

Index

- 21st Century Cures Act of 2016, US, 1
- 3 M Corporation
 HELP system, 438
- Abe, Shinzu, 219
- Abele, John, 334
- Accountable Care Organizations (ACOs), 431
- Adalimumab
 rheumatoid arthritis, 104, 107, 108, 110, 117
 adenosine deaminase deficiency (ADA), 105
- Adrenoleukodystrophy (ALD)
 gene therapy, 106
- Aetna, 459
- Africa, 263
- Agency for Science, Technology and Research
 (A*STAR)(Singapore), 222
- aging, population
 and healthcare, 74
- alliances
 benefits of, 167
 biotechnology and pharmaceutical companies, history,
 171
 challenges facing, 177
 collaborative, 167
 strategic, increasing value, 184
- Alzheimer's disease
 drug development, 111
 medical devices, 355
- Amazon, 77, 78, 316, 325, 394, 460, 475
 healthcare IT, 454
 medical devices, 393
- American Home Products, 138, 316
- American Medical Association, 28, 358, 424
- American Recovery and Reinvestment Act of 2009
 (ARRA) (US), 163, 431
- American Society of Gene & Cell Therapy, 123
- AML (acute myelogenous leukemia), 134
- Amsterdam, Netherlands, 207
- amyotrophic lateral sclerosis (ALS) (Lou Gehrig's disease),
 259
 drug development, 111
- Anderson, William French, 105
- anemia, 104
 biosimilars, 256
 EPO, epigen, 137
 treatments for, 105
- antisense and RNA interference (RNAi), 129
- Apple, 56, 394, 430, 460
 healthcare apps, 444
- Asia, 60, 148, 200, 216, 217, 219, 233, 236, 240, 252, 263,
 289, 290, 294
 healthcare IT market, 465
- Atlas Venture, 100, 154, 164
- Australia, 233, 235, 236
 Biomedical Translation Fund, 234
 biotechnology sector, overview, 233
 drug approval policies, 235
 Entrepreneur Visa Program, 234
 gene therapy, 105
 IPOs, 219
 Medical Research Future Fund, 234
 National Innovation and Science Agenda, 234
 SME Strategic Intervention, 236
- autoimmune disease, 104
 Humira, 108
- AVXS-101, 2
- Bakken, Earl, 334
- Bayh-Dole Act of 1980, 94
- Berlin, Germany, 212
- Berners-Lee, Tim, 316
- Bestbuy, 325
- beta-interferons, 104
- Bio-economy Action Plan
 India, 237
- biologics, follow-on (FOBs)
 insurance coverage, 259
- Biomedical Translation Fund (Australia), 234
- biopharmaceutical companies
 Amgen, 48, 95, 105, 136, 137, 163, 188, 199, 241, 258,
 316
 China, 230

- Amgen, biosimilars, 256
- Amgen, Neupogen, 257
- Amgen, Neupogen, Neulasta, 256
- Amgen, settlement with AbbVie, 258
- Biogen, 48, 89, 95, 104, 108, 144, 145, 163, 171, 199, 199, 241, 311, 316
 - location in Cambridge, MA, 316
- Celgene, 52, 124, 184, 185, 193, 226, 233, 233, 262
 - deal-making, 184
- Celgene, orphan diseases, 262
- Celgene, regenerative medicine, 254
- Centocor, 95, 108, 110, 138
- Centocor, Centoxin, 138
- Cetus, 95, 162
- Chiron, 95
- facilities/biopharmaceutical manufacturing, 54
- Genetics Institute, 95, 105, 108, 137, 137
- Gilead, 48
- Repligen, 95
- Vertex, 41, 48, 130, 186, 241
 - outsourcing, 55
- biopharmaceutical products
 - forms, 55
- biopharmaceutical sector
 - Japan, R&D, 220
 - value of deals, 2016, 95
- Biopolis (Singapore), 223
- biosimilars, 32, 55, 57, 178, 178, 238, 238, 246, 247, 247
 - approval, 247
 - Australia, 235
 - European Medicines Agency, 247
 - India, 237, 238
 - market in Asia, 217
 - regulatory process, 255
 - South Korea, 240
 - US regulation, 256
- Biosimilars Price Competition and Innovation Act of 2009, 57
- Biotechnology
 - antisense and RNA interference (RNAi), 131
 - beta-interferons, 104
 - cell therapy, 123
 - combinatorial chemistry, 130
 - CRISP/Cas9, 125, 127
 - gene editing, 125
 - gene therapy, 128
 - genetic engineering, 90
 - history of, 91
 - proteomics, 129
 - rational drug design (RDD), 130
 - research institutes and foundations, 113
 - single cell sequencing, 128
 - biotechnology companies
 - Abgenix, 117
 - Ablexis, 148
 - Actelion, 202, 213
 - Adimab, 117
 - Affymetrix, 122
 - Agios, 134, 185
 - Alkermes, 202, 251
 - value-based pricing, 251
 - Alnylam, 132, 133, 163, 250, 280
 - Onpattro, development, 250
 - Althea Technologies, 221
 - Ambit Biosciences, 221
 - Ambys Medicines, 187
 - Asterias Biotherapeutics, 253
 - AstraZeneca, 205, 280, 316
 - China, 230
 - Avidity Biosciences, 221
 - BASF, 108, 110
 - BeiGene, 226, 229, 231, 233, 290, 291
 - BFI Shenzhen, 122
 - Bharat Biotech, 239
 - Biomatics Capital, 113
 - Bluebird Bio, 124
 - Blueprint Medicines, 187
 - BTG, 202
 - business models, platform technology, 139
 - Cambridge Antibody Technology, 117
 - Collectis, 213
 - Celltech, 108
 - Chi-Med, 229
 - Clementia, 215
 - Constellation Pharmaceuticals, 135
 - CRISPR Therapeutics, 127, 186
 - CSL, 235
 - Denali, 155
 - Dyax, 117
 - Editas Medicines, 127, 186
 - Elan Corp., 104
 - EMD Serono, 104
 - Epizyme, 135
 - ES Cell International, 252
 - Galapagos, 213
 - Genentech, 89, 91, 92, 95, 139, 161, 171, 172, 189, 190, 190, 192, 199, 231, 245, 311
 - Roche, 190
 - Genovo, 106
 - GenSight, 213
 - Genzyme, 111, 163, 262, 311, 316
 - location in Cambridge, MA, 316
 - Geron Corporation, 253
 - Gilead, 48, 123, 124, 147, 188, 193, 339
 - Hoechst AG, 314
 - Horama, 213

- biotechnology companies (cont.)
 Horizon Pharma, 202
 Human Genome Sciences, 173
 Illumina, 122
 Imclone, 175, 177
 Immunex, 110, 163, 199
 ImmunoMet, 134
 Intellia Therapeutics, 127
 Ipsen, 195, 202, 214
 Jazz, 202, 382
 Juno Therapeutics, 124, 155, 186, 193
 Kite, 123, 124
 Kyn Therapeutics, 134
 Life Technologies, 122
 Lysogene, 213
 MediTech, 226
 MerLion, 223
 Monsanto, 314
 Nanjing Legend Biotech, 124, 226
 Neurocrine Biosciences, 174
 Novozymes, 202
 PvP Biologics, 221
 Qiagen, 202
 Resolvix, 162
 Rheos Medicines, 134
 S*BIO, 223
 Sangamo, 125, 125
 Shire Pharmaceuticals, 117, 193, 202
 merger with Takeda, 221
 orphan diseases, 262
 Sima, 132, 133
 Spark Therapeutics, 2, 107
 Spinifex, 235
 Strand Life Sciences, 238
 Tessa Therapeutics, 223
 The Medicines Company, 145, 146
 ThermoFisher Scientific, 122
 Zafgen, 148
 Zymeworks, 215
- biotechnology drugs
 number of, 101
- Biotechnology Industry Research Assistance Council (BIRAC)
 India, 237
- Biotechnology Promotion Law of 1983 (South Korea), 239
- biotechnology sector
 alliances, 167
 and academic institutions, 111
 and pharmaceutical sector, 99
 anemia, treatment, 105
 Asia, 99, 216
 Australia, 99, 233
 biologic checkpoint therapy, 101
 business models, FIPCO, 136, 137, 139, 148
 business models, NRDOs, 136, 145
 business models, overview, 135
 business models, pure technology platform model, 136
 business models, RIPCOs, 136, 143, 144, 148
 Cares Acceleration Network (CAN), 247
 Canada, 99
 financing/overview, 215
 capital markets, 149
 cell therapy, 101, 123
 China, 99
 overview, 224
 clinical trials, number of, 102, 111
 cost to bring a drug to market, 149
 definition of, 96
 drug pipeline, 112
 EU, Brexit effect on, 207
 economic clusters, 310, 312
 effect on drug pricing, 111
 employment, 111
 Europe, 99
 Europe, Bioeconomy Strategy and Action Plan, 204
 Europe, employment, 202
 Europe, Horizon 2020, 204
 Europe, investments, 202
 Europe, patents, 202
 Europe, sales and growth, 202
 financial performance, 97
 financing, 149
 financing, drug royalty monetization, 162
 financing, Euronext, 213
 financing, government grants, 163, 163
 Financing, PIPEs, 160
 financing, private placement, 158
 financing, R&D limited partnerships, 161
 financing, SBIR grants, 163
 financing, SWORD, 161
 financing, the public market, 156
 financing, venture capital (VC), 152
 France, financing, 213
 France, Inserm, 214
 France, overview, 212
 gene therapy, 101, 105, 128
 genome editing, 125
 genomics, 118
 Germany, 209
 Germany, BioRegions, BioParks, 210
 Germany, HTGF, venture capital, 212
 Germany, life sciences, 212
 global, 99
 government initiatives and growth, 201
 growth/structure, 200
 immuno-oncology therapy, 101
 impact on healthcare, 102
 impact on pharmaceutical sector, 112

- importance of time in success rate, 90
- increasing approval of new drugs, 182
- India, 99, 236
- innovation, overview, 112
- intellectual property, 92
- introduction to, 89
- investment in, 99
- Japan, 218
- Korea, government support, 240
- leadership, CEO, 197, 197
- licensing deals, 100
- mergers and acquisitions (M&A), value of deals, 100
- new discoveries, data, 90
- new venture creation, 303
- number of biologics and vaccines approved, 102
- number of drugs, 102
- organizational development, 306
- overview, 96
- patents, history/importance of, 92
- private philanthropy, 112
- regulation and policy, 241
- relationship with pharmaceutical sector, 166
- research and development, 99
- revenues, US, 101
- Singapore, overview, 222
- single gene sequencing, 128
- size, 99
- South Korea, general, 239
- startups, 25
- Therapeutic Discovery Tax Credit, 247
- therapeutics, 25
- UK data, 205
- US, 200
- venture capital, growth in, 154
- venture capitalists, 100
- virtual model, 147
- Bio-Vision 2016 (South Korea), 240
- Blair, Henry, 311
- blindness
 - drugs, 2
 - gene therapy, 106
 - Luxturna, 107
- Booth, Bruce
 - Atlas Venture, 164
- Boston Consulting Group, 314
- Boston Scientific, 355
 - cost of sales staff, 357
- Boston, Massachusetts, 23, 101, 154, 164, 194, 195, 317
 - early cluster formation, 316
 - economic clusters, 317
 - research hubs, 195
- Boyer, Herbert, 91, 311
 - Genentech, 192
- Brailer, David, 431
- Brazil
 - medical device sector, 354
- Brenner, Sydney, 222
- Brexit referendum, 207, 208, 287
 - effect on biotechnology sector, 207
 - UK, potential drawbacks, 208
- British Columbia, Canada, 216
- Broad Institute, 122, 125, 195
- business models, 307
 - platform companies, 308
 - product companies, 309
- California, 23, 92, 111
 - stem cell research, 252
 - biotech cluster, 314
- Cambridge, Massachusetts, 25, 108, 122, 127, 148, 277, 314, 316, 317, 318
 - Biogen, 144
 - biopharma venture capital funding, 317
 - Cambridge Innovation Center, 316
 - Kendall Square, 314, 318, 319, 320
 - research hubs, 195
- Cambridge Antibody Technologies (CAT), 108
- Canada, 72, 200, 215, 215, 216, 461, 463
 - biotechnology sector, 214
 - economic clusters, 318
 - healthcare IT, 463
 - R&D, 216
 - venture capital, 215
- cancer, 102, 105, 122, 123, 124, 127, 128, 129, 134, 223, 233, 283, 417
 - cancer metabolism, 134
 - drugs, prices, 178
 - Erbitux, 175
 - G-CSF, 137
 - Germany, therapies, 212
 - lymphoma, 106
 - melanoma, 103
 - multiple myeloma, 103
 - neurostim, 343
 - novel drugs, 250
 - Opdivo approval in UK, 207
 - population health management, 448
 - stomach, 220
 - Takeda Pharmaceuticals, 143
 - therapies, 187
 - TNF, cytokine, 108
- cardiovascular disease, 102
- Cares Acceleration Network (CAN), 247
 - research in China, 230

- Car-T, 2, 123, 124, 125, 183, 186, 193, 291
 Kymriah, 2, 123
 Yescarta, 123
- CAR-T therapy
 advanced multiple myeloma, 124
 Rosenberg group, 124
 T-cell receptor (TCR), 124
- cell therapy, 123
- Center for Biologics Evaluation and Research (CBER) (US), 245
- Center for Drug Evaluation and Research (CDER) (US), 245
- Center for Medicare and Medicaid Services (CMS) (US) reimbursement, 424
- Central Drugs Standard Control Organization (CDSCO) (India), 238
- Chakrabarty, Ananda, 92
- Chan, Priscilla, 164
- Charpentier, Emmanuelle, Dr.
 CRISPR/Cas9, 125
- chemotherapy, 103
- China, 1, 23, 148, 218, 222, 224, 226, 230, 231, 234, 238, 291, 318
 biotech investment, 229
 biotechnology growth plans, 216
 biotechnology sector, 224
 government and biotechnology, 201
 Health China 2030, 226
 ICH, 264
 innovation, 230
 life sciences research, 225
 medical device sector, 354
 medical devices, 335, 338
 National Drug Reimbursement List (NDRL), 231
 patents, 210
 regulatory system for IP, 217
- China, IPOS, 219
- chronic obstructive pulmonary disease (COPD), 64, 79, 178
 Nucala, 177
- clinical trials
 database, 52
- Cohen, Stanley, 92, 311
- Coleman, Alan, 252
- Colorado
 value-based pricing, 251
- combinatorial chemistry, 130
- congestive heart failure (CHF), 77, 329, 337, 345
 medical devices, 329
- contract administration fees (CAFs), 22
- Copenhagen, Denmark, 194
- Crick, Francis, 91
- CRISPR/Cas 9, 140
- Crohn's disease, 104, 110
- CVS, 280, 459
- cystic fibrosis, 102, 103, 186, 259
- de Silva, Ashanti
 gene therapy trial, 105
- Deloitte, 284
 pharmaceutical R&D productivity, 180
- Dementia
 population health management, 448
- Denmark
 economic clusters, 318
- Department of Agriculture (US), 242
- Department of Biotechnology (DBT) (India), 237
- Department of Defense, US, 163
- Department of Homeland Security (US), 163
- depression
 medical devices, 331
- diabetes
 glucose monitors, continuous, 325
 population health management, 448
 wearable patch pumps, 325
- diabetic macular edema
 Macugen, 174
- diagnosis-related groups (DRGs), 430
- disease models, 34
- DNA
 discovery of, 91
 rDNA, 91
- Doudna, Dr. Jennifer
 CRISPR/Cas9, 125
- drug approval
 international harmonization, 262
- drug approval testing
 phases of, 35
- drug formulary, 58
- drug prices
 rise in, 20
- drug pricing, 65
 value-based pricing, 250
- drugs
 Ablynx, 183
 Abraxane, 233
 Amjevita, 258
 Avonex, 199
 Biologic License Applications (BLAs), 180
 Bioverativ, 183
 Cialis, 373
 Eliquis, 77
 Enbrel, 199
 competition with, 178
 Erbixut, 175
 generics, 178, 179, 255
 Glybera
 LPLD, 212

- Harvoni, 339
 Herceptin, 104, 192
 Humira, 89, 102, 107, 111, 163, 178, 209, 258
 competition with, 178
 Ibrance
 pricing, 178
 Indiplon, insomnia, 174
 Lantus, 62
 Levemir, 62
 Levitra, 373
 Lipitor, 364
 Macugen, 174
 Neulasta, 256
 Neupogen, 137, 256, 257
 New Drug Applications (NDAs), 180
 Nucala, COPD, 177
 Onpatro, 250
 Opdivo, 207
 pricing, 178
 Remicade, 163, 178, 258
 competition with, 178
 Revlimid, 233
 Rituxin, 199
 Sovaldi, 339
 tPA, 190, 199, 245
 Tylenol, 373
 Viagra, 373
 Vidasa, 233
 volanesorsen, FCS, 177
 Zarxio (filgrastim-sndz), 257
 drugs, prescription
 spending, US, 249
- Eclipsys, 438
 economic clusters
 the Triple Helix, 313, 314
 Egypt
 medical devices, 338
 Electronic health records (EHRs), 431
 adoption of, 432
 Environmental Protection Agency (U.S.), 242
 epigenetics, 134, 135
 Epilepsy
 medical devices, 325, 331
 neurostim, 343
 Erythropoietin, 105
 Europe, 29, 61, 71, 99, 111, 112, 145, 167, 200, 202, 202,
 205, 207, 209, 210, 213, 214, 216, 218, 241, 265, 270,
 286, 299
 drug regulation, 262
 EMA, drug approval, 265
 German biotechnology sector, 209
 governments and biotechnology, 202
 healthcare IT market, 465
 ICH, 263
 medical device regulation, 390
 medical devices, 335
 patents, 210
 European Commission, 265
 drug regulation laws, 267
 EMA, 266
 Horizon 2020, 204
 ICH, 263
 marketing authorization, 211
 European Economic Area (EEA), 208
 European Federation of Pharmaceutical Industries'
 Associations (EFPIA)
 ICH, 263
 European Medicines Agency (EMA), 207, 247
 biosimilar approval, 256
- Fabry's disease, 259, 262
 Feldman, Mark
 University of Oxford, 108
 Film, 80
 financial companies/firms
 Celtic, Royalty Pharma, 162
 financing companies
 500 Startups, 218
 BioScience Manager Fund, 235
 Brandon Capital Partners, 235
 Hanmi Ventures, 240
 Medical Research Commercialization Fund, 235, 235
 One Ventures Capital, 235
 Sofinnova, 213
 Flagship Pioneering, 100
 follow-on biologics (FOBs). *See* biosimilars
 Food and Drug Administration (FDA) (US), 53, 57, 58,
 104, 106, 117, 123, 124, 128, 133, 135, 138, 152, 171,
 175, 177, 177, 180, 182, 219, 223, 240, 242, 243, 244,
 245, 247, 249, 250, 253, 255, 256, 257, 260, 260, 271,
 299, 321, 331, 388, 389, 390, 391, 408
 biologics, 255
 biosimilar approval, 256
 CBER, CDER, 245
 Chinese drugs, 230
 clinical testing, 423
 drug approval, compared to Japan, 220, 271
 drugs approved, 134
 expedited approval pathways, 177
 generic approval process, 179, 255
 ICH, 263
 Medical Device Act, 326
 medical device regulation, 387, 388, 389, 391
 medical devices, Unique Device Identification
 Database, 408
 NeoTract, 404
 new drugs approved, 197

- Food and Drug Administration (FDA) (US) (cont.)
 novel biologic drugs, 247
 orphan diseases, 259
 orphan drug research, 260
 PDUFA, 242
 Recombinant DNA Advisory Committee, 128
 reduced drug approval time, 243
 regulation of biotechnology, 242
 regulatory approval, 423
 Reveal LINQ™ ICM System, 415
 Right to Try Bill, 249
 risk evaluation and mitigation, 244
 Sentinel Initiative, 244
 stem cell research, 253
 timeliness and safety concerns, 243
- Fortune 500 companies, 22
- Fragile X syndrome, 259
- France, 23, 72, 205, 207, 212, 213, 214
 biotechnology sector, 212
 financing, 214
 gene therapy, 105, 106
 Genomic Medicine 2025, 214
 patents, 210
- G7 countries
 drug distribution, 75
- Gates Foundation, 113, 164
- Gates, Bill, 164
- Gaucher's disease, 103, 259
 Cerezyme, 111
- Gelsinger, Jesse
 clinical study, 105
- gene therapy, 128
 AVXS-101, 2
 blindness, 106
 CAR-T, 106
 Leber's congenital amaurosis, 106
 Parkinson's disease, 106
 SCID ("bubble boy" disease), 106
- General Electric (GE), 40, 92
- Genetic testing companies
 12 and Me, 122
 CRIGenetics, 122
 Family Tree DNA, 122
 Living DNA, 122
- genome editing, 125
- Genome Institute, Singapore, 252
- genome-wide association (GWA), 121
- genomics, 118
 alliances between biotechnology and pharmaceutical
 companies, 172
 cost, 121
 Human Genome Project, 118
- George Washington University, 438
- German Research Foundation, 210
- Germany, 72, 205, 207, 209, 211, 212, 213, 214
 Arzneimittelmarkt-Neuordnungsgesetz (AMNOG),
 212
 BioParks, 210
 BioRegions, 210
 biotechnology sector, 209
 biotechnology sector investment, 202
 biotechnology sector, statistics, 210
 government and biotechnology, 201
 life sciences, 212
 medical devices, 333
- Germany, High-Tech Gründerfonds (HTGF), 212
- Gilbert, Walter, 311
 Biogen, 144
- GKV, German health insurance, 210
 reimbursement, 211
- Golub Todd,
 Foundation Medicine, 122
- Google, 316, 460
 medical devices, Verily, 394
- group purchasing organizations (GPOs), 22
- Harvard, 300, 311, 314, 318, 319
- HCV, 79
- healthcare apps, 445
- Health Information Technology for Economic and
 Clinical Health (HITECH) Act (US), 431
- Health Insurance Portability and Accountability Act
 (HIPAA), 431
- healthcare
 and population aging, 74
 information technology (IT), 429
- healthcare reform
 impact on medical device sector, 391
 PPACA, 392
 US, 246
 pharma and biotech expansion, 246
- healthcare sectors
 similarities and differences, 4
- healthcare spending
 biggest categories, 18
- healthcare spending, US
 data, 70
- healthcare, US
 market size, 418
- hepatitis, 64, 102, 103, 144
- hepatitis B, 102, 104, 144
- hepatitis C, 104, 339
- hereditary edema
 ecallantide, 117
- Heywood, Ben, 446
- Heywood, James, 446
- Heywood, Stephen, 446

- HIMSS Analytics, 432
 HIV, 12, 102, 104
 Horizon 2020, 204, 208, 286
 Human Genome Project, 118
 India, 238
 Humira (Adalimumab), 107
 Huntington's disease, 259
 hypertension, 12, 417
 Hyundai, 240
- Iceland, 208
 Independent Payment Advisory Board (IPAB), 248
 India, 148, 236, 238, 239, 241, 294, 461, 463, 476
 Bio-economy Action Plan, 237
 biosimilars, 238
 Biotechnology Industry Research Assistance Council, 237
 biotechnology sector, 236
 Central Drugs Standard Control Organization (CDSCO), 238
 Department of Biotechnology (DBT), 237
 government and biotechnology, 201
 healthcare IT, 463
 healthcare sector, 237
 ICH, 264
 IPOs, 219
 medical device sector, 354
 medical devices, 338
 regulatory process, 238
 regulatory system for IP, 217
 Review Committee on Genetic Manipulation, 238
 Indianapolis, Indiana, 194
 inflammatory bowel disease, 134
 infliximab
 rheumatoid arthritis, 108
 influenza, 102
 information technology (IT), healthcare
 apps, 445
 business models, 467
 Canada, 463
 challenges facing, 455
 consumers, 442
 CPOE, 438
 EHR, ancillary systems, 437
 electronic health records (EHR), usability issues, 457
 future growth, 434
 future of, 468
 health information exchange (HIE), 447
 India, 463
 international adoption, 461
 Internet of Things (IoT), 450
 market growth, 465
 mHealth, 444
 multistakeholder, 446
 overview, 429
 payers, 440
 population health management, 448
 practice and revenue cycle management, 439
 providers, 435
 role of computers in history of, 430
 Saas, 453
 Singapore, 464
 Taiwan, 464
 telehealth, 449
 United Kingdom, 461
 value-based care, 458
 virtual communities, 445
- Innovation
 “effective innovation agenda”, 2
 antisense and Antisense and RNA interference (RNAi), 131
 benefits versus affordability, 2
 biotechnology sector, 91
 cell therapy, bone marrow transplanatation, blood transfusion, 123
 cell therapy, limitations, side effects, 124, 125
 China, 230
 combinatorial chemistry, 130
 commonalities across sectors, 7
 cost of first drug approval, 135
 cost to bring a drug to market, 149
 Crispr/Cas9, 125
 cross-selling, 413
 estimation of impact over time, 10
 financing, 398
 gene therapy, 128
 genome editing, 125
 genomics, 118
 in the healthcare value chain, 2
 innovation gap, 179
 in-house versus acquired or in-licensed, 79
 medical device sector, 358
 monoclonal antibodies (MAbs), 114
 next generation DNA sequencing, 120
 personalized medicine, 120
 pharmaceutical companies adjusting operating models, 196
 pharmaceutical vs biotechnology sector, 182
 proteomics, 129
 public-private partnerships, 112
 rational drug design (RDD), 130
 role of geographic clusters, 317
 single cell sequencing, 128
 Thiel Foundation Breakout Labs, 113
 Institute for Human Gene Therapy
 University of Pennsylvania School of Medicine, 106
 Institute for Protein Innovation, 113
 insulin, 79

- Integrated circuit (IC) industry, 56
 Intermountain Health Care, 438
 International Conference on Harmonization of Technical Requirements for Registration of Pharmaceuticals for Human Use (ICH), 262
 Internet of Things (IoT), 450
 Investment companies
 bpifrance, 213
 iBionext, 213
 i-LAB, 213
 IPOs, 9, 155, 164, 387
 Australia, 235
 European biotechnology sector, 202
 India, 238
 Japan, life sciences, 219
 life science investors, 149
 medical device sector, 383, 386, 426
 South Korea, 240
 Italy, 72, 207
 medical devices, 334

 Japan, 72, 218, 218, 221, 221, 236, 241, 265, 269, 271, 301
 Agency for Medical Research and Development (AMED), 220
 biotechnology sector, overview, 218
 biotechnology, Cool Japan Fud (CJF), 218
 Central Social Insurance Medical Council (Chuikyo), 219
 compared to Australia, 235
 drug approval, 269
 drug price reductions, 178
 drug regulation, 262
 ICH, 263
 medical devices, 333
 Ministry of Health, Labor, and Welfare (MHLW), 219
 National Cancer Center, 220
 orphan diseases, 260
 patents, 210
 Pharmaceutical and Food Safety Bureau, 270
 PMDA, 271
 Prescription Drug and User Fee Act (PDUFA), 219
 stem cell research, 252, 253
 Strategy of Sakigate, innovation, 219
 Japanese Pharmaceutical Manufacturers' Association (JPMA)
 IPH, 263
 Johnson & Johnson, 134, 139, 178, 194, 285, 291, 316, 328, 342
 JLABS, 194
 medical device trauma products, 328
 biosimilars, 256
 Orthoclone OKT3, transplant rejection, 114
 Johnson, Lyndon
 Medicare, 429

 Kamen, Bob, 89, 108
 Kobe, Japan, 221
 Köhler, Georges
 MAbs, 114
 Korea, 237, 239, 294, 294
 biotech financing, 240
 biotechnology growth plans, 216
 government and biotechnology, 201
 IPOs, 219
 patents, 210
 stem cell research, 252
 Korean Biotechnology Industry Organization, 239
 Kymriah, 2
 Kyoto University, 220

 Lander, Eric
 Broad Institute, 195
 Foundation Medicine, 122
 Lawrence Ellison Foundation on Aging, 114
 Leber's congenital amaurosis
 gene therapy, 106
 Leibniz Association, 210
 leucopenia, 103
 Levin, Mark
 Millennium, 89
 Millennium, Third Rock Ventures, 143
 Liechtenstein, 208
 Life sciences industry, 24
 Life Sciences Sector Deal, U.K., 208
 Liu, Edison, 252
 London, U.K., 207, 334
 Lou Gehrig's Foundation, 114
 lupus, 134
 Luxturna, 2, 107, 277

 MAbs, TNF, 108
 Macau, 233
 Macular degeneration
 Macugen, 174
 Massachusetts, 314, 317
 biotechnology growth strategy, statistics, 111
 Department of Economic Development, 316
 value-based pricing, 250
 Massachusetts Biotechnology Council, 195
 Massachusetts Institute of Technology (MIT), 446
 Materials sciences
 medical devices, 377
 Max Planck Institute, 125
 Max Planck Society, 210
 McKesson, 440
 Medical device companies
 Abbott, 324, 343, 348, 367, 382, 384
 Abiomed, 341, 346, 369, 371
 Alere, 384

- American Medical Systems, 380
 AtriTech, Inc., 413
 Auris Surgical Robotics, 341
 Bard, 413
 Baxter, 316, 331
 Becton Dickinson, 324, 331, 356, 384, 413
 Biomet, 331, 368, 369, 382, 413
 Biotronik, 334, 375
 Boston Scientific, 331, 343, 356, 367, 369, 375, 380, 381, 384, 413
 C.R. Bard, 356
 CareFusion, 413
 CoreValve, Inc., 413
 Covidien, 356, 382, 384, 385, 413
 Cyberonics, 334
 Danaher, 331
 Dentsply Sirona, 334
 Dexcom, 342, 394
 Edwards Lifesciences, 340, 346, 356, 369, 390, 413
 Entellus, 385
 Fresenius, 333
 Google, 342
 Guidant, 380, 384
 Howmedica, 380
 Intuitive Surgical, 331, 339, 341, 342, 345, 356, 369, 371
 Johnson & Johnson, 324, 331, 341, 342, 348, 356, 368, 380, 394
 profits, 359
 international sales, 354
 venture financing, 386
 Lazarus Effect, 386
 Livanova, 334, 343
 LMA, 405
 MAKO Surgical, 341, 385, 414
 Mazor, 342
 Medina, 386
 Medrobotics, 341
 Medtronic, 324, 331, 333, 334, 335, 342, 343, 348, 353, 367, 375, 379, 380, 382, 383, 384, 385, 413, 415, 416, 417
 bundling, 417
 cardiovascular devices, 415
 Micra™ Transcatheter Pacing System (TPS), 416
 profits, 359
 Reveal LINQ™ ICM System, 415
 Medtronic, Deep Miniaturization program, 415
 Medtronic, device pricing, 353
 Medtronic, international sales, 354
 Medtronic, M&A, 384, 385
 Medtronic, venture financing, 386
 Medtronic/Covidien, 356
 Merit Medical Systems, 386
 NeoTract, Inc., 404
 Neuropace, 343
 Nevro, 343
 Novocure, 343
 Orthotaxy, 342
 Percutaneous Valve Technologies, Inc., 413
 Philips, 316
 PhysioControl, 385
 production and operating expenses, 369
 relationship between growth and size, 348
 Restore Surgical, 385
 Sage, 385
 selling expenses, 369
 Shiley, 380
 Small Bone Innovations, 385
 Smith & Nephew, 333
 Sorin, 334
 St. Jude Medical, 382, 384
 Straumann Holdings, 334
 Stryker, 324, 328, 331, 341, 369, 414
 acquisition of MAKO Surgical, 384, 385, 414
 Synthes, 328
 Teleflex, Inc., 403
 Terumo, 333
 TransEnterix, 341, 342
 Vascular Solutions, 404, 405
 Vidacare, 405
 Visualase, 385
 Zimmer, 328, 331, 369, 380, 384, 413
 Zimmer/Biomet, 368, 382
 Medical device sector, 25
 acquisitions and product value, 403
 AdvaMed, 335
 Brazil, 354
 cardiovascular, 327
 cardiovascular, structural heart devices, 329
 China, 354
 compared to other sectors, 324, 359
 consolidation, 381
 consumers, customers, and payers, 359
 corporate structural changes, 356
 Department of Justice investigation, 323
 drug/device convergence, 378
 geographic use, 336
 government regulation, 407
 growth drivers, 350
 growth over time, 345
 healthcare reform, 391
 history, 325
 India, 354
 innovation, 358
 innovation and growth, 398
 innovation ecosystem, 410
 intellectual property protection, 419
 international, 332
 key drivers of acquisitions, 405

- Medical device sector (cont.)
 large commercial state companies, 412
 M&A, 382, 383
 management teams, 421
 market size, 327
 marketing and selling strategies, 366
 materials science, 376
 Medical Device Innovation Consortium (MDIC), 391
 NEST, 391
 orthopedics, 327
 overview, 321
 patients, providers, and payers, 407
 physician education, 368
 pricing, 399
 product development, 421
 profits, compared to pharmaceutical sector, 371
 recent slowdown, 339
 reimbursement, 423
 Research and development (R&D), 347, 356
 revenues, 322
 worldwide, 324
 role of investors, 409
 Russia, 354
 segment reshuffling, 355
 size of, 418
 small companies, 411
 statistics, 349
 technologies, 373
 venture capital, 417, 419
- Medical devices
 “Infuse” spine cage, 379
 Apple Watch, 394
 cardiac pumps, 341
 cardiovascular support devices, 330
 continuous glucose monitoring devices (CGM), 339, 343
 coronary bypass graft surgery (CABG), 345
 da Vinci Surgical System, 341
 deep brain stimulation (DBS), 343
 defibrillators, 324, 325, 334, 337, 339, 344, 345, 366, 367, 369, 371, 374, 388
 diabetes, CGM, insulin pumps, 342, 347
 diagnostic equipment, 324
 drug-eluting stents (DES), 329
 ear nose and throat (ENT), 346
 epilepsy, 325
 extremities, 328
Guardian Connect, 343
 heart valve replacement, 325
 hip and knee replacements, 324
 hip implants, 368
 hospital supplies, 324
 implantable defibrillators, 322, 327, 335, 337, 363, 375, 393
 insulin pumps, 364
 interventional cardiology, 352
 Libre CGM, 343
 neuro and robotic surgeries, 331
 neurological diseases, 343
 Neurostim, 343, 346
 pacemakers, 324, 334, 335, 337, 353, 354, 365, 366, 367, 369, 370, 371, 374, 375
 patch pumps, wearable, 325
 percutaneous structural heart interventions, 340
 respiratory, 346
 robotic surgery, 341
 sacral nerve stimulation (SNM), 343
 SAPIEN, 390
 spending, 18
 spinal, 328
 spinal cord stimulation (SCS), 343
 stents, 325, 339
 transcatheter aortic valve replacements (TAVR), 339, 346
 transcatheter heart valve, 329, 330, 335, 364
 UroLift System, 404
 vascular surgery, 351
 Watchman, 355, 413
 wire mesh stents, 322
- Medical Research Future Fund (Australia), 234
 Medicare (U.S.)
 healthcare IT, 429
 Medicare Access and CHIP Reauthorization Act of 2015 (MACRA), 431
 Medicines and Healthcare Products Regulatory Agency (MHRA)
 U.K., 207
- Medtech sector
 startups, 26
- Melbourne, Australia, 234
- Mergers and acquisitions (M&A)
 as strategy, 6
 biotechnology sector, 100
 life sciences, number and value over time, 188
 medical device companies, 383
 medical device sector, 382, 403, 427
 pharmaceutical-biotechnology company relationships, 188
- Mice, transgenic, 117
- Michigan
 value-based pricing, 251
- Middle East, 241, 263
 medical devices, 335
- Milstein, Cesar
 MAbs, 114
- Ministry of Health, Labor and Welfare (MHLW)
 ICH, 263
- MIT, 299, 311, 314, 316, 318
- Molecular diagnostic companies
 Foundation Medicine, 122, 123

- Moll, Frederic*, 341
 monoclonal antibodies (MAb), 91, 92, 102, 104, 108, 110, 114, 117, 140
 European Medicines Agency, 247
 U.S. CDER, 245
 Montreal, Quebec, Canada, 216
 Moore's Law, 32
 multiple sclerosis, 103, 104, 145, 308
- National Cancer Institute, 124, 252
 National Health Service (NHS), U.K., 206, 461, 462, 476
 healthcare IT, 461
 National Innovation and Science Agenda (Australia), 234
 National Institute for Health and Medical Research (Inserm) (France), 214
 National Public Radio (NPR), 195
 neutropenia
 treatment, 256
 New venture creation
 financing, 310
 New York, 23, 194, 396, 473
 stem cell research, 252
 economic clusters, 318
 NICE, U.K., 72, 87, 178, 206
 drug approval process, 206
 Nicholas, Peter, 334
 National Institutes of Health (NIH) (US), 1, 6, 52, 94, 99, 105, 112, 118, 128, 152, 163, 200, 220, 253, 254, 276, 282, 317
 Health Consensus Group, 443
 economic clusters, 317
 stem cell research, 252, 253
 Norway, 208
 Notified Bodies and Ethics Commissions
 EU, 408
 Novartis, 2
 nth compound problem, 51
- Obama, Barack, 246, 253, 254, 323
 healthcare reform, 391
 stem cell research, 252
 Open Payments Act (Sunshine Act), 16
 Orange Book, 255
 Ornithine transcarbamylase (OTC) deficiency, 105
 orphan diseases
 and healthcare reform, 246
 Orphan Drug Law, 259
 small biotech companies, 260
 Osaka, Japan, 221
 Outsourcing, 55
 healthcare IT, 453, 454
 Oxford, UK, 194
 Oyler, John
 BeiGene, 231
 Parker Institute for Cancer Immunotherapy, 164
 Parker, Sean, 164
 Parkinson's disease
 drug development, 111
 gene therapy, 106
 medical devices, 326, 331
 neurostim, 343
 Patent Office Board of Appeals (U.S.), 92
 Patents
 earnings lost due to expirations, 178
 Patient Protection and Affordable Care Act (PPACA) (U.S.), 246, 431
 Patient-Centered Outcomes Research Institute (PCORI), 248
 Payers
 contrast between US and Western European systems, 61
 influence on product selection, 61
 personal health records (PHRs), 443
 personalized medicine, 121, 123, 214
 Germany, 212
 Peter Bent Brigham Hospital, 438
 Pharmaceutical companies
 Abbott Laboratories, 110, 316, 384
 AbbVie, 102, 178, 258, 316, 325
 adjusting operating models to foster innovation, 196
 Agius Pharmaceuticals, 134
 Alexion, 195
 Astellas, 221
 Astellas, regenerative medicine, 254
 Aventis, 23
 Azur Pharma PLC, 382
 Bayer, 173, 221, 373
 CoLaborator, 194
 Boehringer Ingelheim, 220
 Bristol-Myers Squibb, 41, 147, 175, 178, 207, 380
 Dr. Reddy's Laboratories, 238
 Eli Lilly, 171, 177, 220, 226, 373
 Eyetech Pharmaceuticals, 174
 GSK, 134, 177, 325
 Hanmi Pharmaceuticals, 240
 Ionis Pharmaceuticals, 133, 177
 Ipsen Pharmaceuticals, 195
 Istesso Pharma, 134
 Johnson & Johnson, 57, 105, 226, 373
 Kite Pharmaceuticals, 124, 193
 Knoll Pharmaceuticals, 108, 110
 Lilly, 325
 Lupin Ltd., 238
 Merck, 52, 97, 132, 133, 144, 175, 189, 226, 291, 325
 Millennium, 141, 142, 143, 173
 Novartis, 2, 23, 123, 124, 133, 180, 196, 316, 325
 Novo Nordisk, 62, 194

- Pharmaceutical companies (cont.)
 Otsuka, 221
 Abilify MyCite, 445
 Pfizer, 52, 97, 134, 174, 178, 179, 189, 316, 364, 373, 380
 Centers for Therapeutic Innovation, 194
 China, 230
 Ventures, 196
 regenerative medicine, 254
 Roche, 41, 122, 123, 133, 139, 172, 187, 189, 190, 190,
 192, 199
 Genentech, 190
 Sanofi, 23, 62, 183, 183, 196, 214, 262
 Sanofi Sunrise, 196
 Sanofi Ventures, 196
 Schering Plough, 144, 171
 SmithKline French, 173
 Takeda Pharmaceuticals, 141, 143, 183, 187, 193, 221,
 221, 262
 merger with Shire, 221
 platform technology, 141
 Valeant, 382
- Pharmaceutical consumption
 data, 31
- Pharmaceutical companies
 Eli Lilly, 380
- Pharmaceutical Research and Manufacturers of America
 (PhRMA)
 ICH, 263
- Pharmaceutical sector, 31
 alliances, 167
 biotechification, 193
 declining origination of new drugs, 182
 drugs acquired from biotechnology companies, 112
 relationship with biotechnology sector, 166
 research and development (R&D), 31
- Pharmaceuticals
 distribution of, 75
 Millennium Pharmaceuticals, 173
- pharmacies
 retail versus online, 77
- Pharmaceutical consumption
 data, US, 70
- Pharmacy benefit manager (PBM), 20, 22, 62, 64
- Philadelphia, Pennsylvania, 23, 106, 194
- physicians
 role in pharmaceutical sales, 58
- Population health management, 448
- Porter, Michael, 24, 312
- Prescription drugs
 access to, 70
- PricewaterhouseCoopers, 390
 medical technologies innovation scorecard, 24
- Producer sectors, 4
- producers, healthcare products
 importance of, 15
 Project BioShield, 163
 Prospective Payment System (PPS), 11, 430
 Proteus Digital Health
 Abilify MyCite, 445
 psoriasis, 103, 110
- QALY, 71, 72, 250
 value-based pricing, 251
- Rational drug design (RDD), 130
 rDNA, 91, 95, 96, 100, 104, 114, 137,
 142, 173
- Reed, John
 Sanofi, 183
- renal disease, 102, 103, 137
- Research and development (R&D)
 and organizational behaviors, 48
 definition, 6
 failure rate, 37
 financing, 161, 162
 funding for, 6
 growing investment versus productivity, 179
 in-house versus acquired or in-licensed, 41
 in-licensed drugs, 311
 input costs, 37
 investment statistics, 179
 investments in biopharmaceutical sector, 4
 medical device industry, 347
 nth compound problem, 51
 orphan diseases, 260
 patents, 40
 pharmaceutical sector, 31
 seed investing, 304
 spending increase over time, 34
- Research institutes
 Broad, 195
 Koch, 195
 Whitehead, 195
- Review Committee on Genetic Manipulation (RCGM)
 (India), 238
- rheumatoid arthritis, 102, 103, 108, 110, 134
 adalimumab, 110
 etanercept, 110
 Humira, 108
 infliximab, 110
 treatment costs, 111
- Richter, Melinda
 Johnson & Johnson, 194
- Right to Try Bill (U.S.), 248
- Rosenberg, Dr. Steven
 adoptive cell transfer (ACT), 124
- Russia, 337
 medical device sector, 354

- Samsung, 56, 240
 healthcare apps, 444
- San Diego, California, 23, 194, 221
 Japanese pharmaceutical companies, 221
- San Francisco, California, 91, 101, 148, 194, 282, 476
 economic clusters, 317
- Saroukas, Costa
 Takeda, 183
- SCID (“bubble boy” disease)
 gene therapy, 106
- Science and Technology Diplomatic Circle, 318
- seed investing, 304
- Shanghai, China, 194, 290
- Sharp, Phillip, 311, 316
 Biogen, 144
- Shepherd Center, Atlanta, 253
- sickle cell disease, 186
- Singapore, 217, 222, 223, 290, 461, 464, 477
 Agency for Science, Technology and Research (A*STAR), 222
 Biopolis, 223
 biotechnology growth plans, 216
 Genome Institute, 252
 government and biotechnology, 201
 healthcare IT, 464
 life sciences hub, 224
 R&D growth, 222
 SingHealth Investigational Medicine Unit, 223
 stem cell research, 252
- Singapore Clinical Research Institute, 223
- SingHealth Investigational Medicine Unit (Singapore), 223
- single gene sequencing, 128
- SME Strategic Intervention
 Australia, 236
- Smith, Benson
 Teleflex, 405
- South America, 241, 263
- South Korea
 Biotechnology Promotion Law of 1983, 239
 biotechnology sector, 239
 Bio-Vision 2016, 240
 government support for biotech, 240
 innovation, 240
- South Korea Food and Drug Administration (KFDA), 240
- Spain, 207
 medical devices, 337
- spinal muscular atrophy, 2, 103, 106, 133
- Spinraza (nusinersen)
 spinal muscular atrophy, 133
- Springer, Timothy
 Institute for Protein Innovation, 113
- Stanford University, 92
- Starr, Kevin
 Millennium and Third Rock Ventures, 89, 143
- stem cell research, 194, 251
 Asia, 252
 California, New York, funding, 252
 NIH support, 253
 US policy, 254
- Stott, Kevin
 Novartis, R&D productivity, 180
- strategy, 45–47
- Swanson, Robert A., 92
 Genentech, 192
- Switzerland, 108, 127, 205, 205, 209, 213
 biotechnology sector investment, 202
 medical devices, 333
- Taiwan, 216, 233, 461, 464, 477
 healthcare IT, 464
- Tax Cuts and Jobs Act, US, 188, 248, 260
- TCR cell therapies, 186
- technological imperative, 6, 10
 benefits of new technology, 12
 government efforts to control costs, 11
- technology clusters, 23
- technology companies
 Adobe, 324
 Alphabet, medical devices, 393
 Apple, 324
 Apple, medical devices, 393
 Hewlett-Packard, 324, 325
 IBM, 324, 325, 343
 Intel, 56, 324, 325
- technology sectors
 economic impact of, 23
- Telehealth, 449
- Tepper, Bob
 Millennium and Third Rock Ventures, 89, 143
- The Chan-Zuckerberg BioHub, 164
- The Cystic Fibrosis Foundation, 114
- The Fraunhofer-Gesellschaft, 210
- The Helmholtz Association, 210
- the Netherlands
 economic clusters, 318
- The Thousand Talents Plan (China)
- Therapeutic Discovery Tax Credit, US, 247
- Thiel Foundation Breakout Labs, 113
- Third Rock Ventures, 89, 100, 143, 154
- Thirteenth Five-Year Plan (China), 1
- Thomas, Dr. E. Donnell
 first bone marrow transplantation, 123
- Toronto, Ontario, Canada, 194, 216
- Tufts University, 149, 311
- Twelfth Five-Year Plan (China), 1

- United Kingdom, 72, 178, 205, 205, 206, 207, 208, 212, 213, 214, 216
 biotechnology VC investment, 202
 gene therapy, 105
 healthcare IT, 461
 patents, 210
 United States–Korea Free Trade Agreement, 240
 Ubl, Steve
 Advamed, 390
 United States Supreme Court, 92
 UnitedHealthcare, 459
 University of California, 125
 University of California, San Francisco, 92
 University of Indiana, 438
 University of Oxford, 108
 University of Pennsylvania, 106
 gene therapy, 106
 University of Pennsylvania School of Medicine, 106
- value chain, 1, 2, 15, 16, 22, 23, 24, 31, 32, 33, 79, 80, 81
 biotechnology and pharmaceutical company relationship, 167
 biotechnology business models, 136
 medical devices, 364
 venture creation, 307
- value-based care
 healthcare IT, 458
- value-based pricing (VBP), 251
- Venture capital (VC), 152
 Alaska Permanent Fund, 155
 medical technology, 417
- Venture capital firms
 Third Rock Ventures, 143
- Venture capital funds
 American Research and Development Corporation, 316
- Venture creation
 biotechnology sector, 303
 organizational development, 306
- Vincent, James
 Biogen, 144
- Vitravene (formivirsen)
 antisense, 133
- Walmart, 325
- Wang, Xiaodoing
 BeiGene, 231
- Wanless, Derek, 461
- Watson, James, 91
- Welch, Jack
 General Electric, 40
- Worcester, Massachusetts
 biotechnology research and manufacturing, 108
- World Health Organization (WHO), 34, 262
 ATC classification scheme, 40
- Yamanaka, Shinya, 253
- Zhang, Feng, Dr.
 CRISP/CAS9, 125
- Zhangjiang Hi-Tech Park, 318
- Zika, 239
- Zillmer, Chris
 Medtronic, 415
- Zuckerberg, Mark, 164