

A Bradford Book The MIT Press Cambridge, Massachusetts London, England

© 2008 Massachusetts Institute of Technology

All rights reserved. No part of this book may be reproduced in any form by any electronic or mechanical means (including photocopying, recording, or information storage and retrieval) without permission in writing from the publisher.

For information about special quantity discounts, please email special_sales@mitpress.mit.edu

This book was set in Stone Serif and Stone Sans on 3B2 by Asco Typesetters, Hong Kong. Printed and bound in the United States of America.

Library of Congress Cataloging-in-Publication Data

Emergence : contemporary readings in philosophy and science / edited by Mark A. Bedau and Paul Humphreys.

p. cm.

"A Bradford book."

Includes bibliographical references and (p.) index.

ISBN 978-0-262-02621-5 (hardcover : alk. paper) — ISBN 978-0-262-52475-9

(pbk. : alk. paper)

1. Emergence (Philosophy) 2. Science—Philosophy. I. Bedau, Mark. II. Humphreys, Paul.

Q175.32.E44E44 2007

501—dc22 2007000949

10 9 8 7 6 5 4 3 2 1

Aggregativity, 15, 100-108, 151n10 of physical domain, 14, 112, 341, 427, 428-Alexander's Dictum, 341, 436, 438, 440, 442 429, 442 Alexander, Samuel, 12-13, 19, 21, 23-26, 31-Causal fundamentalism, 159–162, 165 32, 81, 84–85, 88–90, 127–129, 139, 141, 144, Causal novelty of emergent phenomena. See Novelty of emergent phenomena, causal 149, 434-436. See also Alexander's Dictum Causal reductionism. See Reductionism, causal Autonomy, 128, 155, 159, 185n4, 340 epistemological, 182, 186n16 Causey, Robert, 25, 45-46, 56n44-n45 explanatory, 6, 160, 179, 181–182 Cellular automata, 157, 256-257, 301, 307, metaphysical/ontological, 6, 120, 157, 161, 312, 341. See also Chaos; Complexity; 183 Dynamical systems; Evolution, nonnomological, 129 biological (cellular automata); Game of life, of sciences, 348, 438 the; Irreducibility, computational and weak emergence, 157, 178-179, 181-184 and complexity, 17, 249, 252, 256, 278, 325 density problem in, 289, 294-295 Bain, Alexander, 19, 21, 23, 25, 29-30, 33, 41, and generation of dynamical hierarchies, 54-55, 81, 84 326-327 Bridge laws, 44-45, 133-136, 218, 339-340, and weak emergence, 164–165, 167, 171, 174, 366-369, 373, 396-400, 404, 406. See also 182-183, 184n1 Reductionism Chaos, 99, 231, 249, 252-257, 260-270, 301, British Emergentism, 14, 19-24, 26, 31, 33, 50-337, 342, 350, 375-376, 378, 380-381, 384-51, 52n7, 53n14, 57n47, 82 386. See also Cellular automata; Complexity; Broad, C. D., 16, 19-21, 23-25, 33-34, 36-51, Dynamical systems; Quantum mechanics; 52n2, 52n7, 53n7, 54n24, 54n27, 55n33-Unpredictability of emergent phenomena n35, 56n37-n38, 56n42, 66n6, 81, 85-93, in cellular automata, 174, 257, 270-271 127, 149, 342 in quantum mechanics, 378 Complexity, 13, 114, 120, 164, 179, 227, 249, Cartesian dualism. See Dualism, Cartesian 251-253, 279, 284, 305, 313-314, 325-327, Causal closure, 121. See also Epiphenome-329-330, 390, 434. See also Cellular nalism; Materialism; Physicalism; Reducautomata; Chaos; Computation theory; tionism; Reductivism Dynamical systems; Irreducibility, of mental realm, 427 computational; Systems theory

Complexity (cont.) of mental properties, 57n48, 112, 149, 159, 437 algorithmic, 164, 325 emergent, 148, 176-178, 185n18 computational, 16, 211-212, 299, 325, 342 reflexive, 145-148 emergence of, 256, 278, 280, 283 diachronic, 147-149 and evolution, 256-257, 283 synchronic, 149 and failure of reductionism, 213, 216 explanatory, 150 Kolmogorov, 275-276 in British emergentism, 21-23, 33, 38, 437 levels of, 20, 33, 41, 85, 139-140, 218, 222, in non-reductive physicalism, 112, 119-120, 251 438-440, 442 object, 313, 322, 324-330 difficulties, 23, 33, 38, 144-150, 152n5, organizational/organized, 5, 20, 22, 31-33, 157n48, 176-177, 185n13, 437-438, 440, 41, 49, 85, 87, 128, 251, 339 442 science of, 155-157, 161, 164, 183, 185n10, weak, 176-178, 186n16 186n15, 209, 211 argument, 14, 112, 120, 340-341 statistical, 278 in dynamical hierarchies, 219, 323, 341 theory, 12, 17, 337-338, 341 Dualism, 72-73, 112, 128, 134, 397, 427. See Complex systems. See Complexity also Mental causation; Mental realism; Mind-Computational complexity. See Complexity, body problem; Supervenience computational; see also Irreducibility, Cartesian, 32, 52n7, 87, 128, 427, 430, 442 computational property, 74, 430, 443 Computation theory, 276-278, 283, 387, Dynamical hierarchies, 307, 320, 326-327, 393n20. See also Complexity 330. See also Cellular automata; Chaos; Conceptual novelty. See Novelty of emergent Complexity; Downward causation; phenomena, conceptual Dynamical systems Consciousness, 4, 12, 14-15, 95, 134, 139, 338, in biological systems, 305 411, 413, 427. See also Irreducibility of and downward causation, 323, 341 consciousness; Mental causation; Mental emergent, 217-219, 309 realism; Mind-body problem; Qualia in molecular systems, 305-306, 311, 314 as causally emergent, 57n48, 69-70, 72, 143, Dynamical systems, 277, 297, 314, 323, 325-153n37, 159, 161, 183 326, 330. See also Cellular automata; Chaos; creation of, 131-132, 136 Complexity; Dynamical hierarchies and logical supervenience, 416 chaotic, 342, 379, 391 and token physicalism, 434 non-linear, 270 Dynamical systems theory. See Systems theory, Darwinian evolution. See Evolution, Darwinian dynamical

Davidson, Donald, 95-96, 191, 401, 420n1,

141-150, 155, 153n37, 159. See also

Mental causation; Mental realism;

and weak emergence, 143, 157, 161, 175-

Downward causation, 6, 51n3, 52n5, 129, 139,

Dynamical hierarchies; Epiphenomenalism;

437, 443n3, 443n6

Supervenience

178

Emergent evolution. *See* Evolution, emergent
Emergent laws, 4, 19–20, 31, 42–43, 47, 88,
128, 163, 174. *See also* Trans-ordinal laws
Emergent materialism. *See* Materialism,
emergent
Epiphenomenalism, 79, 111, 118, 129, 134,
141, 436. *See also* Mental causation; Mind-body problem; Supervenience

Epistemological autonomy. See Autonomy, epistemological

Evolution, 22, 162, 249, 278–279, 281–284, 307, 342. *See also* Cellular automata; Complexity; Dynamical hierarchies; Dynamical systems biological, 50, 184, 196, 231, 237, 264, 277, 279, 283, 305, 330, 386

and complexity, 32, 85, 252, 256–257, 283, 305

Darwinian, 32–33, 85, 280–281 of dynamical systems, 378, 383 emergent, 2, 33, 85, 95, 124n6, 143, 436 non-biological (cellular automata), 167, 233, 257, 295, 312, 314, 326, 387, 389–391

Exclusion argument, the, 111–112, 115, 120, 122, 123n1, 123n3, 124n4, 159. *See also* Causal closure; Epiphenomenalism; Mental causation

Explanatory autonomy. *See* Autonomy, explanatory

Explanatory reductionism. *See* Reductionism, explanatory

Feyerabend, Paul, 369–372 Fodor, Jerry A., 134, 182, 191, 201, 203n3, 203n5, 204n19, 218, 339–340, 429, 437, 443, 444n13

Fundamental laws, 45–46, 54n27, 93–94 of chemistry, 29 of physics, 165, 197, 221–222, 225–226 in special sciences, 22, 83

Game of Life, the, 184n1, 233, 256–257, 301, 312. *See also* Cellular automata; Complexity; Dynamical hierarchies; Evolution, non-biological (cellular automata) patterns in, 5, 166–175, 178, 180, 182–183,

196, 288, 292–293 General systems theory. *See* Systems theory,

Gollub, Jerry P., 382–384

general

Hare, R. M., 78–79, 95–96, 420n1, 422n10 Hellman, G., 420n1, 430–431, 444n5 Heteropathic effects, 26–31, 37–38, 82–85, 88. *See also* Emergent laws; Heteropathic laws; Homopathic effects; Homopathic laws

Heteropathic laws, 11, 25–29, 31, 83–84, 88. See also Emergent laws; Heteropathic effects; Homopathic effects; Homopathic laws Holism, 4, 10–11, 209, 249, 251 Homopathic effects, 26–27, 29, 54n19, 82, 84. See also Emergent laws; Heteropathic effects; Heteropathic laws; Homopathic laws Homopathic laws, 27–29, 82, 84, 127. See also Emergent laws; Heteropathic effects;

Intra-ordinal laws, 42, 46, 87. See also Transordinal laws

Heteropathic laws; Homopathic effects

Intrinsic emergence, 271–273, 278
Irreducibility, 3–4, 10–11, 15, 25, 209, 337–338, 429, 434, 441
computational, 16, 341–342, 387–389
of consciousness, 72, 74–78, 430–431
and weak emergence, 160, 164, 182–182, 185n6

Jackson, Frank, 73–74, 151n12, 420, 422n12, 423n14

Kim, Jaegwon, 12, 14, 51n3, 56n43, 57n49, 79, 81, 111–112, 115–116, 118, 124n9–n11, 159, 175–177, 214, 216, 340–341, 420n1, 422n10, 423n16

Kripke, Saul, 43, 56n44, 73, 90, 416-417

LePore, E., 431–433, 437, 444n11 Lewes, George Henry, 18n1, 19, 21, 23, 25–26, 30–32, 37, 51n2, 52n7, 54n23, 55n33, 56n41, 81, 84–85, 89–90, 130, 151 Loewer, Barry, 52, 57, 431–433, 437, 444n11

Materialism, 191, 397, 419–420, 423n17. *See also* Causal closure; Epiphenomenalism; Physicalism; Reductivism; Reductionism emergent, 52, 81, 89, 94

Materialism (cont.) non-reductive, 81, 128 (see also Physicalism, non-reductive) reductive, 81, 88-90, 94 (see also Physicalism, reductionism) Mayr, Ernst, 348, 352, 354 Mechanism (theory), 37, 39, 48, 50, 55n5, 56n37-n38, 57n46, 85-86, 88, 90, 140, 283. See also Physicalism; Reductionism comprehensive, 39-40, 46 pure, 38-39, 56n38, 85-86 Mental causation, 111, 430, 436-440. See also Consciousness; Downward causation; Epiphenomenalism; Mental realism; Mindbody problem; Reductionism Mental realism, 189-193, 201, 433, 436, 468 Metaphysical autonomy. See Autonomy, metaphysical/ontological Mill, John Stuart, 11, 16, 19, 21, 23–30, 32–33, 37, 41, 51n1, 53n11, 53n14-n18, 54n19, 54n21, 54n26, 54n26-n27, 54n29, 55n31, 55n33, 81-85, 93, 127, 130 Mind-body problem, 429, 437, 443n5, 70, 72, 420n1. See also Consciousness; Downward Causation; Mental causation; Mental realism;

Reductionism; Supervenience
Morgan, Lloyd, 12, 19, 21, 23–26, 31–33, 37–38, 41, 50, 55n33, 64, 81, 84–85, 95–96, 127–130, 139, 143–144, 146, 148–149, 151n11, 153n36, 434–437

Multiple realization, 134, 138, 182, 338–339, 431–432, 443, 443n5

Nagelian bridge laws. *See* Bridge laws Neovitalism. *See* Vitalism, neo-Nominal emergence, 158–160, 185n4 Nomological autonomy. *See* Autonomy, nomological

Non-obviousness of emergent phenomena, 301. *See also* Novelty of emergent phenomena; Underivability of emergent phenomena; Unexplainability of emergent phenomena; Unpredictability of emergent phenomena

Non-reductive materialism. *See* Materialism, non-reductive

Non-reductive physicalism. *See* Physicalism, non-reductive

Non-reductivism, 428–431. *See also*Materialism, non-reductive; Physicalism, non-reductive

Novelty of emergent phenomena, 4, 16, 66, 123, 124n10, 125n24, 130, 270–272, 282–283, 307, 330, 386. *See also* Non-obviousness of emergent phenomena; Underivability of emergent phenomena; Unexplainability of emergent phenomena; Unpredictability of emergent phenomena causal, 15 conceptual, 3, 10–11, 209, 339 ontological, 3, 11, 159

Objective reductionism. *See* Reductionism, objective

Ontological autonomy. *See* Autonomy, metaphysical/ontological

Ontological novelty of emergent phenomena. *See* Novelty of emergent phenomena, ontological

Ontological reduction. *See* Reductionism, ontological

Ontological reductionism. *See* Reductionism, ontological

Pattern formation, 270–273, 279–281
Physicalism, 74, 113, 121, 337–340, 420. *See also* Materialism; Reductionism; Reductivism non-reductive, 119, 429–438, 440–441, 442n3, 444n8 (*see also* Materialism, non-reductive) token, 397–398, 401–403, 434 type, 397–398, 402
Physical reductionism. *See* Reductionism, physical

Qualia, 14–15, 99, 111, 136, 139, 159. *See also* Consciousness, Epiphenomenalism, Mental causation, Mental realism

Quantum mechanics, 23–24, 49–50, 52n5–n6, 55n32, 57n46, 88, 209, 223–224, 264, 283–284, 351–352, 360, 376, 378. *See also* Chaos non-relativistic, 22–23, 55n32, 210, 259

Reductionism, 70-71, 74, 107-108, 176, 221-223, 249, 252, 260, 264-265, 337, 395. See also Bridge laws; Materialism; Nonreductivism; Physicalism; Reductivism; Special sciences, reduction to physical sciences; Supervenience causal, 71, 174-175, 444n11 compatibility with emergentism, 3, 99-101, 174–175, 184, 218, 251 explanatory, 349 and mental causation, 428, 430-431, 436, 438, 443 objective, 352-354 ontological, 70-75, 174 physical, 128, 134, 140, 152n25 theory, 348, 352 Reductive materialism. See Materialism, reductive

Reductivism, 395–403, 405–406. *See also* Bridge laws; Materialism; Non-reductivism; Physicalism; Reductionism; Special sciences, reduction to physical sciences; Supervenience

Segregation, 235–241, 246–247

Special sciences. *See also* Reductionism, theory in British emergentism, 19–22, 25, 27, 29, 38–39, 42–43, 51n2, 56n42, 83, 85–87, 333 reduction to physical sciences, 22, 27, 29, 35, 83, 85–87, 99, 128, 182, 184, 186n19, 218, 395–400, 403–408, 435

Sperry, Roger, 19, 50–51, 57, 127, 143–146, 148–149, 153, 159, 435, 437

Strong emergence, 15, 158–160, 176, 184n2, 185n6–n7

Supervenience, 3, 10, 14, 69, 81, 112, 115, 125n15, 125n17, 125n19, 153n35, 214, 337,

411, 420, 420n1, 421n2-n4, 422n13, 429,

441, 443n4. See also Consciousness; Downward causation; Irreducibility; Reductionism causal, 78-79 and downward causation, 115-118, 120-121, 159, 340-341 etiology of, 94-96 global, 412-413, 417, 419, 422n11, 431-432 local, 412-413, 417 logical/conceptual, 412-419, 422n9, 423n16n17 mereological, 130, 186n19 natural, 412-413, 415-417, 422n10-n11 and physics, 121–123 strong, 93-94, 118, 432 van Cleve definition, 90-91 Swinney, Harry L., 382–384 Systems theory. See also Dynamical systems dynamical, 155, 211, 278, 283, 342, 382 general, 211, 251-252, 258n5

Theory of everything, the, 210–211, 213, 250–263, 265

Theory reductionism. *See* Reductionism, theory

Thompson, F., 420n1, 430–431, 444n5

Token physicalism. *See* Physicalism, token

Trans-ordinal laws, 42–47, 56n39, 87–88, 93–94. *See also* Intra-ordinal laws
emergent, 43, 45–46, 88

Type physicalism. *See* Physicalism, type

Underivability of emergent phenomena, 160–170, 172, 216. *See also* Non-obviousness of emergent phenomena; Novelty of emergent phenomena; Unexplainability of emergent phenomena; Unpredictability of emergent phenomena

Unexplainability of emergent phenomena, 11, 64, 141, 209. *See also* Non-obviousness of emergent phenomena; Novelty of emergent phenomena; Underivability of emergent phenomena; Unpredictability of emergent phenomena

Unpredictability of emergent phenomena, 3, 10–11, 15–16, 55, 65–66, 131–132, 141, 210, 342. *See also* Non-obviousness of emergent phenomena; Novelty of emergent phenomena; Underivability of emergent phenomena; Unexplainability of emergent phenomena and chaos theory, 270, 376, 380

van Cleve, James, 56n38, 81, 90–95, 422. *See also* Supervenience, van Cleve definition Vitalism, 32, 47, 52n9 biological, 88, 249, 352, 434, 436 emergent, 47 neo-, 65, 127–128 substantial, 47

Weak emergence, 15–16, 155, 157, 159–164, 174–175, 177–184, 185n6–n7, 185n9, 186n16–n19, 250