

Index

- achromatic adjustment, 94
- actin filaments, 8, 19
- actors, 178
- adaptive scaling, 89
- adversarial attacks, 191
- afterimages, 84, 88
- Alexa, 162, 170, 175
- algorithms, 155, 164, 170, 176, 188, 191
- ALMA (Atacama Large Millimeter/
sub-millimeter Array) Observatory,
140–142
- Amazon Go, 160, 182
- Amazon Echo, 161
- ambiguity, 40–42, 44, 67, 79, 186
- amphetamines, 54
- Anaximander, 111, 119–120
- anti-competitive behaviour, 176
- Aristarchus, 111, 119–120, 122
- arrow of time, 126–127
- arthropods, 9
- artificial general intelligence (AGI),
170
- artificial intelligence, 118, 170, 180, *see also*
machine learning
- Ashby, Ross, 37–38
- asteroids, 147
- astronomy, *see also* telescopes
 - ancient cultures, 131
 - electromagnetic spectrum, 132
 - gravitational-wave observation,
148–149
 - multi-messenger, 149
 - neutrinos, 150–152
 - time-domain, 146–148
- Athena (Advanced Telescope for High
ENergy Astrophysics), 145–146
- atmosphere
 - exoplanets, 138–139
 - light refraction, 136
- autonomous vehicles, 181, 185–186,
192–193
- avatars, sentient, 172–178
- axons, nerves, 7
- Ayers Rock, 69, 71
- bacteria, 11
- Bayesian probability, 75, 114
- Berners-Lee, Tim, 167
- big data, 155, 166, 169, 187–189, 192
- biological clock, 10, 81
- birds, eyes, 6
- Bitonti, Francis, 176
- black holes, 120–121, 144, 146, 148
- blind spot, 7
- blockchain, 167
- blue, 64, 66
- blue bias, 99
- Bogdanov, Alexander, 118
- Bonnet, Charles, 50
- border control, 161
- brain
 - evolution, 21, 26
 - model of world, 55, 115
 - neuroprostheses, 163
 - prediction hierarchies, 46–47, 115–116
- brain scans, 184
- Brin, Sergey, 177
- buildings, sensors, 162–163

Blake , Carolin Crawford , Paul Fletcher , Sophie Hackford , Anya Hurlbert , Dan-Eric Nilsson , Ca

Index

[More Information](#)

Index

- camera systems, motion capture, 182
- camera-type eyes, 6, 9
- cars, 158–159, 181, 185–186, 192–193
- cartels, 176
- cephalopod eyes, 7–8, 17
- CERN, 124
- Charles Bonnet syndrome, 48, 50–52
- chemoreception, 11
- Chevreul, Michel Eugène, 84–85
- chip architectures, 168
- chitons, 9
- chlorophyll, 69
- chromatic adaptation, 87–89
- chromaticity, 79, 81, 83, 92, 94, 99
- cilia, 7–8, 19–20
- clams, 7, 9, 28
- classification, 188
- colour
 - as physical property, 79–80
 - #thedress, 76–80
 - emotions, 63–64, 99–100
 - French academicians, 18th/19th
 - century, 60
 - meaning, 65–66
 - memory colours, 89
 - object identification, 60–61, 65
 - perception, 64–68, 74–80, 83–85
 - spatial context, 85–86, 89
 - colour circles, 84, 89
 - colour constancy, 68–72, 75, 79–80, 86–87, 91–99
 - common sense, 117
 - compound eyes, 6, 9, 22, 24–25
 - computer vision
 - challenges, 190–193
 - development to date, 180–181
 - principles, 185–190
 - computers
 - architecture developments, 168
 - world as, 154, 156, 164
 - Conant, R. C., 38
 - cones, 7, 80–83, 85, 87–89
 - Constable, John, 57, 100
 - contrast, 86, 100
 - Copernicus, Nicolaus, 107–108, 119–120, 122
 - cornea, 7
 - cosmic rays, 149–150
 - Crick, Francis, 109
 - crustaceans, 6, 9
 - cup eyes, 7, 15, 21
 - cybernetics, 37–38, 47, 118
 - dark ages (Universe), 143
 - dark energy, 132, 147
 - dark matter, 132
 - Darwin, Charles, 109
 - data
 - criterion for science, 114
 - ownership, 167, 176–177
 - patterns and compression, 117–118
 - quality, 168
 - storage, 168–169
 - data capture
 - machine-learning technologies, 155–156
 - management, 169
 - data ethics, 166, 177–178
 - data replication, 163
 - day/night sensing, 10, 17–18, 81
 - daylight, spectral characteristics, 91, 98–99
 - de Finetti, Bruno, 114
 - deep networks, 181, 189–190
 - Delacroix, Eugène, 60
 - diffraction, 135
 - digital online personalities, 173
 - Dirac, Paul, 112
 - DNA, 109, 169
 - Doctorow, Cory, 155
 - doomsday clock, personal, 165
 - dopamine, 54
 - #thedress, 76–80, 99
 - driving, 166, 185–186, 192–193
 - drones, 157–158
 - drugs, hallucinations, 54
 - Dunstanborough Castle illusion, 89
 - dye, 84
 - Eggers, Dave, 162
 - Einstein, Albert, 110–111
 - electric potential, 125

Blake , Carolin Crawford , Paul Fletcher , Sophie Hackford , Anya Hurlbert , Dan-Eric Nilsson , Ca

Index

[More Information](#)

Index

- electromagnetism, 125
- embryo, eye development, 5
- emotions
 - artificial intelligence detection, 162–163, 183–184
 - avatars, 177
 - colour, 63–64, 99–100
 - human recognition, 53
- entropy, 126
- event horizon, 144
- Event Horizon Telescope (EHT), 120–121, 144
- event horizons, 144
- evolution
 - brain, 21, 26
 - Darwin's theory, 109
 - future of humans, 170
 - science as natural process, 117–118
- evolution of eyes
 - colour vision, 80–83, 91
 - high resolution, 26–28
 - independent occurrences, 8, 19
 - lenses, 24–25
 - low-resolution, 22–24
 - opsins, 12, 22
 - photoreceptors, 10, 15, 18–20
 - spatial resolution, 20–21
 - stages still in existence today, 5
 - summary, 28–29
- exoplanets, 138–139
- expectations, 36
- Expressionism, 86
- Extremely Large Telescope (ELT), 134
- eyes. *see also* photoreceptors, *see also* evolution of eyes
 - camera-type, 6, 9
 - chemoreception, 11
 - compound, 6, 9, 22, 24–25
 - cup, 7, 15, 21, 24–25
 - diversity, 5–10
 - embryonic development, 5
 - high resolution, 26–28
 - largest, 26
 - low-resolution, 22–24
- Facebook, 168, 177
- faces, surrogate, 171
- facial recognition, 159–161, 183, 189, 192
- fake data, 164
- fake lives, 173
- Faraday, Michael, 109
- fields (physics), 109, 125
- filter bubbles, 177
- fish, 6–7
- flash-back episodes, 52
- Fletcher, Paul, 115
- fossils, 26–27
- Franklin, Rosalind, 109, 119
- fungi, 11
- galaxies, evolution, 134–135, 137
- Galileo, 131
- gamma-ray light, 149, 151
- gauge theories, 125–126
- geometry, 111
- Get Lauren, 171
- Giant Magellan Telescope (GMT), 133
- Goethe, Johann Wolfgang von, 64, 84, 89–91
- good regulator theorem, 38
- Google
 - Clips, 162
 - Talk to Books, 173
- Google Transparency Report, 177
- G-protein-coupled receptor proteins (GPCRs), 10–11
- graphics processor unit (GPU), 190
- gravitational microlensing, 138
- gravitational-wave observation, 148–149
- gravity, 107, 124–125
- hallucinations, *see also* illusions
 - Charles Bonnet syndrome, 48, 50–52
 - definition, 33–34
 - drugs, 54
 - perception, 49–50
 - prediction hierarchies, 48
 - range of types, 33
 - sensory deprivation, 51

Blake , Carolin Crawford , Paul Fletcher , Sophie Hackford , Anya Hurlbert , Dan-Eric Nilsson , Ca
Index[More Information](#)

Index

- Harris, Moses, 84
- healthcare, *see also* medical diagnostics
 avatars, 175
 sensors, 163, 165
- Heda, Willem Claesz., 63
- Hering, Ewald, 79, 83–84, 89
- Herschel, William, 132
- hierarchies in prediction, 46–50, 115–116
- Hinton, Geoffrey, 185
- Hipparchus, 111, 120
- holes, 146
- Homeostat, 37–38
- Homer (cartoon character), 44
- Horn, Berthold, 181, 188
- Hubble Space Telescope (HST), 136
- human body motion capture, 182–183
- humans
 colour vision, 80
 eyes, 5, 17
- hydrogen, 143
- Hyper-Reality, 167
- IceCube Observatory, 151–152
- illumination discrimination task,
 96–99
- illumination spectrum, 70–71, 87, 94
- illusions, *see also* hallucinations
 afterimages, 84
 ambiguity, 187
 #thedress, 76–80, 99
 Dunstanborough Castle, 89
 lilac chaser, 66–67
 Mach card, 74–75
 perspective, 42
 reality as, 35–36
- ImageNet challenge, 181, 189–190
- image-processing, optimisation, 188
- images
 as scientific inspiration, 110
 metaphor usage in science, 107
- imagination, 39
- immortality, digital, 177
- inference, perception as, 38–42, 49
- infrared light, 132, 136–137
- Ingres, Jean-Auguste-Dominique, 60
- insect eyes, 5–6, 9, 22
- intelligence borrowing, 174
- interferometry, 140–144
- interoception, 39
- interstellar gas, 142–143
- inverse optics, 72–73, 75
- jellyfish, 7, 9, 17, 20, 22–23
- Jung, Carl, 64
- JWST (James Webb Space Telescope),
 136–140
- Kelly, Kevin, 158, 174, 177
- kilonova, 149
- Kinect, 182, 189
- knowledge
 science as extension of vision, 117
 use in inference perception, 40–42, 49
- Kuhn, Thomas, 114
- Kurzweil, Ray, 177
- Land, Edwin, 92
- language analysis, 190
- Large Synoptic Survey Telescope (LSST),
 147–148
- law of requisite variety, 37–38
- learning
 common sense and science, 117
 movement and perspective, 120
- legislation
 personal privacy, 168
 robots, 176
- lenses (eye), 7, 15, 24–25
- Leonardo da Vinci, 59–60
- Leslie, Charles Robert, 57
- Li Fei-Fei, 180
- light
 colour constancy, 69–70, 87, 95–96
 colour perception, 79
 dilution by distance, 133
 discovery of infrared, 132
- light sensitivity
 chemoreception, 11
 day/night sensing, 12, 17–18, 81
 evolution of vitamin A, 5–7, 12

Blake , Carolin Crawford , Paul Fletcher , Sophie Hackford , Anya Hurlbert , Dan-Eric Nilsson , Ca
Index[More Information](#)

Index

- lenses, 25
- non-directional, 10, 12–13
- light waves, 110
- LIGO (Laser Interferometer
Gravitational-Wave Observatory),
148
- lilac chaser illusion, 66–67
- LISA (Laser Interferometer Space
Antenna), 148–149
- lizards, 6, 9
- Lord of the Rings*, 182
- love, 175
- LSD, 54
- luminosity, 135, 146
- LUVOIR (Large UV Optical Infrared
Surveyor), 138
- Mach card, 74–75
- machine ‘mirrorworld’, 154
- machine behaviour, 172
- machine intelligence
 - new reality, 172
 - sentience, 154
- machine learning
 - data capture, 155–156
 - deep networks, 189–190
 - drones, 158
 - few-shot learning, 191–192
 - learning by example, 187–189
 - probabilistic mechanisms, 186–187
- machine vision, *see* computer vision
- magnetic fields, 109
- Manet, Édouard, 166
- Markov random fields, 187
- Matsuda, Keichii, 167
- McCann, John, 92
- McCarthy, John, 180
- McCarthy, Lauren, 171
- median eyes, 7
- medical diagnostics, 163, 183–185, 192
- melatonin, 10–11
- melatonin receptors, 11–12
- membranes, photoreceptors, 19
- memory colours, 89
- metaphysics, 127
- microscopes, 120–121
- Microsoft, 187
- microtubules, 8, 19
- microvilli, 8, 19–20
- Milky Way, 142–143
- Minority Report*, 160, 165
- Minsky, Marvin, 180
- Miquela, Lil, 173
- mirror eyes, 7
- models, perception as, 38, 53
- Mohr, Catharine, 165
- Mondrian, Piet, 86–87
- Mondrian stimuli, 91–94
- Monet, Claude, 69, 89, 94
- Moore’s Law, 168
- Mountcastle, Vernon B., 38, 43
- movement
 - directional photoreceptors, 18–19
 - perspective, 120
 - predation, 26–27
- movie recommendations, 192
- Mukherjee, Siddhartha, 162, 165
- music, 178
- National Gallery experiment, 96
- neurons, 44, 65
- neuroprostheses, 163
- neuroscience, cybernetics, 37–38
- neurotransmitter systems, 54–55
- neutrino astronomy, 150–152
- neutron stars, 148–149
- Newman, Ted, 112–113
- Newton, Isaac, 81, 84, 107–108, 119
- NGRST (Nancy Grace Roman Space
Telescope), 137–138
- nowcasting, 164
- nudging behaviours, 166
- Oamuamua, 147
- object identification, 60–61, 65, 119–120,
186, 188–189, 191
- ocelli, 9
- Onychophora, 23
- opsins, 10–12, 22
- orbits, 107

Blake , Carolin Crawford , Paul Fletcher , Sophie Hackford , Anya Hurlbert , Dan-Eric Nilsson , Ca

Index

[More Information](#)

Index

- Orwell, George, 161
Owen, Wilfred, 52
- Paglen, Trevor, 166
palette, adherence to, 187
Papert, Seymour, 180
parietal eyes, 6, 9
particle physics, 123–125
patterns, data compression, 117–118
Peirce, Charles Sanders, 40
Penrose, Roger, 112–113
perception
 artificial intelligence, 170
 as active process, 35–38
 as 'controlled hallucination', 33, 35
 as inference, 38–42, 49
 colour, 64–68, 74–80, 83–85
personal finances, 175
perspective
 illusions, 42–43
 object identification, 119–120
 relative equivalence, 122–123, 127–128
 scientific discovery role, 118–119, 122–123
photons
 photon noise, 18
 shortage, 25–26
 telescope size, 133, 135
photoreceptors
 adaptation mechanism, 17
 camera metaphor, 21
 ciliary and rhabdomic, 7–9, 19–20
 directional, 7, 14–21
 evolution, 10, 15, 18–20
 opsins, 10–11
 photon noise, 18
phototaxis, 13, 17
physics
 perspective, 122–123, 127
 visualisations, 113
Pierre Auger Telescope, 150
pigment
 chlorophyll, 69
 colour, 64
 dark shielding, 13
 visual, 7
planetary system formation, 140–141
Pointillism, 86
Pokemon Go, 166
police surveillance, 158, 161, 177
Popper, Karl, 114
post-traumatic stress disorder (PTSD),
 52–53
Pound, Ezra, 171
predation, 26–27
prediction
 criterion for science, 114
 in vision, 36, 43–49, 54–55, 115–116
 perspective, 120, 122
prediction error, 46–47, 49, 54
predictive coding, 44
predictive processing framework, 118
Price, Huw, 167
prisoner's cinema, 51
privacy rules, 168
probabilistic mechanisms, 186–187
protein signalling, 10
protists, 11
proto-planetary discs, 140
psilocybin, 54
psychosis, 52–53
quantum computing, 168
quantum field theory, 123–125
quantum gravity, 111, 119
quantum mechanics, 126–127
radiology, 184
Ramsey, Frank, 114
reality
 as 'controlled hallucination', 33, 35
 perspective relations, 127–128
 scientific view, 117, 128
 visual system, 36
recombination, 143
red, 57, 64, 66, 100
redshift, 135, 146
reionisation, 143
Renoir, Pierre-Auguste, 94
retina, 7, 10, 46
rhabdoms, 8

Blake , Carolin Crawford , Paul Fletcher , Sophie Hackford , Anya Hurlbert , Dan-Eric Nilsson , Ca

Index

[More Information](#)**Index**

- rhodopsin, 10
- Roberts, L. G., 180
- robots, 171, 181
- rods, 7–8
- Roomba vacuum cleaner, 159
- Rosling, Hans, 170
- safety-critical technology, 192–193
- Sassoferrato, 66
- satellites, 156–157
- scallops, 5, 7, 9
- schizophrenia, 54
- science
 - discovery and images, 110
 - image metaphors usage, 107
 - process similarity to vision, 107, 116–118, 128–129, 187
 - theories, prediction and data, 114
- sea urchins, 9
- searching, speed and colour, 63
- sensation, 39–40, 44
- Sensetime, 160
- sensors, ubiquity of, 156
- sensory deprivation, 36, 51
- sentience
 - avatars, 172–178
 - machine intelligence, 154
- shape
 - algorithms, 181
 - object identification, 60–61
- Simpsons, The*, 44
- size constancy, 69
- SKA (Square Kilometre Array) telescope, 142–143
- sleep
 - melatonin, 11
- sleep, melatonin, 10
- snails, 6, 9
- social credit scores, 166
- Solar System, 107–108, 119–120, 122
- solitary confinement, 51
- space travel, 175
- spacetime, 111, 113
- spatial coherence, 187
- spectroscopy, 138–139
- spiders, 6, 9
- spin network, 111
- sponges, 12, 20
- squid, 26
- star formation, 135, 139–140, 142–143, 145–146
- starfish, 7, 9, 22–23
- starlight, twinkling, 136
- superintelligence, 170
- supernovae, 147–148, 151
- surveillance, 156–158, 160–161, 177
- systems theory, 118
- tactile receptors, 17
- Taine, Hippolyte, 33, 35, 115
- telescopes
 - angular resolution, 135, 141
 - aperture, 133
 - cosmic-ray detection, 149–150
 - Galileo, 131
 - interferometry, 140–144
 - large-aperture, 133–136
 - space, 136–140, 145
 - time-domain, 146–148
 - X-ray, 144–146
- televisions, 45–46
- theories, scientific, 114
- Thirty Meter Telescope (TMT), 133
- time machines, 164–165, 169
- time, arrow of, 126–127
- time-domain astronomy, 146–148
- Transit Exoplanet Survey Satellite (TESS), 138
- trauma, 52–53
- tumour identification, 184, 192
- Turkle, Sherry, 177
- Turner, J. M. W., 57–59, 64, 81, 88–91, 99–100
- ultraviolet light, 11
- Uluru, 69, 71
- Unruh effect, 124
- vacuum cleaner, 159
- van Gogh, Vincent, 84

Blake , Carolin Crawford , Paul Fletcher , Sophie Hackford , Anya Hurlbert , Dan-Eric Nilsson , Ca

Index

[More Information](#)

Index

- velocity, 123
- Vermeer, Johannes, 73
- vertebrates, 5, 22
- Vicon, 182
- virtual data, 166
- vision, *see also* eyes, *see also* perception
- vision, process overview, 114–116
- visions, *see* hallucinations
- vitamin A, 11–12
- Vold, Karina, 167
- von Helmholtz, Hermann, 39–40, 68, 70
- Watson, James, 109, 119
- Weiner, Norbert, 37–38
- white, 94–95
- Woebot, 175
- worms, 6, 9, 17, 21, 23–24, 28
- X-ray astronomy, 144–146
- X-ray vision, 159
- YouTube, 164–165
- Zuboff, Shoshana, 159