INDEX

NUMBERS	amino acids, types of, 23, 57, 74	thermus aquaticus, 204
3' (3 prime) end, 117-118	alanine, 74, 75, 167-171	basal cells, 103, 128
5' (5 prime) end, 117–118	arginine, 74, 154, 169	base sequences
o (o pe, ea, 11. 11e	asparagine, 74, 169	DNA, 79-80, 86, 88, 108,
A	aspartate, 74	112, 139, 150, 157, 191,
A (adenine), 85, 107–108, 157	cysteine, 74, 169	197, 208
acetaldehyde dehydrogenase	glutamate, 74	mRNA, 146, 153, 167-168,
(ALDH1, ALDH2), 66–67,	glutamic acid, 74, 76,	170–171
69–70	154, 169	RNA, 141, 146-150, 153,
acetic acid, 67, 69, 70	glutamine, 74, 169	160–161, 170–171, 203
actin, 71, 72	glycine, 74, 169	tRNA, 165, 170-171
actin filament, 71	histidine, 74, 167-170	bead structure, DNA, 42–44, 70,
ADA (adenosine deaminase)	isoleucine, 74, 154, 169	144–145
deficiency, 199–200	leucine, 74, 154, 169	benzene rings, 75
adenine (A), 85, 107–108, 157	lysine, 74	biocatalysts, 69
adenosine deaminase (ADA)	methionine, 74, 166-170	blood, 49, 75-76
deficiency, 199–200	phenylalanine, 74, 169	blood cells, 75–76
ADH (alcohol dehydronase),	proline, 74, 154, 169	blood sugar, 61-62, 185, 196.
66-67, 69-70	serine, 74, 75, 154, 167–169	See also glucose
adipose tissue, 49	threonine, 74, 169	blood vessels, 51, 59
agar-based plates, 190, 191, 192	tryptophan, 74, 169	bone tissue, 49
alanine, 74, 75, 167–171	tyrosine, 74, 75, 154, 169	breed improvement, 183–184
alcohol, 59, 64-65, 67-70, 191	valine, 74, 76, 169	breeding, 193, 195, 206
alcohol dehydronase (ADH),	amoebas, 19, 22, 48	C
66-67, 69-70	anaphase, 126	
ALDH1 (acetaldehyde dehydroge-	animal cloning, 205–208	C (carbon), 117–118, 159
nase), 66–67, 69–70	animal genome, 192-193, 207 animals, transgenic, 192-195	C (cytosine), 85, 107–108,
ALDH2 (acetaldehyde dehydroge-	antibiotic, 190	157, 158
nase), 66–67, 69–70	anticodons, 171–172	cancer
amino acids	arginine, 74, 154, 169	brain tumors, 200
about, 23, 38, 57-58, 73-76	asexual reproduction, 100	breast cancer, 200
codons, 166, 168–170,	asparagine, 74, 169	causes of, 130, 137, 194, 196–198
171, 173	aspartate, 74	gene therapy for, 196,
protein creation and, 73–76,	aspiration, 33	198–200
77–80, 167–172	ATP, 33	intestinal cancer, 196
replacing one with another,	axons, 24	as lifestyle-related disease,
75–76, 77		196–198
sequences of, 57–58,	В	screening DNA for, 88
77–80, 174	bacteria	skin cancer, 194
side chains, 74–75 strings of, 57, 167, 172–174	about, 22, 32, 33, 48, 52, 155	treatments for, 181–184, 194
strings of, 57, 167, 172–174 structure of, 74–75, 86	E. coli (Escherichia coli),	tumors, 130, 200
in transcription/translation,	100, 185	carbohydrates, 23
57, 154, 166–173	intestinal bacteria, 48	carbon (C), 117–118, 159
37, 134, 100-1/3		

carbon dioxide, 67, 69, 70	dendrites, 24	cut and paste gene recombina-
carboxy-terminal domain	embryonic stem (ES), 193,	tion, 186, 188-189
(CTD), 153	208, 209	cysteine, 74, 169
carcinogens, 137	human, 21, 24, 31, 32, 123	cytokinesis, 124, 127, 129
cardiac muscle, 50	induced pluripotent stem	cytoplasm, 25, 31, 38, 44-45, 52
catalysts, 65, 69	(iPS), 209	125, 126, 152, 201
cDNA (circular DNA), 188, 190	liver, 59, 62, 62n, 67, 141	cytosine (C), 85, 107-108,
cDNA libraries, 188	muscle, 60-62, 71	157, 158
cell body, 24	nerve/neurons, 24, 50, 141	
cell cycle, 128-129	plant, 127	D
cell division	prokaryotic organisms, 51-52	dehydrogenase enzymes, 66-67,
about, 70, 92, 97-103, 122,	skin, 49, 57, 102-103,	69–70
123, 124–127	128, 209	demographic studies, 196
cancer and, 130	somatic, 207–208	denatures, 204
cell cycle, 128-129	stem, 193, 208, 209	dendrites. 24
cytokinesis, 124, 127, 129	totipotent, 193, 209	deoxyribonucleic acid, 43. See
mitosis, 124-127, 129	cell walls, 127	also DNA
cell membranes, 23, 27-32, 36,	centrosomes, 25, 124-125	deoxyribonucleotides, 83, 158.
52, 70	chemical reactions, 65-67,	See also nucleotides
cell nucleus. See nucleus	69–70, 72	deoxyribose, 84-85, 117-118,
cell organelles, 23, 31-35, 52,	cholesterol, 23	158–159
127, 174	chromatins, 122, 128,	dermis, 102
cell plates, 127	144–145, 148	destination DNA, 189
cells	chromosomes, 88-89,	detoxification, 67, 69
abnormalities in, 10, 130,	122–126, 128	diabetes, 184, 196
137-138, 182-183	sex chromosomes, 123	digestive system, 32, 48-51, 59
communication between, 29	circular DNA (cDNA), 188, 190	61–62, 67, 69–70
defined, 16-19	circulatory system, 51	diseases. See also cancer
discovery of, 18, 20	cloning	adenosine deaminase (ADA)
energy production in, 23,	animal, 205–208	deficiency, 199-200
32–33, 61, 75	Dolly the sheep, 207-208	brain tumors, 200
eukaryotic organisms, 51-52,	ethical concerns, 208	causes of, 10, 130, 137, 194,
152n	human, 208	196–197
functions, 59-60	transduction and, 186,	gene therapy for, 196,
as living organisms, 20-24, 31	189–191	198-200
multicellular organisms, 19,	coding strands, 146–147	heart disease, 197, 209
48-52, 100-103	codons, 166, 168-170, 171, 173	lifestyle-related, 196-198
name origin of, 18, 18n	anticodons, 171-172	macular degeneration, 203
single-celled organisms, 19,	stop, 169, 170, 172-173	metabolic syndrome, 196, 197
22, 24, 48–52, 97–100	collagen, 49, 57, 72	personalized medicine for,
structure of, 23, 25–26,	columnar epithelium, 49	196-198
73, 124	conditions. See diseases	RNA-based medicines for, 203
cells, types of	connective tissue, 49, 50	sickle-cell, 76
animal, 123, 127	cristae, 33	treatments for, 181-184, 194,
basal, 103, 128	crossbreeding, 193, 195, 206	196–200, 203
blood, 75–76	CTD (carboxy-terminal	dizygotic cells, 89
cancer, 130	domain), 153	

DNA (deoxyribonucleic acid), 43 abnormalities and mutations, 130, 137-138, 158, 193, 208 about, 11-12, 35-36, 37, 52, 56-59 bases/characters of, 85-86, 107-108, 157-160 base sequences of, 79-80, 86, 88, 108, 112, 139, 150, 157, 191, 197, 208 bead structure of, 42-44, 70, 144-145 characters of/bases, 85-86, 67-108, 157-160 chromosomes, 88-89,	5' (5 prime) end, 117–118 about, 138 double-helix, 81–82, 106, 108–109, 146 duplex structure and, 105–108, 146 genes and, 105–106 hydrogen bonds, 76, 107, 110 Okazaki fragments, 118–119 polymerase role in, 108–120, 158 proteins and, 114–115 RNA primer, 115–116, 188 Dolly (sheep), 207–208 double-helix, DNA, 81–82, 106, 108–109, 146	RNA polymerase, 148–154 spliceosomes, 154 epidermis, 102 epithelial tissue/epithelium, 49, 50 ES (embryonic stem) cells, 193, 208, 209 Escherichia coli (E. coli), 100, 185–186, 189–191 eukaryotic organisms, 51–52, 152n evolutionary process, 142, 155–156, 208 molecular evolution, 208 exons, 153–156 exon shuffling, 155–156
122–126, 128 coding strands, 146–147	E	F
double-helix, 81–82, 106, 108–109, 146 double-stranded structure of, 106–109, 117, 146, 149–150 genome, 88–90, 192–193 manipulating, 181–183 nucleotides, 70, 73, 80–87, 106, 107, 109, 111, 115, 117, 158 proteins and, 42–45, 56–62, 70, 72, 114–115 pure, 191–192 structure of, 42–44, 70, 77–87, 106–109, 117, 144–145, 160, 164 sugar-phosphate backbone of, 107, 158–159, 191 synthesis, 114, 116–117 DNA, types of circular (cDNA), 188, 190 destination, 189 junk, 143 pure, 191–192 DNA ligase, 189, 205 DNA polymerase, 70, 108–120, 158, 203 DNA replication, 58, 69, 70, 92,	E. coli (Escherichia coli), 100, 185–186, 189–191 EcoRl, 188 embryonic stem (ES) cells, 193, 208, 209 embryos, 193, 205–206, 209 endoplasmic reticulum, 25, 31–32, 36, 165, 174 energy production, cell, 23, 32–33, 61, 75 enzymes about, 57, 61–68, 72 acetaldehyde, 66–67 binding to, 64 catalysts, 65, 69 chemical reactions, 65–67, 69–70, 72 conformation changes in, 64 defined, 61–62, 64, 72 dehydrogenase enzymes, 66–67, 69–70 DNA ligase, 189, 205 DNA polymerase, 70, 108–120, 158, 203 protective enzymes, 66 proteins and, 61–70 restriction enzymes, 188, 204–205	fats, 23, 26–27, 49, 59, 61, 196 fertilization, 96, 101, 205–207 fibrous connective tissue, 49 Fire, Andrew Z., 201 5' (5 prime) end, 117–118 flat epithelium, 49 foraminifera, 177 G G (guanine), 85, 107–108, 157 G ₁ /G ₂ phases, 128–129 gel electrophoresis, 191 gene expression, 46–47, 143, 201–204 gene recombination, 183–191 genes abnormalities and mutations, 130, 137–138, 158, 193, 208 about, 11, 36, 44–46, 52, 56–58 ADA gene, 199–200 as blueprints, 11, 44, 45, 57–58, 77–79, 106, 137–139, 146, 153, 183 building proteins and, 77–80 cancer and, 88, 130, 137, 194, 196, 197, 200

genes, continued DNA replication and, 105–106 evolutionary process and, 142, 155–156, 208 exons, 153–156 fossil remains of, 143 introns, 153–154, 155, 165, 188 pseudogenes, 142–143 splicing, 154, 155 structure of, 78–80 transgenes, 193	human, 88–90 Human Genome Project, 88 genomics, 209 globins, 76 glucose, 23, 33, 61–62, 69 glutamate, 74 glutamic acid, 74, 76, 154, 169 glutamine, 74, 169 glycine, 74, 169 glycogen, 61–62, 62n, 69 glycogen synthase, 61, 69 Golgi apparatus, 25, 31, 32,	induced pluripotent stem cells (iPS cells), 209 insulin, 72, 185 intestinal bacteria, 48 intestines, 48, 51, 59, 61, 196 introns, 153–154, 155, 165, 188 iPS cells (induced pluripotent stem cells), 209 isoleucine, 74, 154, 169 J junk DNA, 143
tumor suppressor genes, 130 gene therapy, 196, 198–200 genetic advances, future, 209 genetic code, 80, 167–168 genetic diseases. See diseases	34, 174 Greek prefixes/suffixes chroma, 122 lyso, 34 peroxi, 34 some, 34	K keratin, 57, 72 knockout mice, 192–195
genetic information, 138-141 genetic technologies animal cloning, 205-208 breed improvement through hybridization, 183-184 breeding/crossbreeding, 193,	guanine (G), 85, 107–108, 157 H H (hydrogen), 9, 159 hair, 57	L lacteal glands, 207 large intestine, 48, 51, 196 leucine, 74, 154, 169 lifestyle-related diseases, 196–198
195, 206 cut and paste gene recombination, 186, 188-189 detecting and isolating DNA, 191-192 future of molecular	heart, human, 21, 31, 51, 57, 103 heart disease, 197, 209 hemoglobin, 72, 75–76, 138 heterochromatin, 145 histidine, 74, 167–170	ligaments, 49 lipids, 23, 27–30 liver cells, 59, 62, 62n, 67, 141 functions, 32, 61–64,
biology, 209 gene recombination, 176, 183-191 gene therapy, 196, 198-200 genomics, 209	histones, 42, 43, 122, 123, 144 homeostasis, 72 Hooke, Robert, 18, 20 Hooke's microscope, 18 hormones, 72	66-67, 69 toxicity, 64, 66-67 lungs, 51, 103 lysine, 74 lysosomes, 25, 32, 34
multiplication, 189–190 personalized medicine using, 196–198 polymerase chain reac- tion (PCR), 70, 108–120,	human cloning, 208 Human Genome Project, 88 hybridization, 184 hydrogen (H), 9, 159 hydrogen bonds, 76, 107, 110	macular degeneration, 203 maltose, 61 matrix, 33 medical treatments. See diseases
187–189, 191, 203–205 proteomics, 209 RNA interference, 201–203 RNA renaissance, 201 transduction and cloning, 186,	hydrophilic phospholipids, 28 hydrophobic interactions, 76 hydrophobic phospholipids, 28 hydroxyl (OH), 159 hypodermis, 102	Mello, Craig C., 201 membrane fusion, 29–30, 32 membranes, cell, 23, 27–32, 36, 52, 70
189-191 transgenic animals, 192-195 genome animal, 192-193, 207	I immune system, 57, 69 immunoglobin, 72	membrane transport vesicles, 26 messenger RNA. <i>See</i> mRNA metabolic syndrome, 196–197 metabolism, 59, 67, 199, 203

metaphase, 125 methionine, 74, 166–170 mice, 192–195, 202, 208 microRNA (miRNA), 202 microtubules, 125–126 miRNA (microRNA), 202 mitochondria, 25, 32–34 mitosis, 124–127, 129 mitotic division, 126 mitotic spindle, 126 molecular evolution, 208 molecules, 9–10, 16–18, 23, 29–36, 57, 60 monomers, 86 monozygotic cells, 89 mosaics, 193, 195 M phase, 128–129 mRNA (messenger RNA), 44, 201–202 base sequences, 146, 153, 167–168, 170–171 in transcription, 146–147, 153–154 in translation, 80, 165–166 MSG, 74 Mullis, Karry, 204 multicellular organisms, 19, 48–52, 100–103 muscle cells, 60–62, 71 muscle fibers, 71 muscles, 49–50, 59, 60, 62n, 71–72 muscular contraction, 57, 60, 71–72 muscular tissue, 49, 50	Nobel Prize, Physiology and Medicine, 194, 201 nonnucleated organisms, 52 nuclear envelope, 36, 44, 52, 124–126, 128, 152, 165 nuclear localization signal, 38 nuclear pore complex, 36, 44 nuclear transfer, 208 nucleated organisms, 52 nucleic acids, 23, 36, 43, 153, 199, 201, 202. See also DNA; RNA nucleoid body, 52 nucleosides, 85 nucleosomes, 43, 144 nucleotide bases, 85–86, 107–108, 157–160 nucleotides, 70, 73, 80–87, 106, 107, 109, 111, 115, 117, 158 nucleus defined, 35–36, 124 image of, 25, 35, 36, 81, 124, 126 presence or absence of in cells, 51–52 structure of, 37–47 true, 52 nutrients, 31, 48, 59, 69, 72, 127, 130 O obesity, 196 OH (hydroxyl), 159	liver, 59, 61–64, 62n, 66–67, 69, 141 lungs, 51, 103 in nervous system, 50 in respiratory system, 51 skin, 49, 57, 102–103, 128, 209 overhangs, 188–189, 205 oxygen, 9, 33–34, 72, 75 P paramecia, 18, 48, 52, 98, 100 PCR (polymerase chain reaction), 70, 108–120, 187–189, 191, 203–205 Pegapatnib, 203 peroxisomes, 32, 34 personalized medicine, 196–198 phenylalanine, 74, 169 phosphate groups, DNA, 107, 191 phospholipids bilayers, 28–29, 31 phospholipids, 27–30 phosphoric acid, 84–85, 117, 158–159 plasmid, 189–190, 204–205 pluripotent stem cells, 209 polymerase, DNA, 70, 108–120, 158, 203 polymerase, RNA, 148–154 polymerase chain reaction (PCR), 70, 108–120, 187–189, 191, 203–205 pores, of nuclear envelope, 36 polysaccharides, 23, 28
muscular tissue, 49, 50	OH (hydroxyl), 159	polysaccharides, 23, 28
mutations, 130, 137–138, 158, 193, 208	Okazaki, Reiji, 119 Okazaki fragments, 118–119	pre-initiation complex, 166 prokaryotic organisms, 51-52
myosin, 57, 71, 72 myosin filament, 71	organelles, 23, 31–35, 52, 127, 174	proline, 74, 154, 169 prophase, 124
N neomycin, 195 nerve cells, 24, 50, 141 nervous system, 50 nervous tissue, 49, 50 neurons, 24, 50, 141 Nobel Prize, Chemistry, 204	organs in circulatory system, 51 defined, 50 in digestive system, 32, 48-51, 59, 61-62, 67, 69-70 heart, 21, 31, 51, 57, 103 intestines, 48, 51, 59, 61, 196 lacteal glands, 207	proteins about, 11–12, 23, 28, 29, 32, 36, 56–60 amino acids and, 73–76, 77–80, 167–172 creation of, 56–58, 73–76, 77–80, 132, 138, 161, 167–172 defined, 57, 60

DNA and, 42–45, 56–62, 70, 72, 114–115 DNA replication and, 114–115 enzymes and, 61–70 folded forms, 174, 174n functions of, 56–60, 72 genes and building proteins, 77–80 hemoglobin and, 72, 75–76, 138 muscular contraction and, 57, 60, 71–72 in nucleus, 37–39 properties of, 77 role in cell division, 70 starch breakdown and, 61, 62 structure and shape of, 73–76, 86, 161, 174, 174n synthesis, 46–47, 165–167, 202 proteins, types of, 57, 69, 72 actin, 71, 72 ADA, 199–200 globins, 76 histones, 42, 43, 122, 123, 144 insulin, 72 myosin, 57, 71, 72 subunits, 76, 165–166 proteomics, 209 protozoa, 48, 52, 100, 178 pseudogenes, 142–143 pure DNA, 191–192 pyruvic acid, 33 Q quantitative PCR, 204. See also PCR (polymerase chain reaction)	restriction enzymes, 188, 204–205 ribonucleotides, 159 ribose, 159 ribosomal RNA (rRNA), 161, 165 ribosomes, 31, 32, 34, 38, 45, 80, 114, 152 in translation, 165–166, 170–173 ribozymes, 202 RISC (RNA-Induced Silencing Complex), 202 RNA. See also mRNA; tRNA about, 11–12, 37, 43, 44, 45, 56, 57, 156–162 bases/characters of, 156–158 base sequences of, 141, 146–150, 153, 160–161, 170–171, 203 characters of/bases, 156–158 flexibility of, 160–161, 164 messenger (mRNA), 152, 153, 161 miRNA (microRNA), 202 molecules, 202 ribonucleotides, 159 siRNA (short interfering RNA), 201–203 structure of, 160–161, 164 sugar-phosphate backbone of, 158–159 types of, 161–162 RNA-based medical treatments, 203 RNA-Induced Silencing Complex (RISC), 202 RNA interference, 201–203 RNA polymerase, 148–154 RNA primers, 115–116, 188, 204 RNA renaissance, 201 RNA sequences, 58 rough endoplasmic reticulum, 25 rRNA (ribosomal RNA), 161, 165 RT-PCR, 204. See also PCR (polymerase chain reaction)	SELEX method (Systematic Evaluation of Ligands by Exponential Enrichment), 203 sensory epithelium, 49 serine, 74, 75, 154, 167–169 sex chromosomes, 123 short interfering RNA (siRNA), 201–203 sickle-cell disease, 76 single-celled organisms, 19, 22, 24, 48–52, 97–100 siRNA (short interfering RNA), 201–203 skeletal muscle, 50 skin, 49, 57, 102–103, 128, 209 skin cancer, 194 small intestine, 48, 51, 59, 61 smooth endoplasmic reticulum, 25 somatic cells, 207–208 S phase, 128–129 spindle apparatus, 126 spindle fibers, 125–126 spliceosomes, 154 splicing, 154, 155 starch, 23, 61 stem cells about, 193, 208, 209 embryonic stem (ES) cells, 193, 208, 209 induced pluripotent stem cells (iPS cells), 209 totipotent cells, 193, 209 steric structure, 76 sticky ends, 188, 205 stomach, 48–51, 59 stop codons, 169, 170, 172–173 stratum basale, 103 substrates, 64 subunits, 76, 165–166 sugar-phosphate backbones, 107, 158–159, 191 sugars blood, 61–62, 185, 196 DNA vs. RNA, 158–159
respiratory system, 51		glucose, 23, 33, 61–62, 69

symbiotic relationships, 48	codons, 166, 168–170,
Systematic Evaluation of Ligands	171, 173
by Exponential Enrichment	mRNA in, 80, 165-166
(SELEX) method, 203	pre-initiation complex, 166
	protein synthesis mechanism,
Т	165–167
T (thymine), 85, 107–108,	ribosomes in, 165-166,
157–160	170–173
telophase, 126	tRNA and, 165-167, 170-173
tendons, 49	wobble base pairing, 171
thermus aquaticus, 204	transport vesicles, 26
3' (3 prime) end, 117–118	tRNA (transfer RNA)
threonine, 74, 169	about, 161, 165–167, 202
	base sequences of, 165,
thymine (T), 85, 107–108,	170–171
157–160	in translation, 165–167,
tissues	170-173
about, 49–50, 73, 103	true nucleus, 52
adipose, 49	tryptophan, 74, 169
blood, 49, 75-76	tumors, 130, 200
bone, 49	tumor suppressor genes, 130
connective, 49, 50	tyrosine, 74, 75, 154, 169
epithelial/epithelium, 49, 50	tyrosine, 74, 75, 154, 169
fibrous connective, 49	U
muscular, 49, 50	
nervous, 49, 50	ultraviolet (UV) light, 137,
stomach, 48–51	191, 194
topoisomerase, 70	unicellular organisms. See single-
totipotent cells, 193, 209	celled organisms
trachea, 51	UV (ultraviolet) light, 137,
transcription	191, 194
about, 45, 58, 138–142	
chromatin and, 144-145, 148	
coding strands, 146-147	V
exons and introns, 153-156	valine, 74, 76, 169
heterochromatin, 145	vectors, 185, 189-190, 195,
mRNA in, 146–147, 153–154	199, 205
pseudogenes, 142-143	vesicles, 26, 31, 32
RNA polymerase, 148–154	visceral muscle, 50
splicing, 154	
transcription of genetic	W
information, 139	water, 8-9, 23, 67, 69, 70,
transduction and cloning, 186,	84, 187
189–191	wobble base pairing, 171
transfer RNA. See tRNA	g,
transgenes, 193	Z
transgenic animals, 192-195	zygotes, 101
translation	2,90(63, 101
amino acids in, 166-173	