

## Subject Index

### A

academic freedom, 4, 6, 7, 135, 212  
 accident, 21, 32, 69, 93, 115, 139, 141, 177, 178, 204  
*also see:* chance  
 accuracy, 17, 18, 20, 25, 27, 29, 45, 102, 103, 113,  
 114, 120, 122, 137, 146, 148, 175  
 compared to precision, 20, 103  
 definition of, 17  
 quantitative, 148-151  
 scientific value, 146, 148, 151  
 algebra, 7  
 analogy, *see:* comparison  
 anthropology, 98, 126, 136, 137  
 applied research, *see:* science - applied  
 astronomy, 1, 4, 6, 10, 44, 45, 68, 90, 98-101, 122,  
 151, 157, 188, 194, 208, 212  
 axiom, 4, 13

### B

basic research, *see:* science - basic  
 bias, 5, 17-20, 25, 34, 35, 50, 51, 91, 114, 116, 118-  
 120, 125-127, 129, 131, 136-143, 148, 164, 165,  
 207  
 removal via randomization, 19, 42, 67, 118  
 biology, 60, 90, 98, 139, 149, 151, 177, 178, 209  
 brain, 51, 132, 133, 142, 176, 177, 204

### C

calibration, 18, 114  
 standard, 102, 112, 118, 121  
 career, 165, 186, 189, 195, 199, 200, 206, 210, 211  
 causality, 7, 13, 43, 60-64, 68, 89, 90, 94, 118, 129,  
 136, 146, 157  
 definitions of, 60-64  
 determining cause and effect, 42, 60-67, 70, 89,  
 120  
 scientific, 62-64  
 chance, 16, 19, 20, 21, 26, 30, 38, 41, 45, 46, 57, 72,  
 84, 97, 100, 101, 108, 114, 136, 140, 147, 159,  
 161, 171, 172, 178, 196, 206  
*also see:* accident  
 change  
 artificial variation, 119  
 detection of, 13, 15, 37, 65, 69, 139  
 scientific, 1, 3, 6, 8, 9, 11, 161, 163, 164  
*also see:* experiment – changes to  
 chemistry, 9, 45, 151, 166, 206

classification, 4, 43, 45, 55, 84, 99  
 classification statement, 75-82  
 definition of, 44  
 lumpers and splitters, 45  
 us/them, 183  
 comparison, 43, 44, 61, 62, 115, 148  
 analogy, 43, 44, 131, 132, 137, 156, 163, 167, 174  
 symmetry, 31, 32, 43, 80  
 competition, 194  
 competitive strategies, 203, 204  
 cooperation and, 202-204  
 industrial, 190  
 computers, 15, 34, 102, 116, 121, 122, 173, 205  
 backups, 115  
 information handling, 123  
 software proficiency, 121, 198  
 troubleshooting, 104, 105  
 concept, 12, 13, 136  
 concept map, 153-155  
 confidentiality, 190, 207  
 confirmation and refutation, 13, 94, 147, 150, 159,  
 160  
 confirmation bias, 209, 138, 140, 142, 145  
 conventionalism, 160  
 definition of, 13, 20  
 diagnostic experiment, 111, 123, 158, 159, 212  
 falsificationism, 14, 156-158, 161  
 justificationism, 156-158  
 of hypotheses, 42, 146-148, 156-159, 164  
 power of evidence, 46, 67, 68, 76, 147, 150, 157,  
 159, 161  
 techniques of, 152  
 correlation, 43, 46, 55, 58, 60, 67-70, 119, 165  
 causality and, 60, 65-70  
 coincidence, 45, 46  
 confidence levels for, 57  
 correlation coefficient (R), 55-60  
 rank correlation coefficient, 55, 59  
 creativity, *see:* insight  
 curiosity, 8, 9, 198

### D

data, 12  
 accuracy, *see:* accuracy  
 collection of, 136, 161, 162, 169  
 definition of, 13  
 handling, *see:* computers - information handling  
 interpretation of, 140-142  
 recording, 114, 119, 123

reduction, 116  
 rejection of, 121, 138, 140, 164  
 deduction: Chapter 4  
   formal, 74, 75  
   scientific, 71, 74  
   square of opposition, 80, 81  
   substitution, 77, 79  
   Venn diagrams, 76, 78, 81  
   *also see*: classification, fallacy, syllogism  
 dependent variable, 46, 112, 139  
   definition of, 117  
 deviation, 55, 56  
 discovery, 17, 46, 139, 157, 162, 169, 173, 178, 179  
   *also see*: insight

## E

economics, 55, 63, 96  
 education, scientific, 1, 186, 192  
 empiricism, *see*: experiment  
 equation, 6, 150  
 equipment, *see*: instruments  
 error, 17, 55, 179  
   checking, 16  
   definition of, 16  
   experimental design and, 18, 29  
   mistake, 16, 17, 20, 71, 72, 86, 88, 102, 138, 139, 144, 151  
   random, 17-19, 22, 23, 28, 36, 56, 118, 122  
   statistics and, 25-30, 32, 56  
   systematic, *see*: bias  
   value of, 16  
 ethics, 32, 93, 201, 205, 206  
 evidence, evaluation of: Chapter 7  
 evolution, biological, 14, 17, 60, 62, 99, 133, 149, 157, 163, 170, 172, 186, 187, 200, 203, 204, 208, 209  
 experiment, 12-14, 16-18, 20, 64, 83, 99, 117  
   changes to, 37, 98, 100, 102, 105, 112-116, 118  
   control group, 66, 118, 140  
   control of variables, *see*: variable – control of  
   definition of, 97  
   diagnostic, *see*: confirmation and refutation – diagnostic experiment  
   observation process, 131  
   pilot, 102-104  
   pitfalls, 98, 117, 137-141, 178  
   planning, 16, 65, 72, 97, 98, 101, 113, 138  
   replication, *see*: replication  
   seizing an opportunity, 101  
   troubleshooting, 104, 105, 109, 117

experimental design, 16, 18, 46, 64-66, 70, 79, 98, 100, 110-118, 121, 138-142, 148, 159, 160  
   pitfalls, 137, 138  
 experimental science, *see*: science - experimental  
 experimental techniques: Chapter 5  
 explanation, scientific, *see*: causality, classification, comparison, concept, correlation  
 exploration, 9, 14, 105, 109  
 extrapolation, 18, 19, 51, 53-55, 60, 95, 96

## F

facts, *see*: data  
 fallacy, 42, 44, 77, 82, 87, 91-96, 134, 156  
 falsifiability, *see*: confirmation and refutation - falsifiability  
 fraud, 206  
 freedom, *see*: academic freedom  
 funding, *see*: science - funding

## G

generalization, 4, 5, 13, 18, 20, 43, 45, 46, 73, 74, 87, 94-96, 127, 134, 136, 147, 156  
 genetics, 20  
 genius, *see*: intelligence  
 geography, 4, 96  
 geology, 99, 101, 144, 157, 177-179  
 goals of science, 2, 20, 43, 136, 143, 158, 175, 191, 207, 212

## H

Heisenberg uncertainty principle, 130  
 histogram, 22, 23  
 history of science, 3-12  
 history of scientific methods, 3-12  
 hypothesis  
   confirmation, *see*: confirmation and refutation – of hypotheses  
   creation of, 10, 12, 14, 42, 44, 46, 99, 143, 148, 156, 176, 177  
   definition of, 13  
   experiment and, 10, 13, 99  
   method defined, 13, 14  
   modification of, 17, 68, 159-162, 165  
   null, 30, 43  
   predictions of, 14, 151  
   refutation of, 10, 14, 42, 64, 94, 156-160  
   reinforcement, 128, 138, 164  
   testing of, 12-14, 30, 46, 64, 66, 68, 71, 72, 74, 86, 89, 90, 100, 111, 123, 124, 138, 146-149, 151-153, 156-160, 164, 165, 188, 200

hypothetico-deductive method, 13, 82

## I

ideal class, 45  
 imagination, *see*: insight  
 independent variable, 46, 108, 139  
   definition of, 117  
 induction: Chapter 3  
   scientific, 42, 86  
 industrial research, *see*: science - applied  
 innovation, *see*: insight  
 insight: Chapter 8  
   characteristics of, 170, 173, 177  
   concentration and, 176  
   conviction of truth, 174  
   factors fostering, 6, 44, 45, 99, 115, 117, 139, 171-173, 176, 178-180, 200  
   inhibiting factors, 173, 174, 179  
   joy of, 170, 180-182, 210, 212  
 inspiration, *see*: insight  
 instrument, 101, 102  
   borrowing or buying, 112  
   computer interface, 102  
   drift, 36, 112, 118, 121, 137  
   new vs. used, 102  
   prototype, 103  
   troubleshooting, 104-109, 117  
   use, 112  
 intelligence, 69, 184, 199, 200  
   artificial, 148  
   IQ, 142, 200  
 interpolation, 53-55, 60  
 invention, *see*: discovery, insight

## J

jargon, scientific, 163, 184  
 journals, *see*: literature  
 judgment, 10, 11, 146, 160, 205  
   values, 147-151  
 justificationism, *see*: confirmation and refutation - justificationism

## K

kinship theory, 203  
 knowledge, 2, 5, 6, 8, 211, 212  
   new, 7, 153, 161  
   objective, 2, 125, 135, 137, 145  
   organized, 155  
   reliable, 2, 14, 96, 136, 160, 191  
   specialized, 192

useful, 2, 189, 191

## L

law, 4, 13, 61  
   definition of, 13  
   universal vs. statistical, 146  
 library, 7, 8  
   of Alexandria, 5, 88  
 linear regression, *see*: statistics - linear regression  
 literature, scientific, 9  
   publication, *see*: publication  
   reading of, 2, 89, 123, 138, 147, 150, 188  
 logic: Chapters 3 & 4  
   argument, 73  
   deduction vs. induction, 73, 74  
   definition of, 73  
   logical equivalence, 64, 78, 79  
   *also see*: deduction, induction

## M

mathematical description of nature, 4, 7, 13, 148  
 mathematics, 76, 129, 194, 200, 208  
   development of, 4, 6, 8, 10, 208  
 measurement types  
   interval, 15  
   nominal, 15  
   ordinal, 15, 50, 55  
   ratio, 15  
 medicine, 4, 67, 139, 191  
 memory, 131-134  
 meteorology, 178  
 Mill's Canons, 64, 65, 72  
   joint method of agreement and difference, 67  
   method of agreement, 65  
   method of concomitant variations, 67  
   method of difference, 66  
   method of residues, 67  
 model  
   definition of, 13  
   quantitative, 45, 100, 122  
 model/observation table, 152, 153

## N

National Science Foundation, 104, 203  
 note taking, 104, 114, 115, 123, 155, 169, 208  
 numbers  
   Arabic system, 7  
   significant digits, 123  
   *also see*: measurement types

**O**

objectivity, 2, 91, Chapter 6  
 abandonment of, 144  
 group, 143-145, 151  
 individual subjectivity, 151  
 lapse of, 89, 140-145, 164, 188  
 myth of, 12, 125, 126, 137, 138, 141, 199  
 perception and, *see*: perception  
 postmodernism and, *see*: postmodernism  
 observational science, *see*: science - observational  
 Occam's razor, 149  
 oceanography, 101, 106, 122, 178, 193  
 outline, 153

**P**

paradigm  
 anomaly, 162  
 change or overthrow, 162, 163, 209  
 definition of, 161  
 effects on hypotheses, 99, 162  
 effects on scientific change, 161, 162  
 examples of, 11, 59, 161, 164, 178, 207, 208  
 pitfalls, 164, 165  
 pre-paradigm, 161, 188  
 testing paradigm, 158  
 pattern recognition: Chapter 3  
 perception, 125  
 assumptions of, 62, 129  
 bias of, 125-129, 139  
 expectation and, 125, 126, 128, 129, 135  
 memory and, 131-135  
 schema, 44, 132-135, 177  
 philosophy, 4, 136  
 philosophy of science, 1, 2, 10, 12-14, 61, 72, 143, 146, 156, 157, 159, 163, 164, 188  
 physical science, 15, 62, 125, 164, 189, 194  
 physics, 10, 11, 20, 44, 59, 61, 63, 125, 129, 130, 132, 146, 149, 161, 178, 179, 187, 194, 206, 208  
 pilot study, 27, 29, 102, 103  
 plagiarism, 207  
 planning, *see*: experiment - planning  
 plotting of data, 36, 50  
 plotting hints, 52, 53  
 postmodernism, 135, 136  
 postmodern critique, 135, 136  
 precision, 17, 18, 20, 26, 27, 102, 103, 113, 120, 122, 143  
 definition of, 17  
 prediction, 13, 14, 20, 43, 139, 147, 148, 156, 160, 162, 164

preparation, 98, 111, 169-171  
 probability, 20, 108  
 combined, 21  
 definition of, 20  
 logical, 156  
 problem  
 problem solving methods, 104, 105, 109, 169, 171-173, 180  
 recurrence of, 109  
 reformulation of, 64, 111  
 setback, 98  
 statement of, 111, 171  
 proof, 160  
 pseudoscience, 187, 188  
 psychology, 55, 96, 98, 100, 118, 126, 139, 181, 188  
 publication  
 case studies of, 207-210  
 concept mapping of, 154  
 necessity of, 197, 207  
 pitfalls, 140, 209  
 productivity, 198, 205  
 style, 12, 123, 140, 184, 205, 207  
 writing, 155  
 pure research, *see*: science - basic  
 puzzle solving, 180, 181

**R**

random sampling, *see*: sampling - random  
 Raven's Paradox, 158  
 reading, *see*: literature – reading of  
 regression analysis, *see*: statistics – linear regression  
 reliability, 18, 20  
 religion, 5, 6  
 Christianity, 5-9, 88  
 Islam, 6-9  
 relationship to science, 8, 9, 60  
 replicatability, 17, 20, 188  
 replicate measurements, 17, 18, 20, 22, 66, 105, 113, 123  
 replication of experiments, 20, 27, 101, 142, 143, 145, 206  
 representative sampling, *see*: sampling - representative  
 research, *see*: experiment, experimental design, experimental technique, science

**S**

sampling  
 distribution, *see*: statistics - normal distribution  
 function

independent, 36, 55  
 nonrepresentative, 18, 94, 96  
 random, 19, 113, 118  
 representative, 18, 19, 42, 46, 156  
 stratification, 19  
 science: Chapter 9  
   applied, 2, 6, 8, 103, 150, 151, 185, 189-192, 194, 195, 206  
   arts and, 9, 187  
   basic, 2, 103, 185, 189-192, 194, 195, 206  
   big and little, 193, 194  
   comparison of basic and applied, 189-191  
   experimental, 5, 8, 10-14, 68, 99, 101, 162, 194  
   funding, 191-193  
   history of, 3-12  
   lay perspective, 183-187  
   observational, 98-100, 194  
   scope, 14  
   theoretical, 10, 194  
 scientific freedom, *see*: academic freedom  
 scientific instruments, *see*: instruments  
 scientific literature, *see*: literature  
 scientific method  
   myth of, 12  
   summary of, 12, 13, 169  
   variety of, 12, 14, 100, 188  
 scientific pecking order, 194, 195  
 scientific progress, 13, 14, 74, 113, 123, 136, 146, 150, 151, 162, 164, 194, 198, 201  
 scientific research, *see*: science  
 scientist: Chapter 10  
   egotism, 195  
   motivations, 184, 210-212  
   personal characteristics, 184, 197-202  
   variety of, 12  
 search procedure, 104-109  
 social science, 15, 19, 20, 54, 60, 62, 69, 96, 118, 136, 141, 189, 194  
 society and science, 189, 190  
 sociology, 70, 96, 136, 139, 188  
 standard, *see*: calibration  
 statistics: Chapters 2 & 3  
   arithmetic mean, 32  
   Chauvenet's criterion, 33, 35, 41  
   confidence limits, 18, 25-27, 33-35  
   correlation, *see*: correlation  
   degrees of freedom, 31  
   geometric mean, 32  
   harmonic mean, 32  
   linear regression, 55-60  
   mean, 23-27, 31, 34, 35  
   median, 33-35

nonlinear relationships, 58, 60  
 nonparametric, 30, 32-37, 59  
 normal distribution function, 23, 24  
 parametric, 30, 32-37, 50  
 pitfalls, 29  
 probability, *see*: probability  
 propagation of errors, 28, 29  
 quartile, 34  
 range of data, 34, 51, 60  
 rejecting anomalous data, 32, 33, 35  
 skewness, 30, 31, 41  
 standard deviation, 23-27, 34  
 standard error, 25-27  
 standardize, 31  
 variance, 24, 26  
 weighting, 26, 35, 56  
 $\chi^2$  test, 30, 31  
 stereotype, 127  
 syllogism, 4, 5, 72, 82-85  
   categorical, 83, 84  
   hypothetical, 85, 86  
   substitution, 84  
 symmetry, *see*: comparison - symmetry  
 systematic error, *see*: bias

## T

technology  
   economic effects of research, 190, 191  
   effects on science, 101, 163, 179, 186  
   predictions, 8  
   relation to science, 4, 6, 185, 186, 190  
   side effects, 185, 186  
   transfer, 192  
 testing, *see*: hypothesis – testing of  
 textbook science, 147, 161, 186, 188, 192, 210  
 theoretical science, *see*: science - theoretical  
 theory, 148, 160  
   definition of, 13  
 time series, 52-55, 60  
 troubleshooting, *see*: experiment – troubleshooting,  
   instrument - troubleshooting

## V

values, 184, 187, 201  
   judgment, 146-151, 160  
 variable  
   causal, 18, 46, 60-69, 117, 165  
   control of, 8, 11, 12, 63, 66, 89, 98-100, 103, 108, 112, 117-119, 138, 163  
   definition of, 13, 15

dependent, *see*: dependent variable  
explanation of, 43  
independent, *see*: independent variable  
intervening, 69  
isolation of, 20, 62, 103, 112, 117, 119, 143, 146  
measurement, *see*: measurement types, data  
quantification, 15  
relations among, 13, 15, 22, 43, 46, 50, 53-60, 119  
significant, 27  
uncontrolled, 18, 105, 116-118  
unknown, 7, 18, 20, 32, 37, 118  
verification, *see*: confirmation and refutation

## W

work  
intensity of, 197, 198  
satisfaction, 200