 Random Walk down Wall Street (Malkiel), 394 random walks, in the stock market, 392–94,

398–99, 400, 405–7 The Realm of the Nebulae (Hubble), 234, 252 recession of the nebulae, velocity of, 131, 132 recession of nebulae: Brightest Star Magnitude

hypothesis, 232, 237–38, 244; *Clustering of Nebular Luminosity* hypothesis, 232, 233, 238–39, 244, 245, 246; determination of distances, 236–40; extragalactic nebulae, 64n1, 231, 232, 234; generalities to particulars, 245–47; Hubble on, 109–10, 231, 232–33, 234–36, 242–44; linearity, evidence for, 248–49; luminosities, 232–33, 234, 236–37, 243t, 244, 245, 246, 252–54; overview, 231–34; particulars to generalities, 240–42

red shift(s): in galaxy's light, 73, 130–33; for nebula, 64, 234, 240, 245, 249; of quasars, 133 Regnault, measurements of physical properties of steam, 208

regresses, 90, 157; benign termination of, 204, 213, 214, 216; end, 176, 177; of factual warrants, 206; formulation, 195–97; foundationalist's, 146–47, 155; of inductive support, 208, 209, 218; of justifications in material theory, 216; in material theory of induction, 206–9; of problem of induction, 175–76, 177, 179, 180, 195–98, 204–9, 213–14, 216, 218; Sober on, 213–14; start, 176, 177; traditional problem, 205–6; unsustainable infinite, 179; to warranting propositions, 8, 95

Reichenbach, Hans, 107-8, 179, 191-94, 195, 196-97n10, 224 Reid, Thomas, 185 Reimer, Paul J., 292, 293f relations of support, 60, 64, 120, 141, 144, 169, 233; as arch, 316; circularities in, 90, 99, 103; crossing of, 66, 68, 69, 88, 257, 271, 277, 278, 294, 359-61; deductive, 4, 5, 60, 81-83, 258, 263, 278, 279; discovery problem, 73-75; in Hubble's paper, 234; hypotheses, illustrations of, 75-78; hypothetico-deductive confirmation, 78-79; inductive, 5, 6, 18, 69, 73-79, 81-83, 176, 258, 267, 279; intersecting, 12; inversion of, 286; in mature science, 162; mutual, 12, 69, 267, 269, 270, 282, 317, 321, 326; overall structure of, 267; prodigious array of, 69; summation of, 149, 157; two sets of propositions, 289 relativity: of geometry, 108; principle of, Einstein, 139; theory of, 85-86 Rescher, Nicholas, 145 resistance by skeptics to dowsing, 371-72 Review of Modern Physics on the Ritz combination principle (Gibbs), 285-86 Rheticus, 354 Riddick, Thomas, 376 Riemann's four index symbols, in general relativity, 34 rigidity, inductive, 83-86 Ritz, Walther. See Ritz combination principle Ritz's combination principle, 72, 78, 269, 273, 275-76, 279; applications of, 270; Balmer series, 277, 278; Bohr's theory and, 281-82; direct explanation of, 271; heuristic guidance of, 279; inferences of support, 82; Paschen series, 277, 278; physical basis of, 281, 282f; quantum theory, support for, 69, 271, 282-86; supporting, 279-80; warranting authority of, 10-11

293, 294, 295
rule: inductive, 211–12, 214–15; of inference,
211–12; selection rule, 285; of succession,
Laplace's, 16, 45–46, 47–48, 52–54, 169, 186
Russell, Bertrand, 101, 102, 112, 113, 179,
190–91, 195–96, 197, 198–99, 234n5
Russell, H.N., 234n5
Rutherford, Ernest, 24, 25–26, 280
Rydberg, Johannes R., 72, 275

R propositions, in radiocarbon dating, 68, 290,

Roberts, Kenneth, 376

Rosenfeld, Léon, 282

Sagredo, in Galileo's Dialogue, 36 261; motion of, 234-36, 248; nebulae and, Salmon, Wesley, 179, 194, 195n9, 199, 210-12, 234-36; orbit, 25; vector velocity of, 240, 241 224 solar system distance measurements, 77 Salviati, in Galileo's Dialogue, 36 some-all inferences, 23-24, 26 Sommerfeld, Arnold, 274, 275-76, 279n6, Samuelson, Paul, 392-93, 394 Sand-Reckoner (Archimedes), 339 282n7, 283, 284, 285 Saturn, 355, 358, 359, 360, 361; moon of, 360; Sophistes (Plato), 106 motion of, 265, 349; Ptolemy's analysis, 349, sound, analogy with light, 139-40 350, 351; relative distance, 345 specific heat(s): Cannizzaro's, 319t, 320t; "saving of appearances," 34-35 Dulong and Petit law of, 299, 308-10 scaffolding, as analogy to hypotheses, 61, 74 spectroscopists, 72, 269, 273, 275 scaling hypothesis, 395, 396, 397, 398 spectrum, atomic: emission spectra, discovery Scheunen experiment, on dowsing, 379 of regularities in, 271-75; Harvard spectral Schiller, Ferdinand C.S., 187 classification system, 66; helium, 275; Schott, Gaspard, 380 hydrogen, 10, 82, 269, 270, 271-75, 276, 279, Schupbach, Jonah, 163 281, 284, 285; Ritz combination principle for, 279, 281, 284. See also atomic spectra, Schurz, Gerhard, 218, 219 Security Analysis (Graham and Dodd), 389 mutually supporting evidence in Selby-Bigge, Lewis Amherst, 190 Spencer, Herbert, 348 self-affinity, of fractals, 395 Stanford, Kyle, 134, 135n9 self-refutation of skeptics, 101, 102, 197 Stanford Encyclopedia of Philosophy (Olsson), self-similarity, of fractals, 395-96, 397 "statistical syllogisms," 223 self-supporting inductive structures: closure, 88-90; mature sciences, 90-91 steady state cosmology, 129-30, 157 Shapley, Harlow, 234 stock market prediction. See inductive logics, competition Shogenji, Tomoji, 163 Shour, Robert, 93n14 The Structure of Empirical Knowledge Siderius nuncius — the Starry Messenger (BonJour), 145 (Galileo), 32 Stuiver, Minze, 291-92 simplicity, 37-44; curves, tides, and comets, Suess, Hans E., 291-92 40-42; failed hypothesis of, 304-5; principles sulfate of potassium and aluminum, 311 sulphur, 38; in Lavoisier's Elements, 300 of parsimony, 37-39; as surrogate, 39-40 Sirius, spectrum of light, 273 Sun, 41-42, 76, 258, 359; absolute diameter of, 343; Aristarchus on, 335-39; atom of, 38; Skeels, Patrick, 223 Skeptical Inquirer, 366 cloud of matter surrounding, 128; distances, skepticism, 93, 123, 136, 147-48; ancient 12, 76, 77, 263, 265–66, 331, 335–39, 341–42, tradition of, 181; assaults, 186; Hume's, 343, 344, 345, 346, 359-60; distances and 47, 185, 190, 213, 214; Popper, 196n10; sizes of, 333-35; Earth and, 32, 42-43, 76, Reichenbach, 196-97n10 77, 137-38, 253n22, 335-39, 341-42, 344, skeptics: of Avogadro's hypothesis, 312, 326; 358, 359; eclipse of, 340; electron neutrinos emitted by, 85; evidential circle, 333-35; critics, 13, 87; dowsing and, 121, 125, 367, 368, 382, 387; evidential case for, 121; gravitational force of, 38, 138; Hipparchus ideo-motor principle, 380, 381; instability on, 344n13, 346; inverse square law of in competition, 367; problem for, 380; attraction from, 265; Moon and, 109, 137, proponents and, 367; resistance by, 371-72; 333-39; parallax of, 341, 342; perigee of, self-refutation of, 101, 102 351, 353; planets and, 263, 264, 265-66, 267; Slipher, Vesto, 236 principal solar semidiurnal S2, 42; Ptolemy's Smithsonian Museum of Natural History, 234 Planetary Hypotheses, 348-53; relative snowflakes, illustrating regular shapes, 26-27 positions of, 137; sunrises, Hume on, 190-91; Sober, Elliott, 180, 212-15 sunrises, Laplace's, 45-46, 47, 48-50; Venus solar system, 136, 137-38, 344; distance and, 332, 342, 348-49, 354-55, 359

measurements, 77; inverse square law,

surrogate for background facts, simplicity as, 39–40
System of Logic (Mill), 181–82, 187, 188

technical analysis, inductive logic and: against, 402–5; multiple systems of, 390–92 telekinesis, as pseudoscience, 366 telepathy, as pseudoscience, 366 telescopes, 231n2, 331, 332, 341, 359 telescopic aids, improvement to celestial distance measures, 76 terrestrial bodies, 81, 258, 260, 261, 262, 263 terrestrial gravity and celestial centripeal forces, identity of, 67–68 Thagard, Paul, 152, 167 Theoretical Chemistry from the Standpoint

(Nernst), 327

The Theory of Probability (Reichenbach), 193

The Theory of Water Finding by the Divining

of Avogadro's Rule and Thermodynamics

The Theory of Water Finding by the Divining Rod: Its History, Method, Utility and Practice, 373

Thomson, J. Radford, 189, 190 Thomson, J.J., 127 Thomson, William, 42 Thorn, Paul, 218, 219 Thorpe, Edward, 312n9 tides, curves fitted, 40-42 Timaeus (Plato), 345 Times, letter by Faraday, June 30, 1853, 381 Tompkins, on water divination, 373 tower, hierarchical conception, as analogy to inductive inference, 62-63 transits, of Venus, 77, 332, 341-44, 358 Treatise (Hume), 183n3, 185 Trimble, Virgina, 234 truism of evidence, principle of indifference, Tutor (Moxon, A Tutor to Astronomy and

Tutor (Moxon, A Tutor to Astronomy and Geography, 1665), 353 two-dimensional model, on analogical

reasoning, 30–31
"Two Dogmas of Empiricism" (Quine), 3

Tychonic geocentric system, 137, 138

umbra, Earth's shadow, 337 unconceived alternatives, as limit to inductive inference, 133–34 underdetermination thesis, 120, 121, 122, 134–37 unidirectionality, respect of fails for relations inductive support, 64 uniformity assumptions, as grounding induction, 218 uniformity of nature, Mill's principle of, 21 uniqueness of domain-specific inductive logics. See domain-specific inductive logics, uniqueness of universal forces, defined, in Reichenbach's conventionality of geometry, 108 universal gravitation, Newton on, 81; elliptical orbits and, 263-65; inferences summarized, 260-63; inverse square law of gravity, 263-67; Moon test, 258-60; overview, 257-58. See also inverse square law of gravity, Newton's universal inductive rules, 6 universal logic of induction, 91 unstable inductive competition, 124-25 uranium ore residue, as source for Radium, 24 Uranus, role in discovery of Neptune, 128; and Kepler's third law, 361 Ursa Major, nebula cluster, 239n11

van Cleve, James, 200–201, 202–3 Van Helden, Albert, 339, 341, 351n19 vaulted ceilings, analogy to inductive inference, 69–72, 74; illustration, 71–72 vaulted inductive structure, 311–13 velocities: determinations, nebulae, 236–40; of recession, distance-dependent, 131, 132 velocity-distance relation, nebulae, 232, 233, 241f, 245, 246, 248

Venus: apogee of, 351; in Copernican system, 354, 355, 356f, 357f, 358–59; Earth and, 77, 341–42, 344, 350, 355; epicycle for, 349f, 354, 355, 358; fixing size of orbit of, 357f; Galileo on, 359; Mars and, 332; Moon and, 342, 359; motion of, 138n11; orbit of, 355; parallax of, 342; perigee of, 351; Ptolemy's construction for, 348, 349, 350, 351, 354, 359; relative distance, 345; Sun and, 332, 342, 348–49, 354–55, 359; transits of, 77, 332, 341–44, 358 vicious-circle principle, 102, 112

vicious circularity, 177, 197, 210; contradictions of, 161; idea, 100–103; in material theory of induction, 103–5

vindication of inductive inference, distributed, 86–87

Viola, Emanuele, 404 Virgo (nebula) Cluster, 239n11, 244, 246 Vulcan, posited as new planet, 128 warranting authority of Ritz's combination principle, 10

warranting facts, 15, 33, 93, 155, 209, 223, 257; applicable, 21, 178; deductive inferences, 19, 79; domains, 1, 19, 20, 168; elliptical orbits, 68; evidence and, 148, 149; Haüy's principle, 27, 28, 80; hypothesizing, 218; of inductive inference, 6, 19–20, 21, 33, 50, 60, 74, 79, 162, 176, 177, 178, 204, 218, 408; probabilistic analysis, 168; requirement, 214; Ritz's combination principle, 279, 283; skeptics, successes of, 368

warrant(s), 182; Curie's inference, 79–80; for deductive inferences, 19, 22; for enumerative induction, 196; generalizations, 280; hypothesis, 74, 218; in material theory of induction, 206; propositions, 1, 5, 8, 61, 91, 177, 214, 257–58; regresses of, 206; some-all inferences, 24

water, 300, 306; atomic weights and molecular formula, 11, 71, 109, 297, 301, 303–4, 305, 317; formation of, 307; hydrochloric and hydrobromic acids, 315

waves: character, 139; electromagnetic, 114, 374; in ether, 127; light, transverse character of, 140; mechanics, of quantum theory, 285; number, 275; packet, 149–50; radio, 114; sound, 140

wave theory: Elliot (stock market), 390n3; Lenard's ether (of electrons), 127; of light, corpuscular vs., 133 Weintraub, Ruth, 221–22 Whately, Richard, 105, 186–87 Wheeler, Gregory, 163 White, Harold, 87 Whitehead, Alfred North, 102 Williams, W. Carleton, 223 Wirtz, Carl Wilhelm, 235 Wolfram, Stephen, 93 wooden centering, analogy to hypotheses in inductive inference, 74–75 Worrall, John, 216–19, 220 Wylie, Alison, 290

yin-yang symbol, illustration of benign circularity, 111

Zabell, Sandy, 45n17, 185
Zermelo-Fraenkel system, set theory, 102, 112, 113
The Zetetic, 366

A must read for anyone who wonders about what makes science rational.

—HANS HALVORSON, Stuart Professor of Philosophy, Princeton University

Will be an essential touchstone for all future work on the logic of scientific reasoning.

—Marc Lange, Theda Perdue Distinguished Professor of Philosophy, University of North Carolina at Chapel Hill

The Large-Scale Structure of Inductive Inference investigates the relations of inductive support among the totality of facts comprising a science or science in general. These relations form a massively entangled, nonhierarchical structure, discovered by making hypotheses provisionally that are later supported by further inductive inferences. The result is a benignly circular, self-supporting inductive structure in which the classical Humean problem of induction cannot be formulated and analogous regress arguments fail.

The earlier volume, *The Material Theory of Induction*, proposed that individual inductive inferences are warranted not by universal rules but by facts particular to each context. This book now investigates how the totality of these inductive inferences interact in a mature science. Each fact that warrants an individual inductive inference is in turn supported inductively by other facts. Numerous case studies in the history of science support, and illustrate further, those claims. This is a novel, thoroughly researched, and sustained remedy to the enduring failures of formal approaches to inductive inference.

JOHN D. NORTON is a distinguished professor of history and philosophy of science at the University of Pittsburgh. He works in history and philosophy of physics and general philosophy of science.



