

# Index

- A bands, 172
- a-amylase, 321
- accumulation
  - in mass balance, 283
- acetaminophen, 544
- acetyl salicylate
  - half-life, 382
- acetylation, 171, 184
- acetylcholine, 249
- acetylcholinesterase, 250
- acid
  - definition, 52, 83
  - dissociation constant, 55, 84
  - proteins as, 62
  - strong, 55
  - weak, 55
- acidosis, 57, 83
- acquired immune deficiency syndrome, *See* AIDS
- actin, 172
- actin microfilament
  - mechanics, 435
- action potential, 243, 270
  - cardiac, 362
- active site, 175, 184
- active transport, 75, 83
- adaptive immune system, 256
- adaptive immunity, 265
- adenine, 66, 83, 107
- adenosine diphosphate, *See* ADP
- adenosine triphosphate, *See* ATP
- adenovirus, 136, 145
- adenylate cyclase, 241
- adjuvants, 611, 620
- adoptive immunotherapy, 688, 701
- ADP, 48
- adrenaline, *See* epinephrine
- affinity, 184, 232, 262, 270
  - enzyme–substrate, 177
- agar, 134
- agonist, 236, 270
- $\alpha$ -helix, 107, 163
- AIDS, 174
- albumin, 55, 58, 76
  - filterability, 392
- alcohol, *See* ethanol
- allele, 102, 146
  - dominant, 103, 147
  - frequency, 104
  - recessive, 103, 149
- alpha particles, 672
- alveolus, 297, 333
  - pressure within, 300
  - relation to lung capillaries, 310
  - surface tension, 431
- Alzheimer's disease, 24, 38
- amino acids, 44, 61, 69, 120
  - acidic, 71
  - basic, 71
  - essential, 324
  - functional groups, 61, 85
  - ionization, 165
  - nonpolar, 71
  - polar, 71
- amperometric sensor, 461
- amphiphilic
  - molecules, 45, 83
- ampicillin, 133
- amylases, 317
- anabolism, 321
- anaphase, 207, 221
- anchorage independence, 218
- aneurysm, 356, 369
- Anger, Hal, 516
- angiogenesis, 18
- angioplasty, 466, 490, 648
- animal models, 139
- anion, 39, 83
- anisotropy, 425, 440
- antagonist, 271
- antagonists, 237
- antibiotic resistance
  - in plasmids, 132

- antibodies, 170, 184, 259
  - antigen-binding region, 594
  - broadly neutralizing, 602
  - chimeric, 599
  - complementary determining region, 595, 621
  - drug conjugates, 602
  - effector region, 592, 621
  - humanized, 599, 621
  - in cancer treatment, 687
  - in drug-delivery systems, 273
  - in mother's milk, 601
  - manufacturing, 590
  - mechanism of action, 259
  - structure, 592
- antibodies, monoclonal, *See* monoclonal antibodies (mAb)
- antibody
  - engineering, 592
  - mucosal, 596
  - structure, 591
  - subclasses, 595
- anticodon, 122
- antidiuretic hormone, 400
- antigen, 240, 259
- antigen-presenting cell, 240, 271
- antisense oligonucleotides, 126
- antiserum, 597, 620
- aorta, 345
- aortic valve, *See* valve, aortic
- Apligraf, 564
- apoptosis, 214, 221, 263, 271
- aptamer, 483
- aquaporins, 79
- arrhythmia, 476
- arterioles, 347
  - afferent renal, 404
  - control of glomerular filtration, 388–9
  - efferent renal, 405
- artery, 347
  - hepatic, 318
  - occlusion, 559
  - tissue-engineered, 567
- arthroscopy, 522
- artificial heart, 6, 9–10
  - AbioCor, 647
  - Jarvik 7, 647
- artificial heart valve, 648
- artificial joints, 7, 39
- artificial kidney, *See* hemodialysis
- artificial liver, 657
- artificial organs, 21
  - biohybrid, 650
- artificial pancreas, 652, *See* pancreas, artificial
- ascorbic acid, 55
- aspirin, *See* acetyl salicylate
- association constant, 233, 271
- asthma
  - prevalence in childhood, 281
- asymmetrical division, 210, 221
- atherosclerosis, 352, 369
- atomic bonding, *See* bonds, atomic
- ATP, 45, 48, 83, 113
  - energy exchange, 48
  - high-energy bonds, 48
  - hydrolysis, 48
  - hydrolysis and chemical conversions, 48
  - in active transport, 200
  - structure, 62
- atrioventricular node, *See* AV node
- atrium, 361
- auscultatory method, *See* blood-pressure measurement
- auscultation, 469
- autocrine, 263, 271
- AV node, 363
  - delay at, 365
- avidity, 596, 620
- axons, 243, 271
  
- B cells, 258
- bacillus Calmette–Guérin, 701
  - in bladder cancer, 687
- Banting, Frederick, 124
- barium
  - in x-ray imaging, 505
- basal lamina, 197
- basal metabolic rate, 321
- base-pairing rules, 118
- bases, 52, 65, 83
  - conjugate, 55, 84
  - definition, 52, 83
  - strong, 55
  - weak, 55
- basolateral, 398
- Baxter, Walt, 438
- Beer–Lambert law, 480
- Berg, Paul, 131
- beta cells, 254
- beta particles, 672

- beta-adrenergic receptor, 240
- bicarbonate, 55, 57, 307
- bilayer, lipid, *See* lipid bilayer
- bile, 318, 324, 404
- bile ducts, 318
- biochemical energetics, 45
- biochemical engineering, 5
- biocompatibility, 627, 661
- bioengineering, 5
- bioinformatics, 146, 169
- biological engineering, 5
- biological therapy, 701
  - in cancer treatment, 687
- biomarkers, 701
  - of cancer, 695
- biomaterial
  - polymers, 627
- biomaterials, 627
  - history, 627
  - metals, 627
  - polymers, 630
- biomechanics, 16, 19
- biomedical engineer, *See* biomedical engineering
- biomedical engineering, 8
  - definition, 5
  - ethics, 25
  - history, 14
  - subdisciplines, 15
- Biomedical Engineering Society, 30
- biomedical imaging, 16, 18
- biomedical instrumentation, 16, 18
- BioMEMS, *See* MEMS
- biomolecular engineering, 5, 16, 20, 128, 171, 544
- bioprocess engineering, 5, 574, 580
- biopsies, 580, 669, 701
- bioreactor, 580
  - cell growth model, 565
- biosensors, 482, 490, 550
- biosystems engineering, 5
- biotechnology, 5, 544
  - agricultural, 139
  - definition, 5
- biotransformation, 379, 404
- bladder
  - capacity, 386
  - urinary, 386
- blastomeres, 207, 221
- Bleichroeder, Fritz, 629
- blood
  - composition and properties, 343
  - fluid behavior, 422
  - viscosity, 343
- blood clots, *See* coagulation cascade
- blood flow
  - imaging, 510
- blood pressure
  - changes on standing, 355
  - measurement, 353
- blood pressure
  - in health, 468
- blood transfusion, 580
- blood treatments
  - extracorporeal, 635
- blood vessel, 345
  - bifurcation, 352, 370
  - biomaterials, 632
  - compliance, 355
  - constriction, 350, 370
  - dilation, 350, 370
  - models, 16
  - tissue-engineered, 567
- blood-brain barrier, 358, 370, 379, 682, 701
- BMES, *See* Biomedical Engineering Society
- body
  - mechanical support, 413
- bonds
  - atomic, 39
  - covalent, 39, 84
  - hydrogen, 42
  - ionic, 39, 86
  - molecular, 42
  - van der Waals interactions, 42, 88, 166
- bone marrow, 210, 258
- bones, 415, 424
  - architecture, 425
  - composition, 425
  - number in body, 413
- Bowman's space, 387, 405
  - pressure, 389
- Boyer, Herbert, 132
- brachytherapy, 678, 701
- bradycardia, 477, 490
- breast implants, 632
- bronchi, 297, 333
- bronchoscopy, 522
- Brooklyn Bridge, 9
- bruits, 352, 370
- brush border, 318
- buffering, 55, 57, 83

- buffering power, 308
  - of non-bicarbonate buffers in blood, 308
- burns
  - skin substitutes, 564
- cadherin, 206
- caffeine
  - half-life, 380
- cAMP, 241
- camptothecin, 116, 146
- cancer, 18, 115, 666
  - bladder, 668, 687
  - breast, 671, 687
  - cervical, 670
  - grading, 668
  - melanoma, 669
  - pancreatic, 671
  - prostate, 670, 689, 695
  - stages, 668
- capillary, 357
  - fenestrated, 357, 370
  - osmotic pressure, 359
  - permeability, 359
- capsid
  - viral, 135
- carbohydrates, 63, 83
  - chemical formula, 63
  - digestion, 317, 321
- carbon dioxide, 53
  - carriage in the blood, 305
  - interaction with water, 53
- carbon monoxide, 311
- carbon-11, 515
- carbonic acid, 53, 57, 307
- carbonic anhydrase, 180, 307, 333
- carboxypeptidase, 317
- carcinogens, 114, 146
- cardiac cycle, 364–5, 370
  - mechanics, 367
  - role of valves, 364
- cardiac defibrillation, 477, 490
- cardiac output, 305
- cardiopulmonary bypass, 644
- cardiovascular system, *See* circulatory system
- carriage in the blood
  - relation to pH, 307
  - role as a buffer, 308
- cartilage, 413, 422
  - tissue-engineered, 559
- Casson's equation, 345
- catabolism, 321
- catalyst
  - definition, 175, 184
- catheter, 466, 490, 559, 580, 629, 661
  - blood-pressure measurement, 469
- catheterization, *See* catheters
- cation, 39, 84
- cause of death, 25
  - accidents and trauma, 2
- cDNA, 134, 146
- cell
  - mechanics, 433
  - muscle, 172
- cell delivery, 557
- cell membrane, 73, 84
- cell therapy
  - adoptive transfer, 689
  - islets, 654
- cell-mediated immunity, 257, 271
- cellophane, 635
- cells
  - adhesion, 192
  - assays for growth, 481
  - cancer, 667
  - cancer mechanics, 433
  - cartilage, 436
  - cell cycle, 206
  - cell cycle control, 209
  - cell wall, 193
  - cell–cell communication, 231
  - culture, 191, 214
  - culture medium, 216
  - death, 213
  - diversity in the body, 190
  - division in the embryo, 110
  - DNA damage from radiation, 672
  - endothelial, 389, 436
  - epithelial, 283
  - forces in, 436
  - human umbilical vein endothelial, 564
  - intestinal epithelial, 320
  - mechanics, 436
  - membrane, 73, 75
  - membrane composition, 73
  - myeloma, 599, 622
  - number in the body, 190
  - pancreatic beta, 652
  - proliferation, 206

- proliferation models, 217
- proximal tubule epithelial, 320
- proximity to blood vessels, 359
- smooth muscle, 315
- sources of cultured, 215
- transplanted pancreatic beta, 557
- variety of epithelial renal tubule, 388, 397
- white, 434
- cells, red blood, *See* red blood cells
- cellular engineer, 19
- cellulose, 65–6, 83
- Celsius, Anders, 465
- Centers for Disease Control, 281
- central dogma of molecular biology, 116
  - revised, 120
- central nervous system, 243
- centromere, 208, 221
- chaperones
  - in protein folding, 168
- character
  - genetic, 102, 146
- chemical engineering, 545
- chemical reaction
  - kinetics, 53, 84
  - reversible, 53, 88
  - thermodynamics, 46
- chemotherapy, 580, 681
  - history, 680
  - in cancer treatment, 680
- chest wall
  - mechanical properties, 300
- chest x-ray, 505
- Chiron, 613
- chromatids, 208, 221
- chromatin, 99, 146, 171
- chromophore, 480, 490
- chromosomal crossover, 209
- chromosomes, 99, 111, 146, 207
  - homologous, 101, 148
  - packaging, 99
  - X and Y, 101
- chronic myelogenous leukemia, 685, 701
- chymotrypsin, 317
- circuit analysis, 454
- circulatory system
  - function, 341
  - of the liver, 318
  - pulmonary vs. systemic, 357
- citric acid, 55
- Clark electrode, *See* oxygen electrode
- Clark, Barney, 647
- Clark, Leland, 461
- clearance
  - in dialyzers, 639
  - in kidney function, 405
  - mathematical definition, 393
- cleavage furrow, 221–2
- clinical engineers, 449
- clonal expansion, 263, 271
- clonidine, 554
- cloning
  - cells, 129
  - definition, 129, 146
  - DNA, 130
  - genes, 130
- cloning vector, 130, 146
- coagulation cascade, 631, 661
- codon, 121, 146
  - termination, 118, 150
- Cohen, Stanley, 131
- coincidence detection, 518, 537
- collagen, 197
  - in bone, 425
  - in tissue engineering, 564
- collecting duct, 397
- collecting tubule, 400
- collimator, 516
  - parallel-hole, 517
  - pinhole, 517
- colon, *See* large intestine
- colonoscopy, 522
- colorimetric reagents, 480, 490
- compact bone, 425
- complement system, 258, 271
- complementary DNA, *See* cDNA
- compliance
  - definition, 355, 370
- concentration gradient, 75–6, 84, 245
- confocal microscopy, *See* microscopy, confocal
- conjugate base, 55, 84
- connective tissues, 425
- connexins, 247, 271
- contact inhibition, 218
- contact lens, 7, 11–12, 311
- contrast, 537
  - in imaging, 504
- contrast agent, 537
  - in imaging, 513
- Cormack, Allan, 506
- coronary artery bypass, 644–5

- cotransporters, 201, 222
- countercurrent concentration, 401
- countercurrent flow, 401
  - osmotic gradient creation, 400
- Crick, Francis, 94, 107, 128
- CT imaging, 506
  - micro, 508
- CT scanner, 506
  - spiral, 508
- current clamp, 459, 490
- Curtiss, Larry, 522
- cuvette, 479
- cyclic adenosine monophosphate, *See* cAMP
- cyclophosphamide, 385
- cyclotron, 515, 537
- cystic fibrosis, 89, 96, 106, 136, 145, 337
- cytokines, 265, 271
  - in cancer treatment, 263
- cytokinesis, 222, 224
- cytosine, 66, 84, 107
- cytoskeleton, 170, 194, 222
  - mechanics, 435
- cytosol, 73, 84
- cytotoxic T cells, 262, 271
  
- dashpot
  - model of viscous liquid, 423
- daughter cell, 206
- deep-brain stimulator, 19
- deformation
  - elastic, 440
  - energy storage, 421
- denatured
  - DNA, 165
- dendrimers, 41
- dendrite, 247, 271
- dendritic cells, 258
- deoxyribonucleic acid, *See* DNA
- deoxyribose, 63, 65, 84, 107, 113
- dephosphorylation, 242
- depolarization
  - membrane, 244, 271
- Dermagraft, 564
- DeVries, William C., 647
- diabetes, 471
  - cell-based treatments, 650
  - skin substitutes, 564
  - treatment, 132
- diabetes, 651
- dialysance, 405
- dialysate, 635, 662
- dialysis
  - kidney, 21
  - peritoneal, 642, 662
- diaphragm
  - role in respiration, 299
- diastole, 364, 370
- diet
  - human, 313
- differentiation
  - cellular, 210
  - control of, 211
  - hormones, 253
- diffraction grating, 169
- diffusing capacity, 311
- diffusing capacity of lung, 311
- diffusion, 75–6, 82, 84, 309, 358, 685
  - coefficient, 76
  - facilitated, 75, 85
  - in dialysis, 636
  - through respiratory membrane, 312
- digestion, 313
  - proteins, 323
- digestive system
  - functions, 316
- dimer, 168, 184
- diploid, 101, 147
- disaccharides, 63
- dissociation constant, 233, 271
- distal tubule, 405
- disulfide bonds, 168, 184
- disulfide interactions, 165
- diuresis, 400
- DNA, 65, 95, 147
  - base pairing, 69
  - chemical structure, 107
  - complementary sequences, 67
  - discovery of structure, 107
  - double helix, 67
  - microarray, 7, 692
  - sequencing, 6, 696
  - symmetrical sequence, 132
  - synthesis, 206
- DNA binding proteins, 115, 147
- DNA fingerprinting, 111, 130
- DNA polymerization, 113, 142
- DNA replication, 110, 206
  - errors, 114
- dominance
  - of genes, 103, 147

- Doppler effect, 510, 537  
 dose fractionation, 675, 701  
 double helix, 108  
 drug delivery, 106, 546  
   closed-loop systems, 550  
   controlled, 547  
   history, 546  
   in cancer treatment, 680  
   insulin, 473  
   ocular, 553  
   of DNA, 557  
   polymers, 552  
   proteins, 556  
   transdermal, 554  
 drugs  
   biomedical engineering and, 20  
   chemotherapy, 73  
   dosage forms, 547  
   immunosuppressive, 559–60  
 duodenum, 317  
  
 ECG, 363, 370, *See* electrocardiogram  
 ectoderm, 210  
 Edmonton protocol, 654  
 EEG, 476  
 Einthoven, Willem, 474  
 Einthoven's triangle, 474  
 elastic limit, *See* yield strain  
 elastic recoil, 440  
 elastin, 427  
 electrical stimulation, 477  
 electrocardiogram, 3, 11, 370  
 electrocardiography, *See* ECG  
 electroencephalograph, *See* EEG  
 electromagnetic spectrum, 462, 503  
 Eli Lilly, 132  
 elimination of waste  
   mechanism, 379  
 embryo, 207  
 embryonic development, 206  
   cell proliferation, 206  
 emergency medicine, 2  
 endocrine, 237  
 endocrine system, 251, 271  
 endocytosis, 203  
   of nanoparticles, 571  
   receptor-mediated, 203  
 endoderm, 210  
 endoplasmic reticulum, 174  
   rough, 195, 224  
   smooth, 195, 224  
   smooth, of hepatocytes, 384  
 endoscope, 522, 537  
   in cancer, 671  
 endothermic, 47, 84  
 energy  
   storage in molecules, 60, 64, 72  
 engineering, 8  
   achievements, 9  
   definition, 8, 10  
   history, 14  
   problem solving, 27  
 engineering analysis, 39–40, 282  
 dialyzer extraction ratio, 638  
   in hemodialysis, 636  
   in systems biology, 691  
   of drug delivery for cancer, 681  
 engineers  
   work of, 9  
 enterokinase, 318  
 enthalpy, 46, 84, 88  
 entropy, 47, 84, 88  
 envelope  
   viral, 604, 621  
 enzyme  
   in glucose measurement, 483  
 enzymes, 175  
   as catalysts, 171  
   in digestion, 317  
   in drug delivery systems, 556  
   in signal transduction, 235  
   mathematical models, 178  
   models of action, 186  
   pH dependence, 51  
   role as catalysts, 280  
   saturation, 179  
   specificity, 175  
   transition state, 176, 186  
   turnover number, 180, 186  
 epidermal growth factor, 204  
 epiglottis, 429  
 epilepsy, 476  
 epinephrine, 240, 251  
 equilibrium  
   acid–base, 56  
   definition, 293, 334  
   definition of chemical, 84  
   equilibrium constant, 54, 85,  
     88  
 erythropoietin, 212

- esophagus, 316  
 estradiol, 383, 554  
 estrogen, 256  
 ethanol  
   metabolism, 381  
 eukaryotes, 119, 193  
 eukaryotic cells  
   overall structure, 194  
 exchangers, 202, 222  
 excretion  
   biliary, 383  
 exons, 119  
 exothermic, 47  
 expiration, 299, 334  
 expression vector, 147  
 extent of reaction, 326  
 external beam radiation therapy, 676, 701  
 extinction coefficient, 480  
 extracellular matrix, 170, 196  
   production by cells, 197  
   proteins, 197  
   relation to tissue properties, 197  
 extracellular space, 193  
 extracorporeal devices, *See* blood treatments,  
   extracorporeal  
  
 facilitated transport, 199  
 Fahrenheit, Daniel G, 465  
 failure stress, 440  
 fats  
   digestion, *See* triglycerides  
 fatty acids, 72, 122, 323  
   saturated, 72  
   unsaturated, 72  
 feedback  
   in homeostasis, 291  
   in the endocrine system, 251  
   negative, 251–2  
 feedback control, 252, 581  
   in drug delivery, 550  
 femur, 415, 425  
 fever, 453, 490  
 fiber optics, 538  
   mechanism, 522  
 fibrin, 631  
 fibrin in clotting, *See* coagulation cascade  
 fibrinogen, 631  
   in blood, 343  
 fibroblasts, 197  
 fibronectin, 197  
  
 fibrous capsule, 634  
 Fick, Adolph, 311  
 Fick's Law of Diffusion, 76, 311, 334  
 field of view, 528, 538  
 filterability, 392  
 filtering  
   to improve images, 529  
 filtration  
   kidneys, 386  
 first-order reaction  
   definition, 85  
 flow patterns  
   laminar vs. turbulent, 351  
   pulsatile, 353  
 fluorescent dye, 459, 521  
 fluorine-18, 515  
 fluorophores, 521, 538  
 flux  
   diffusion, 76, 85  
 fMRI, 498, 538  
 Food and Drug Administration, 699  
 force  
   measurement, 456  
 force analysis, 416  
 forces  
   in the body, 415  
 foreign body response, 630, 662  
 forensic science, 144  
   and DNA technology, 138  
 formation reaction, 46, 85  
 Forssman, Werner, 629  
 Fourier transform, 538  
*Frankenstein*, 7  
 frequency  
   of human hearing, 509  
   resonant, 509  
 fructose, 63, 85, 314, 323  
 functional group, 61–2, 85  
  
 galactose, 63, 85, 200  
 galvanometer, 474  
 gametes, 101, 147  
 gamma camera, 500, 514, 538  
 gamma ray, 504, 702  
 gammaglobulin, 601  
 gap junctions, 237, 272  
   in the heart, 362  
 gap phase, G1 and G0, 206  
 gastric fluids, 316  
 gastrulation, 210



- gel electrophoresis, 111
- gene
  - delivery, 41, 85
  - expression, 118, 123, 147
  - ideal delivery vector, 136
  - inhibition of expression, 123
  - locus, 102, 148
  - therapy, 95–6, 135, 145
  - transfer, 128
- gene therapy, 557
  - synthetic polymers, 559
- Genentech, 132, 138
- genetic code, 117, 121, 147
- genetic diseases, 95, 138
  - polygenic, 95
- genetic engineering, 8
- genetic information
  - relation to nucleic acids, 85
  - transmission to offspring, 64
- genetically modified organisms, 139
- genetics, 99, 147
- genome, 107, 147
- genotype, 103, 147
- genotypic frequencies, 104
- germ cells, 101, 110, 147
- Gibbon, John H., 644
- Gibbs free energy, 47, 85
  - of enzyme-catalyzed reactions, 176
- Gibbs, J. Willard, 14
- Gliadel, 22
- glial cells, 246, 272
- glomerular filtration, 388, 390, 405
- glomerular filtration rate, 405
  - magnitude, 392, 395
- glomerular membrane
  - structure, 389
- glomerulus, 387, 405
- glucagon, 254, 272
- glucoamylase, 323
- glucose, 63, 85, 254
  - blood measurement, 7
  - combustion, 90
  - control, 473
  - cotransporters, 201, 323
  - filterability, 392
  - homeostasis, 254
  - membrane permeation, 75, 199
  - membrane transport, 198
  - oxidase, 483
  - reabsorption in the kidney, 387
  - size, 58
  - transporters, 199
- glutamic acid, 49
- glutamine, 49
- glycocalyx, 74, 85
- glycogen, 45, 48, 61, 64
  - breakdown for fuel, 251
- glycosaminoglycans, 197, 222
- glycosylation, 122, 147, 171, 184
- Golgi apparatus, 175, 222
- gp120, 613
- G-protein-coupled receptors, 239
- G-proteins, 240
- granulocyte colony-stimulating factor, 212
- gravity, 415
- green fluorescent protein, 521
- growth factors, 209, 222, 240
- growth hormone
  - human, 556, 581
- guanine, 66, 85, 107
  
- Hagen, Gotthilf Heinrich Ludwig, 349
- Hagen–Poiseuille flow, 349
- half-life
  - drug, 550
  - of radioisotopes, 538
- haploid, 101, 148
- Hardy–Weinberg equilibrium, 104
- Hawkins, Bill, 488
- health problems, 631
- heart, 361
  - anatomy, 361
  - artificial, 645
  - electrical activity, 362
  - valves, 361
- heart block, 476
- heart, artificial, *See* artificial heart
- heart–lung machines, 644
- heat of formation, 46
  - use in energy calculations, 46
- helicase, 115, 148
- helium, 380
- hematopoietic stem cells, 212, 222
- hemodialysis, 626, 634, 636
  - number of procedures, 636
- hemoglobin
  - in red blood cells, 343
  - role in oxygen carriage, 306
  - saturation, 306

- Henderson–Hasselbalch equation, 56–7, 165,  
 187–8, 308, 339
- Henry's law, 312
- hepatitis A, 597, 601
- hepatitis B, 597
- hepatitis B virus  
 disease progression, 610  
 disease transmission, 609
- hepatitis C, 24
- hepatocytes, 318  
 microsomal fraction, 384
- heredity, 99, 148
- heterozygous  
 gene, 103, 148
- hip replacement, 7, 21
- Hirschowitz, Basil, 522
- histidine, 324
- histones, 99, 148, 171
- HIV, 23, 135, 173  
 broadly neutralizing antibodies, 602  
 impact, 588  
 vaccine, 612
- hollow fibers  
 in dialysis, 636
- home testing, 6, 71
- homeostasis, 85, 291, 334
- homozygous  
 gene, 102, 148
- Hooke, Robert, 418
- Hooke's law, 418, 440
- hormonal therapy, 702  
 in cancer, 686
- hormones, 251, 272  
 steroid, 253
- Hounsfield, Godfrey, 506
- HPV, 667
- Hufnagel, Charles A., 631, 648
- human chorionic gonadotropin, 483
- Human Genome Project, 6, 14, 95, 145, 162
- human immunodeficiency virus, *See* HIV
- human papillomavirus, *See* HPV
- humoral immunity, 258, 272
- Huntington's disease, 106, 275
- hybridization, 67, 85  
 DNA, 110, 131, 149, 574
- hybridomas, 599, 621
- hydrochloric acid, 55, 57
- hydrogel, 581
- hydrogen bonds  
 in DNA, *See* bonds, hydrogen
- hydrolysis  
 definition, 48, 86
- hydronium ion, 50
- hydrophilic molecules, 44, 86
- hydrophobic effect, 44, 86
- hydrophobic molecules, 44, 86
- hydroxide ion, 50
- hyperglycemia, 255, 272
- hyperpolarization, 248, 272
- hypertension, 468, 490
- hyperthermia, 464
- hypertonic, 79, 86
- hypoglycemia, 255, 272
- hypotension, 469, 490
- hypothermia, 465
- hypotonic, 79, 86
- hypoxemia, 470, 490
- hysteresis, 432, 440
- I bands, 173
- ibuprofen, 544
- IgA, 596
- IgD, 595
- IgE, 595
- IgG, 595
- IgM, 596
- ileum, 317
- image processing, 527
- image projected, *See* projection
- imaging  
 abdomen, 508, 522  
 biomedical, *See* biomedical imaging  
 bone, 504  
 brain, 497, 516  
 comparison of modalities, 499  
 computer tomography, *See* CT imaging  
 digestive system, 505  
 digital, 498, 527  
 Doppler, 510  
 fetal, 508  
 functional magnetic resonance, *See* fMRI  
 gamma camera, 500  
 heart, 508  
 helical computed tomography, 3  
 joints, 522, 524  
 liver, 516  
 magnetic resonance, *See* MRI  
 nuclear medicine, 513  
 optical, 520  
 PET, 497

- registration, 532
- segmentation, 533
- SPECT, 514
- spleen, 331
- thyroid, 516
- tissue function, 19
- ultrasound, 106
- x-ray, *See* x-ray imaging
- imatinib, 686
- immune system, 256
  - innate, 258
- immunization
  - passive, 600–1, 622
- immunotoxins, 600, 603
- in vitro
  - definition, 191, 222
- in vivo
  - definition, 192
- infectious diseases, 23
- influenza, 588
- infrared, 504
- inheritance
  - of genes, 99
- innate immune system, *See* immune system, innate
- inositol, 240
- inspiration, 299, 334
- insulin, 123–5, 168, 174, 186, 254, 272
  - activation, 174
  - closed-loop delivery, 473
  - cow and pig, 125
  - delivery systems, 550
  - determining dose, 472
  - endocrine signaling, 254
  - feedback control, 255
  - human, 125
  - human recombinant, 125
  - mechanism, 254
  - receptor, 255
  - recombinant, 556
  - response to glucose, 254
  - therapy in diabetes, 651
- Integra, 564
- integrins, 205, 222, 240
- interferon, 265
- interleukin-2, 212, 263
- intermediate filaments, 435
- internal energy, 46, 84
- interphase, 207, 223
- intestine
  - fluid absorption, 320
  - models, 324
- intra-arterial infusions
  - in cancer, 683
- intrapleural space, 428, 440
- introns, 119, 148
- inulin, 395
- iodine-131, 514
- ion channels, 170, 185, 202, 239, 244, 272
  - and neurotransmitters, 247
- ion selective electrode, 461
- ionizing radiation, 502, 538, 672
  - biological effects, 672
- ions
  - membrane permeation, 243
- iPS cells, *See* stem cells, induced pluripotent
- islet transplantation, 654
- isoleucine, 324
- isotonic, 79, 86
- isotropy, 425, 440
  
- jejunum, 317
- Jenner, Edward, 605
  
- Karp, Haskell, 647
- karyotype, 101, 148
- Katona, Peter, 14
- kidney
  - blood flow, 387
  - overall function, 386
  - regulation of fluid, 386
  - tubule function, 387
  - workload, 387
- kidneys
  - daily excretion, 385
  - elimination of molecules, 386
  - role in homeostasis, 295
- kinase, 272
- kinase inhibitors, 685
- kinetics
  - definition, 53, 84
- kinetochores, 208, 223
- Kirchhoff's
  - current law, 454
  - voltage law, 454
- knee replacement, 7
- knockout animals, 140, 148
- Kohler, Georges, 599
- Kolff, Willem, 21
- Krogh, August, 359

- lab-on-a-chip, 450, 484, 487, 491
- lactase, 323
- lactic acid, 55
- lactose, 64, 86
- lagging strand, 114, 148
- Lambert–Beer law, *See* Beer–Lambert law
- laminar flow, 351, 370
- laminin, 197
- land grant colleges, 14
- Langer, Robert, 28
- laparoscopy, 522
- Laplace, Pierre-Simon, 430
- Laplace’s law, 355, 370
- large intestine, 321
- Larmor frequency, 525, 538
- Lauffenburger, Douglas, 268
- Lauterbur, Paul, 524
- leading strand, 114, 148
- leucine, 324
- life expectancy, 2
  - human, 1
- ligament, 413, 427
- ligands, 185, 203, 272
  - for targeted drug delivery, 571
  - in cell communication, 231
- ligase, 114
  - DNA, 114, 147
- Lincoln, Abraham, 14
- Lineweaver–Burke plot, 179, 185
- Liotta, Domingo, 647
- lipases, 317
- lipid bilayer, 73, 75, 127, 191–2, 202
- lipids, 60, 72, 74, 86
- lipopolysaccharides, 194
  - in immunity, 258
- liposomes, 38, 682
- Liptai, Laura, 143
- liver, 318
  - architecture, 318
  - biliary system, 383
  - circulatory system, 318
  - excretion, 383
  - functions, 318
  - metabolism of drugs, 384
  - role in homeostasis, 295
- loop of Henle, 397, 401–2
- low-density lipoprotein, 204
- lung, 295
  - mechanical behavior, 432
  - mechanical properties, 300
  - mechanics, 425
  - organization, 330
  - static mechanical properties, 428
  - volumes and capacities, 297
- Luo, Dan, 331
- Lupron Depot, 556
- luteinizing hormone-releasing hormone, 687
- lymph node
  - involvement in cancer, 668
- lymph nodes, 258
- lymphatic system, 360
- lymphoid organs, 258
- lymphomas
  - B cell, 602
- lysine, 324
- lysosomes, 195, 223
- M line, 173
- M phase, 222–3
- Mackey, Tiffanee Green, 80
- MacLeod, John, 124
- macromolecules, 58, 86
  - hydrogen bonding in, 42
- macrophages, 258
- magic bullet, 592, 600
- magnetic dipole, 524
- magnetic resonance imaging, 11, 524, *See* MRI
- major histocompatibility complexes,
  - See* MHC
- malaria, 603, 616
- Mann, Brenda, 182
- Mansfield, Peter, 524
- mass balance equation
  - open system, 283
- mass balances, 281
- materials
  - deformability, 418
  - mechanical properties, 415
- mathematical models
  - cell growth, 565
  - enzymes, 178
  - feedback control, 252
  - hemodialysis, 641
  - mass balance, 283
  - Nernst potential, 245
  - pharmacokinetics, 549
  - receptor–ligand interaction, 233
- mathematical models
  - blood viscosity, 344
- maximum stress, *See* failure stress
- measles, 597
- mechanical properties
  - of typical materials, 419
- medical degree, 8

- Medtronic, 19  
 meiosis, 110, 148, 208, 223  
 membrane  
   gas diffusion across, 310  
   permeability in dialyzers, 639, 641  
   respiratory, 310, 334  
   respiratory, diffusion, 311  
   semipermeable, 84  
 membrane oxygenators, 643  
 membrane potential, 243  
   measurement, 458  
 memory  
   in immunity, 258  
 MEMS, 484  
   Bio, 485  
 Merck, 611  
 mesoderm, 210  
 messenger RNA, *See* mRNA  
 metabolism, 313  
   definition, 321  
   relation to weight, 321  
 metaphase, 207, 223  
 metastasis, 433, 668, 702  
 methionine, 324  
 methotrexate, 680  
 MHC  
   class I, 260, 273  
   class II, 260, 273  
   presentation of peptides, 260  
 micelles, 569  
 Michaelis constant, 179, 185  
 Michaelis–Menten equation, 179, 185  
 Michaelis–Menten equilibrium, 325  
 microarrays, 1, 450  
   DNA, 692  
   protein, 693  
   tissue, 694  
 microelectromechanical systems, *See* MEMS  
 microfabrication, 217  
 microfilaments, 435  
 microfluidics, 487, 491  
 microinjection, 134  
 micropipette, 459  
 micropipette aspiration, 434  
 microRNA, 141, 690  
 microscopy, 520  
   confocal, 522  
   cryo-electron, 169  
   electron, 500  
 microtubules, 435  
 microvilli, 319  
 Milstein, Cesar, 599  
 miRNA, *See* microRNA  
 mitochondria, 195, 223  
 mitosis, 110, 148, 206, 223, 320  
 mitotic spindle, 223–4  
 modeling physiology, *See* physiological modeling  
 molecular biology  
   central dogma, 69  
 molecular bonding, *See* bonds, molecular  
 molecular cloning, *See* cloning, genes  
 molecules  
   size, 58  
 moment analysis, 415  
 monoclonal antibodies (mAb), 622  
 Monod model, 565  
 monomers, 86  
   definition, 58  
   diversity, 59, 61  
   functional groups, 61  
   role in polymers, 58, 87  
 monosaccharides, 61, 63, 86  
 morphine, 383  
 movement  
   human body, 413  
 MR scanner, 524  
 MR spectroscopy, 527  
 MRI, 3, 18, 38  
 mRNA, 69, 86, 118, 126, 134, 148  
 MTT assay, 481  
 multiple sclerosis, 247  
 muscle, 413  
   intestinal, 315  
   force generation, 415  
 muscle protein  
   mechanics, 172  
 mustard gas, 680  
 mutations, 114, 149  
 myelin, 246, 273  
 myocardium, 362  
 myofibrils, 172  
 myosin, 172  
 myristoylation, 171, 185  
 Na<sup>+</sup>/K<sup>+</sup> ATPase, 75, 201  
 nanobiotechnology, 567  
 nanoparticles, 203  
   for drug delivery, 569  
 nanotechnology, 567, 582  
 National Institutes of Health, 7  
 natural killer cells, 258  
 Navier–Stokes equations, 348  
 Neason, Curtis, 368

- necrosis, 214, 223  
 negative feedback, *See* feedback, negative  
 Neher, Erwin, 459  
 nephron  
   number, 387  
   structure, 389  
 Nernst potential, 244–5, 273–4  
 neuromuscular junction, 249  
 neurons, 194, 242  
   motor, 243  
   postsynaptic, 247  
   presynaptic, 247  
   sensory, 243  
   shape, 243  
 neurotransmitters, 243, 273  
   in signaling, 243  
 neutrons, 672, 702  
 neutrophils, 258  
 Newton's laws of motion, 416  
 nicotine, 380, 554  
   half-life, 380  
 nitrogen-13, 515  
 nitroglycerin, 554  
 nitrosoureas, 683  
 NMR, 162, 169  
 N-myristoylation, 122, 149  
 Nobel Prize, 124, 131, 359  
 nodes of Ranvier, 247, 273  
 noisiness  
   of images, 529  
 nonpolar, 86, 89  
 Norplant, 553  
 nuclear localization signals, 174  
 nuclear magnetic resonance, *See* NMR  
 nuclear medicine, *See* imaging, nuclear medicine  
 nuclear membrane, 207, 223  
 nucleic acids, 58, 60, 64, 66, 87, 95  
   hybridization, 67, 85  
   structure, 65  
 nucleotides, 61, 64, 67, 87  
   chemical structure, 67  
   nitrogenous bases, 66  
 nucleus, 195, 223  
 nutrition, 377  
   recommended diet, 292  
 NuvaRing, 106  
  
 obesity, 281  
 Ocusert, 553  
  
 Ohm's law, 349  
   in instrument design, 452  
 Okazaki fragments, 114, 149  
 oligodendrocytes, 246, 273  
 oligonucleotide, 149  
   delivery, 134  
 Olympic performance, 413  
 Ommaya reservoir, 683  
 oncoproteins, 236, 273  
 oncotic pressure, 405  
   relation to osmotic pressure, 389  
   role in glomerular filtration, 389  
 open heart surgery, 644  
 ophthalmoscope, 448  
 opsonization, 258, 273  
 organelles  
   in cells, 195  
 organs  
   in relation to tissues, 196  
 organs, artificial, *See* artificial organs  
 Orthoclone, 592  
 osmoregulators, 403  
 osmosis, 77, 80, 87  
 osmotic pressure, 75, 77, 87  
 ova, 102, 208  
 oximeter, *See* oxygen, saturation measurement  
 oxygen  
   carriage in the blood, 303  
   consumption rate, 302  
   electrode, 461  
   partial pressure in alveolus, 302  
   role in energy metabolism, 295  
   saturation measurement, 470  
   solubility, 305  
   tension, 305  
 oxygen-15, 514, 538  
  
 P wave, 476  
 pacemaker, 477, 648  
   number in US, 477  
 pancreas, 317  
   artificial, 473, 551  
 para-aminohippuric acid, 395  
 paracellular pathway, 397  
 paracrine, 237  
 Parkinson's disease, 18, 237,  
   275  
 partial pressure, 303, 334  
 patch-clamp method, 458

- pathogens, 590, 622
  - immune response to, 258
- PCR, 134, 149
- penicillin, 388, 574
- pepsin, 316
- peptidases, 317
- peptide bond, 122
- peptides
  - in adhesion, 198
  - signal, 174
- peptidoglycan, 194
- peristalsis, 315
- permeability
  - glomerular filtration, 390
  - relationship to resistance, 359
- peroxisomes, 195, 223
- personalized medicine, 450, 687
- PET, 497
- Peters, Wilbur, 522
- pH, 50
  - definition, 51, 87
  - disease, 51
  - measurement, 478
  - neutral, 51
- pH meter, 479
- pH, Henderson–Hasselbalch equation,
  - See* Henderson–Hasselbalch equation
- pharmacodynamics, 549
- pharmacokinetics, 547
- phenotype, 103, 149
- phenylalanine, 324
- phosphodiester bond, 114, 149
- phospholipid, 60, 72, 87
- phosphorylation, 171, 173, 185, 240
- photodiode, 462, 491
- photography, 499
- photomultiplier, 462, 491, 516
- physiological modeling, 15
- piezoelectric, 457, 491
- piezoelectric crystals, 509
- plants
  - genetically modified, 139
- plasma, 342
- plasma cell, 591, 622
- plasma membrane, 193, 198
  - cleavage, 208
  - protein anchorage, 171
- plasmid
  - map, 132
- plasmids, 125, 130, 132, 149
- plastic deformation, 418, 440
- platelets, 343
- pluripotent, 211, 223
- pneumothorax, 431, 441
- podocytes, 389
- point-of-care, 449, 491, 573
  - glucose measurement, 472
- Poiseuille, Jean Léonard Marie, 349
- Poisson probability, 519
- Poisson probability distribution, 518–19
- Poisson, Siméon Denis, 519
- polar, 87, 89
- polio, 603, 609
- poliomyelitis, *See* polio
- poliovirus, 607
  - disease, 607
  - oral polio vaccine, 608
  - vaccine development, 607
  - vaccine, clinical testing, 608
- poly(ethylene terephthalate), 59
- poly(ethylene-co-vinyl acetate), 553
- poly(glycolic acid), 586, 627
- poly(lactide-co-glycolide), 555
- poly(methyl methacrylate), 627, 631
- poly(vinyl chloride), 630
- polyamides, 629
- polyanhydride, 556
- polyesters, 629
- polyethylene, 629
  - structure, 59
  - uses, 60
- polygenic diseases, 95
- polymerase
  - DNA, 113, 137, 147
- polymerase chain reaction, *See* PCR
- polymerization, 59, 87
  - condensation reactions, 61, 84
- polymers, 58
  - biodegradable, 556, 580
  - biological, 58
  - cross-linked gels, 555
  - definition, 87
  - in drug delivery, 552
  - microspheres, 556
  - nondegradable, 555, 582

- polymers, (cont.)
  - synthesis and breakdown reactions, 61
  - synthetic, 59
- polypeptide, 70, 87
  - denaturation, 165
- polypropylene, 59
- polysaccharides, 58, 60–1, 64
- polystyrene, 216
- polytetrafluorethylene, 631
- positron emission tomography, 514, *See* PET
- post-translational modifications, *See* proteins,
  - post-translational modifications
- potassium, 244
- potential
  - electrical, measurement, 473
- potentiometric, 461
- PR segment, 476
- pregnancy, 7, 18, 71, 106
- prenylation, 122, 149
- pressure
  - circulatory system, 365
- pressure drop
  - axial vs. transmural, 352
- primers
  - in DNA replication, 115, 134
  - in PCR, 112
- progenitor cells, 211
- Progestasert, 553
- proinsulin, 125
- projection, 539
  - reconstruction of images, 506
- prokaryotes, 120, 146, 193
  - doubling time, 194
- proliferation
  - in the immune system, 263
  - in the intestine, 320
- prometaphase, 207, 224
- promoter, 118, 149
  - in RNA synthesis, 118–19
- prophase, 207, 224
- prophylaxis, 600, 622
- prostheses
  - dental, 627
  - hip, 626
- proteases, 173, 185
  - inhibitors, 174, 185
- protein
  - assays, 481
  - generation of urea on metabolism, 400
  - three-dimensional structure, 168
- proteins, 38, 58, 60, 69, 162
  - cleavage into active forms, 173
  - daily consumption, 323
  - denaturation, 165
  - diversity, 170
  - expression, 114
  - folding and hydrophobic effect, 87
  - function, 170
  - in adhesion, 204
  - in extracellular matrix, 197
  - molecular weight, 170
  - nascent, 168, 185
  - post-translational modifications, 122, 195
  - primary structure, 163
  - protein-folding problem, 165
  - quaternary structure, 168
  - recombinant, 160
  - secondary structure, 163
  - synthesis, 120, 174
  - synthesis from DNA, 69
  - tertiary structure, 165
  - three-dimensional structure, 44, 70, 167
- proteins, transport, *See* transport proteins
- proteoglycans, 197
- proteolysis, 122, 149
  - in immunity, 258, 273
- proteome, 162
- proteomics, 162, 185
- proton, 50, 87
- proximal tubule, 397, 406
- pulmonary valve, *See* valve, pulmonary
- Punnett square, 104, 154
- purines, 68, 85, 87, 107
- pyrimidines, 68, 87, 107
- pyroelectricity, 468, 491
- pyrogens, 464, 491
  
- QRS wave, 476
- Quijano, Elias, 659
  
- rabies, 597
- radiation, 503
- radiation oncologists, 675
- radiation therapy
  - biological effects, 671
  - in cancer, 671
- radioactive molecules, 513, 539
- rate constant
  - for tracer elimination, 289



- reabsorption
  - kidney, 396, 406
- reaction
  - reversible, 56, 88
- reaction kinetics
  - first-order, 380
  - zero-order, 380
- reactor
  - batch, 325
  - chemical, 325
  - ideal plug flow, 328
  - ideal stirred tank, 329
- receptor tyrosine kinases, 239
- receptor–ligand binding
  - models, 233
- receptors, 162, 170, 233, *See* receptor tyrosine kinases
  - acetylcholine, 249
  - cell surface, 239
  - down-regulation, 204
  - on the cell surface, 239
- recombinant DNA technology, 128, 138, 149
- recombinant proteins, 97, 128
- red blood cells, 102, 342
  - deformation, 433
- red cells, *See* red blood cells
- refraction, 520, 539
- refractory period
  - in action potentials, 244, 273
- registration, 539
  - of images, 532
- renal, *See* kidneys
- renal plasma flow, 387
- renatured
  - DNA, 109
- replication fork, 110, 149
- replication origins, 110, 149
- repolarization
  - membrane, 244, 273
- reproductive health, 106
- resistance
  - electrical, 299
  - in parallel, 454
  - in series, 454
  - of arterioles and capillaries, 350
  - to air flow, 299
  - to blood flow, 350
  - to glomerular filtration, 389
- resistors, *See* resistance
- resolution, 529, 539
- respiration, 295
  - external, 295, 334
  - internal, 295, 334
- respiratory distress syndrome, 431
- respiratory membrane, *See* membrane, respiratory
- restriction endonucleases, *See* restriction enzymes
- restriction enzymes, 111, 130, 132, 150, 175
  - microbial defense, 132
- restriction fragment length polymorphism, 111, 142
- retinoids, 256
- retrovirus, 612
  - life cycle, 135
- reverse transcriptase, 134, 150
- Reynolds number, 352, 370
- Reynolds, Osborne, 351
- ribonucleases, 317
- ribonucleic acid, *See* RNA
- ribose, 63, 65, 88, 107
- ribosomal RNAs, *See* rRNA
- ribosomes, 120, 150, 195, 224
- rice
  - genetically modified, 139
- Richards, Jack, 219
- Richards-Kortum, Rebecca, 535
- RNA, 61, 65
  - antisense, 146
  - chemical structure, 107
  - RNA sequencing, 696
  - RNA-induced silencing complex (RISC), 168
- RNA interference, 150, 690
- RNA polymerase, 70, 150
- RNA primase, 115, 150
- RNA synthesis, 118
- Röntgen, Wilhelm, 501
- rRNA, 120
- S phase, 206, 224
- SA node, 362
- Sabin, Albert, 608
- Sakmann, Bert, 459
- Salk polio vaccine, 6
- Salk, Jonas, 607
- saltatory conduction, 247, 273
- Saltzman, W. Mark, 28
- sarcomeres, 172
- SARS, 24
- Scatchard analysis, 234
- schistosomiasis, 589
- Schwann cells, 246, 273

- scintillation detector, 516  
 scopolamine, 554  
 second messengers, 240  
 secondary active, 201  
 secretion, 406  
   kidney, 396  
 Seebeck effect, 453  
 segmentation, 539  
   of images, 533  
 selectins, 205, 224  
 selection  
   by antibiotic resistance, 134, 146  
 self-renewal, 210  
 semiconservative  
   replication of DNA, 113, 150  
 sensors, 451  
   blood glucose, 471  
   types, 453  
 sequence homology analysis, 171, 185  
 Serrano, Katie, 699  
 Severe Acute Respiratory Syndrome,  
   *See* SARS  
 Shamir, Eliah, 618  
 shear stress, 344  
 Shelley, Mary, 7  
 shunts, 629  
 SIgA, 596  
 signal, 491  
   in bioinstrumentation, 452  
 signal transduction, 232, 273  
   and drug targets, 236  
 signal-to-noise ratio, 539  
   in nuclear medicine, 518  
 silicone, 59  
 single photon emission CT imaging,  
   *See* imaging, SPECT  
 sinoatrial node, *See* SA node  
 siRNA, 126, 141, 150, 690  
 skeletal system, 413  
 skin, 192  
   role in immunity, 258  
   tissue-engineered, 562  
 small interfering RNAs, *See* siRNA  
 small intestine, 319  
   surface area, 319  
 smallpox, 588, 605  
   disease development, 605  
   vaccine development, 605  
 smooth muscle  
   in arterioles and arteries, 353  
   Snell's law, 520  
 sodium  
   reabsorption in kidney, 387  
   reabsorption in kidney tubules, 398  
   regulation by kidney, 400  
 sodium hydroxide, 55, 57  
 sodium potassium pump, *See* Na<sup>+</sup>/K<sup>+</sup> ATPase  
 somatic cells, 101, 115  
 Southern blotting, 142, 150  
 speckles  
   in ultrasound imaging, 510  
 SPECT, *See* imaging, SPECT  
 spectrophotometer, 449, 479  
 speed of light, 503  
 sperm, 101, 110, 147, 208, 228  
 sphincter, 315  
   ileocecal, 321  
   lower esophageal, 315  
   pyloric, 317  
 sphygmomanometer, 448, 469  
 spider silk, 43  
 spirometer, 297, 334  
 spleen, 258  
 splicing  
   in RNA processing, 119, 150  
 spongy bone, 425  
 spring  
   perfectly elastic, 423  
 ST segment, 476  
 starch, 66, 83, 321  
 Starling, Frank, 359  
 Starling's equation, 359  
 start codon, 121  
 STAT, 265  
 steady-state, 77  
   definition, 291, 335  
   in weight regulation, 293  
 stem-cell engineering  
   ethics, 25  
 stem cells, 210  
   adult, 210  
   embryonic, 210  
   in human therapy, 1  
   in tissue engineering, 213  
   induced pluripotent (iPS), 213, 222  
 stent, 467, 491, 662  
   drug-eluting, 467, 648  
   vascular, 648  
 steroid, 72, 123, 256  
   signaling, 257

- steroid hormone receptors, 123, 231
- stethoscope, 448
- sticky ends, 130
- stimulation, electrical, *See* electrical stimulation
- stoichiometry, 326
- stomach, 316
  - contractions, 317
  - function, 316
- strain, 417, 441
- strain energy, 421, 441
- strain gauge, 457, 491
- stress–strain relationships, 417
- stroke volume, 365, 370
- substrates, 175
  - for enzymes, 175, 185
- sucrase–isomaltase, 323
- sucrose, 64, 88
- surface tension, 430, 441
- surfactant
  - lung, 431
- surgery
  - in cancer, 669
- sutures, 555, 627
- synapses, 247, 274
  - chemical, 247
  - electrical, 247
- synaptic cleft, 247, 274
- system
  - boundaries, 283, 335
  - definition, 283, 335
- systems biology, 16, 22, 95, 150, 160, 691
- systole, 364, 370
- T cell, 258
  - antigen-specific, 259
  - helper functions, 259, 272
  - receptor, 261
  - signaling, 261
- T wave, 476
- tamoxifen, 237
- technetium-99m, 380
- technology
  - definition, 10
- telomerase, 209
- telomeres, 209, 224
  - shortening, 209
- telophase, 207, 224
- temperature
  - measurement, 453
  - radiation, 503
  - scales, 465
- tendon, 413
- tensile elastic modulus, *See* Young's modulus
- testosterone, 687
- tetracycline, 125
- thermistor, 457, 492
- thermocouple, 453, 492
- thermodynamics
  - definition, 46, 88
- thermometer, 465
  - IR radiation, 468
  - mercury, 465
- thick filaments
  - of muscle proteins, 172
- thin filaments
  - of muscle proteins, 172
- thorax, 427, 441
- three-dimensional reconstruction, 506
- threonine, 324
- thrombin, 631
- thymine, 66, 88, 107
- thymus, 258
- thyroid hormones, 256
- tidal volume, 297, 335
- tight junctions
  - in epithelial cells, 397
- tissue
  - types, 196
- tissue engineering, 192, 213, 559, 582
  - biomaterials, 627
- tissue factor, 632
- tissue plasminogen activator, 556, 582
- Tools, Robert, 647
- topoisomerases, 115
- total internal reflection, 522, 539
- toxins
  - in the environment, 281
- tracer
  - balance in the body, 289
  - in nuclear medicine, 514, 540
  - in reactor, 289
- trachea, 297, 335, 429
  - specialized in newborns, 324
- traits
  - genetic, 99, 103, 150
- transcellular pathway, 397
- transcription, 69, 88, 116, 123, 150
- transcription factors, 118, 123, 256

- transduction, 134, 151
- transfection, 134, 151
  - methods, 134
- transfer RNA, *See* tRNA
- transferrin, 204
- transformation
  - bacterial, 134, 151
  - in cell culture, 207
- transgenic animals, 140, 151
- translation, 69, 88, 116, 151
- transmission light, *See* spectrophotometer
- transport proteins, 198
- tricuspid valve, *See* valve, tricuspid
- triglycerides, 45, 60, 72, 88, 317, 324
- tRNA, 151
- tryptophan, 324
- tubular reabsorption, 396
- tumor
  - brain, 681
  - microcirculation, 343
- tumor suppressor proteins, 236, 274
- tumorigenicity, 218
- tumor-infiltrating lymphocytes, 689
- turbulent flow, 351, 370
  
- ultrafiltration, 406, 640, 662
  - coefficient, 392
- ultrasound, 508
  - imaging, 2
- ultraviolet, 504
- uracil, 88, 107
- urea, 385, 662
- ureters, 386, 406
- urine, 385
  - concentration mechanisms, 386
  
- vaccination
  - smallpox, 614
- vaccine, 1, 545, 588, 622
  - adjuvants, 611
  - DNA, 614
  - for cancer, 616
  - inactivated, 608
  - killed, 608
  - recombinant subunit, 611
  - Salk, 607
  - subunit, 623
- vaccines, 603
  - childhood, 589
  - DNA, 614
  - history of introduction, 604
  - in cancer treatment, 690, 701
  - role of biomaterials, 616
- vaccinia, 605, 622
- valency, 596, 622
- valine, 324
- valve
  - aortic, 362
  - in the heart, 361
  - intestine, 315
  - mitral, 362
  - pulmonary, 362
  - tricuspid, 361
- valve, artificial heart, *See* artificial heart valve
- van der Waals interactions, *See* bonds, van der Waals interactions
- van Leeuwenhoek, Antonie, 520
- van 't Hoff equation, 78
- variola, 605, 622
- vascular endothelial growth factor, *See* VEGF
- VEGF, 566
- vein
  - hepatic portal, 318
- velocity, 177
  - of a chemical reaction, 177–8
- ventilation, 299, 335
  - driving force, 300
  - rate, 300
- ventricle, 361
- ventricular assist device, 645
- Vesalius, Andreas, 499
- vessel
  - blood flow in a cylindrical, 347
- vessel, blood, *See* blood vessel
- viral vectors
  - gene therapy, 135
- virus, 136
  - attenuated, 611
  - life cycle, 604
- viscoelastic materials, 422
- viscoelasticity, 423, 441
- viscosity, 370, 422
  - blood, 343, 345
  - cellular, 434
  - measurement, 344
  - water, 343
- visible light, 504
- vitamin A, 139, 256
- vitamin C, *See* ascorbic acid

- vitamin D, 256
- voltage clamp, 459, 492
- voltage gradient, 245
- Voorhees, Arthur B., 631
  
- wall tension, 430
- water, 41–3
  - chemical structure, 39
  - composition of human body, 44
  - condensation reactions, 61
  - dissociation reactions, 50
  - formation, 41
  - hydrolysis reactions, 48, 86
  - ion product, 52
  - permeations from capillaries, 360
  - properties as a solvent, 44
  - reabsorption in kidney, 386
  - regulation by kidney, 389
  - total body distribution, 403
- Watson, James, 94, 107, 128, 145
  
- Watson–Crick base-pairing rules,
  - See* base-pairing rules
- wavelength, 503
- West Nile virus, 24
- Whitaker Foundation, 14, 30
- World Health Organization, 589
  
- x-ray
  - imaging, 501
- x-rays, 500, 672, 703
  - crystallography, 162, 169, 186
  
- yield
  - materials, 418
  - strain, 418, 441
- Young's modulus, 413, 418, 430, 441
  
- Z line, 172
- zymogens, 318