reducing removal of CO_2 from the atmosphere by plants. Both of these activities contribute to an increased greenhouse effect, because more CO_2 in the atmosphere could trap more heat. A temperature increase of just a few degrees could melt polar ice, flooding coastal regions. Storms could intensity and droughts become more common. We could reduce our contribution to the greenhouse effect by using fossil fuels more efficiently, recycling forest products, and replanting trees on deforested land.

Apply the Concepts

Multiple Choice: 1. a 2. d 3. e 4. c 5. a 6. c 7. c 8. a 9. c 10. e 11. d

Essay: 1. Plants would grow most slowly under green lights, because green light is not absorbed well by photosynthetic pigments. Green is reflected, which is why plants are green.

2. Carotenoids absorb all colors except yellow and orange. Because carotenoids absorb green light, they are able to capture some light energy not absorbed by chlorophyll and channel this energy to chlorophyll for use in photosynthesis.

3. Energy from the movement of excited electrons along a chain of electron carriers is used to pump H^+ through the membrane into the thylakoid space. This buildup of H^+ lowers the pH of the solution in the thylakoid space.

4. In photosynthesis, high-energy electrons come from chlorophyll whose electrons are excited by light. These electrons are replaced by splitting water. In cellular respiration, glucose is the source of high-energy electrons. In both processes, movement of the electrons through electron carriers is harnessed to move H^+ through a membrane; this energy is ultimately used by ATP synthase to make ATP. In photosynthesis, the high-energy electrons are also used to make glucose. In cellular respiration, the electrons combine with O_2 and H^+ to form water. Photophosphorylation takes place in the thylakoid membranes of the chloroplast; oxidative phosphorylation takes place along the inner membrane of the mitochondrion. In both processes, ATP synthase harnesses flow of H^+ through the membrane to make ATP.

5. In the light reactions of photosynthesis, sunlight excites chlorophyll in a leaf, causing it to give up excited electrons. High-energy electrons move through electron carriers, which generate an H^+ gradient, which in turn is harnessed to make ATP. The electrons and hydrogen are picked up by $NADP^+$, forming NADPH. In the Calvin cycle, energy from the ATP and hydrogen and electrons from NADPH are used to reduce CO_2, forming sugar. When you consume the plant, the sugar is "burned" in cellular respiration. The glucose is oxidized, and its hydrogen and electrons are transferred to NAD^+ and FAD, forming NADH and $FADH_2$. These molecules deliver the high-energy electrons to the electron transport system in the mitochondrion. The electrons move through electron carriers, which generate an H^+ gradient, which in turn is harnessed by ATP synthase to make ATP. The ATP is then hydrolyzed to ADP and P to power muscle movement.

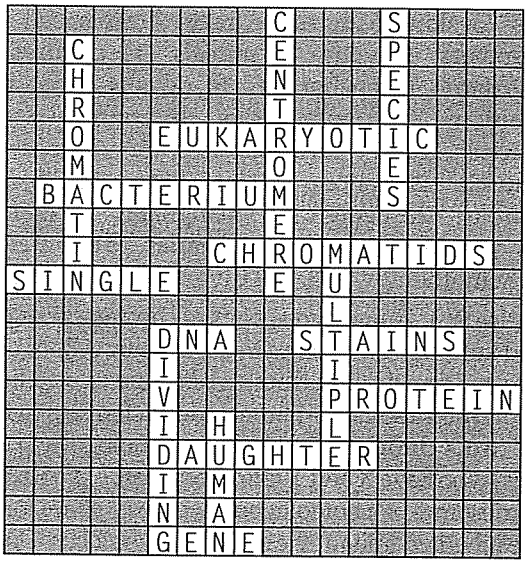
6. Van Helmont was correct in concluding that the soil did not contribute much material to the growth of the tree, but he was wrong in thinking that the weight gain must have come from the water. What van Helmont couldn't know (but we do) is that water supplies only the hydrogen atoms used in photosynthesis to build the carbohydrates that make up most of a plant. The bulk of the atoms in carbohydrate molecules—all the carbon and oxygen—come from CO_2 that the plant gets from the air!

Chapter 8

Review the Concepts

Exercise 1: 1. like 2. asexual 3. DNA 4. DNA 5. chromosomes 6. identical 7. mother 8. binary fission 9. circular 10. smaller 11. duplicates or replicates 12. plasma membrane 13. wall 14. genomes 15. egg 16. sperm 17. fertilization 18. variation

Exercise 2:



Exercise 3: 1. interphase, activity between divisions 2. G_1, cell growth following division 3. S, growth and DNA synthesis 4. G_2, growth and activity between DNA replication and division

5. mitotic phase, mitosis plus cytokinesis 6. mitosis, division of nucleus and chromosomes 7. cytokinesis, division of cytoplasm

Exercise 4: *Nucleus:* I—envelope intact, chromatin dispersed; P—envelope intact, chromosomes condense; PM—envelope breaks down; M—none; A—none; T—daughter nuclei and envelopes form. *Spindle:* I—none; P—spindle begins to form from microtubules; PM—spindle microtubules attach to chromosomes and move them toward center of cell; M—fully formed; A—microtubules guide chromosomes to poles; T—breaks down. *Chromosomes:* I—duplicated but dispersed as chromatin; P—chromatin coils to form shorter, thicker pairs of chromatids joined at centromeres; PM—spindle microtubules attach to kinetochores, move chromosomes to center of cell; M—line up on metaphase plate; A—sister chromatids separate move toward poles; T—chromosomes uncoil to form chromatin. *Cell size and shape:* I—rounded, doubles in volume; P—rounded; PM—rounded; M—rounded; A—spindle elongates cell; T—elongation continues; cytokinesis splits cell into two smaller rounded cells. *Sketches:* See Module 8.6 in the text.

Exercise 5: 1. interphase 2. telophase 3. metaphase 4. prophase 5. prometaphase 6. anaphase

Exercise 6: 1. F 2. A 3. C 4. B 5. D 6. E

Exercise 7: For example: In animals, microfilaments produce a cleavage furrow that pinches the cell apart, while in plants, vesicles align in a cell plate, where a cell wall grows to split the cell.

Exercise 8: 1. asexual 2. growth 3. liver 4. repairs 5. skin 6. digestive tract 7. replaced 8. numbers 9. types 10. mitosis 11. cultures 12. surface 13. anchorage 14. density-dependent inhibition 15. growth factors 16. control 17. stops 18. G_1 19. S 20. receptor 21. nerve or muscle 22. cancer 23. inhibiting 24. 20–50 25. tumor 26. benign 27. malignant 28. metastasis 29. Sarcomas 30. Leukemias 31. radiation 32. chemotherapy 33. cell division 34. spindle

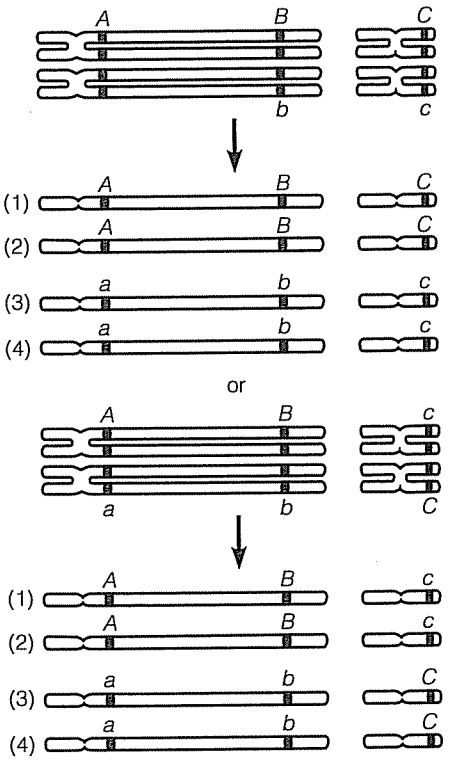
Exercise 9: 1. Homologous pairs of chromosomes called autosomes are found in the somatic cells of both males and females. Sex chromosomes are an additional pair of chromosomes—homologous in females (who have two X chromosomes) but not homologous in males (who have X and Y chromosomes). 2. The two chromosomes of a homologous pair carry genes for the same inherited traits at the same place, or locus. One is inherited from the father and one from the mother. 3. The two chromatids of a single chromosome are exactly identical, having been produced via the process of DNA replication during the S phase of interphase. 4. A diploid cell contains two homologous sets of chromosomes. A haploid cell contains one chromosome set. Diploid cells divide to form haploid cells in meiosis. 5. Gametes are haploid reproductive cells—sperm and eggs. Somatic cells are body cells other than gametes. In humans, somatic cells are diploid. 6. An egg is haploid. A zygote, formed by fusion of a sperm and egg, is diploid. 7. In meiosis, a diploid cell divides to form haploid cells. In fertilization, haploid cells (egg and sperm) fuse to form a diploid cell (zygote). 8. Mitosis produces two cells that are genetically identical to the mother cell. Meiosis is the division of a diploid cell to produce four haploid cells that are not genetically like the mother cell or each other. 9. These are the sex chromosomes. They are mostly not homologous. A female mammal has two X chromosomes; a male has an X and a Y. 10. A gene that determines a particular characteristic is located at a particular place (called its locus) on a chromosome.

Exercise 10: See Module 8.14 in the text for appearance of chromosomes, homologous chromosomes, sister chromatids, and crossing over. 1. interphase I 2. prophase I 3. metaphase I 4. anaphase I 5. telophase I and cytokinesis 6. prophase II 7. metaphase II 8. anaphase II 9. telophase II and cytokinesis 10. meiosis I 11. meiosis II

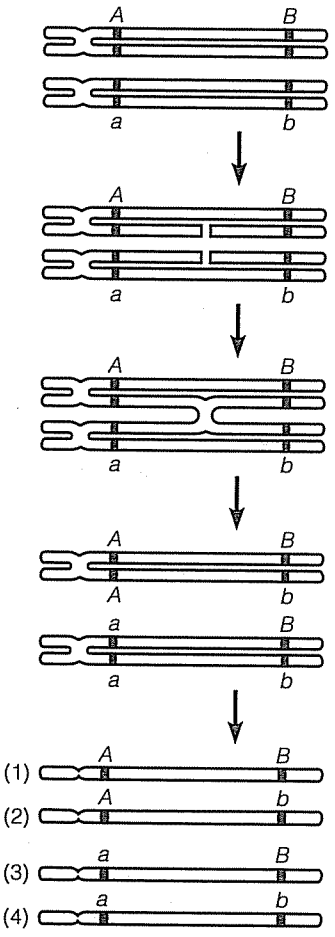
Exercise 11: 1. produces daughter cells identical to parent cell 2. involves two cell divisions 3. produces four daughter cells 4. sister chromatids of each chromosome separate 5. homologous pairs (tetrads) line up at metaphase plate 6. crossing over occurs between homologous chromosomes 7. provides for asexual reproduction, growth, replacement, repair

Exercise 12:

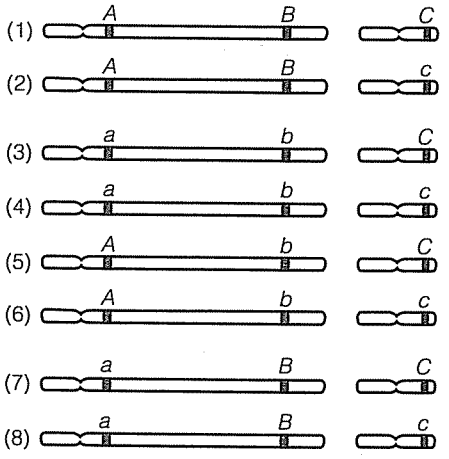
1.



2.



3.



8 combinations are possible

Exercise 13:

S	T	E	R	I	L	I	T	Y									F			
						H								T	U	R	N	E	R	
			F	E	W	E	R				H		A	G	E			M			
						E				O				S			A			
					L	E	U	K	E	M	I	A		T			L			
										O				E			E			
								M	A	L	E	N	E	S	S		S			
				Z						O						S				
				Y						G		G	A	M	E	T	E	S		
R				G						O				E			X			
E			N	O	N	D	I	S	J	U	N	C	T	I	O	N				
T		B			T				H		S				O					
A	B	O	R	T	E	D			O						S					
R		R		R		O			R					B	I	R	T	H		
D		N		I		W			T						S			A		
E				S		N		F	E	T	A	L			S			L		
D				O					R			E			P			F		
				M								S	I	S	T	E	R			
	K	A	R	Y	O	T	Y	P	E			S				C				
																I				
															T	E	T	R	A	P	L	O	I	D
																S				

Exercise 14: 1. C, X 2. D, W 3. B, Z 4. A, Y

Test Your Knowledge

Multiple Choice: 1. d 2. a 3. d 4. b 5. a 6. c 7. d 8. b 9. a 10. c 11. c 12. b 13. e 14. d 15. b

Essay: 1. In asexual reproduction, the cells or buds that give rise to offspring are produced by mitosis. Because in this process genetic information is copied and passed on to identical daughter cells, the offspring produced by asexual reproduction are exactly like the single parent and each other. In sexual reproduction, each offspring

inherits a unique combination of chromosomes and genes from two parents. Because of this genetic recombination, the offspring produced by sexual reproduction are not exactly like either parent or each other.

2. In mitosis, the nucleus and duplicated chromosomes divide and are equally distributed to daughter cells. In cytokinesis, the cytoplasm divides in two and is distributed to the daughter cells.

3. Cancer cells escape from the control mechanisms that regulate division in normal cells. Cancer cells do not need to be anchored to a solid surface to grow. They seem unaffected by density-dependent inhibition and will pile up on one another in cell culture. They either don't require growth factors or manufacture their own growth factors. Unlike normal cells, cancer cells can divide indefinitely. If they stop dividing, they stop at random points in the cell cycle, not at the restriction point.

4. Mitosis produces two cells that are genetically identical to the mother cell. Meiosis is the division of a diploid cell to produce four haploid cells that are not genetically like the mother cell or each other. In humans, mitosis is responsible for producing diploid somatic cells for growth, replacement of worn-out cells, or body repair. Meiosis produces haploid gametes (eggs and sperm) for sexual reproduction. Many (but not all) somatic cells undergo mitosis; special cells in ovaries and testes undergo meiosis.

5. Because sister chromatids are produced when DNA is duplicated, the genes of sister chromatids are identical. Homologous chromatids carry genes for the same traits (eye color, for example) at corresponding places, or loci, but they might carry different versions of the gene (blue or brown) at these loci.

6. The two chromosomes—maternal and paternal—of a homologous pair carry different genetic information. Because the two chromosomes of each pair line up independently of other pairs at metaphase I of meiosis, many different combinations of chromosomes are possible in the gametes produced by meiosis. Also in meiosis, homologous chromosomes exchange corresponding segments in the process of crossing over, creating chromosomes with a variety of gene combinations. Finally, the tremendous variety of eggs and sperm create many possible combinations at fertilization, further increasing genetic variation.

7. Sometimes a pair of homologous chromosomes fails to separate during meiosis I. One of the cells resulting from this division ends up with 24 chromosomes, the other with 22 chromosomes. All of the gametes produced by meiosis II have abnormal numbers of chromosomes. Some have 24 chromosomes—one of each kind plus an extra of one kind. Others have 22 chromosomes—one of each kind but one missing. Sometimes meiosis I is normal, but a pair of sister chromatids stays together during meiosis II. In this case, some gametes have the normal number of chromosomes, but some have one extra and some are one short. Fertilization of these abnormal gametes by a normal egg or sperm (containing the normal 23 chromosomes) produces a zygote with 47 or 45 chromosomes. Such genetic abnormalities have serious consequences.

8. An extra copy of chromosome 21 is usually not fatal, but it does produce Down syndrome. In most other situations in which an abnormal number of chromosomes occurs, the offspring is spontaneously aborted, so these abnormalities must be so serious as to be fatal.

Apply the Concepts

Multiple Choice: 1. d 2. b 3. c 4. c 5. a 6. b 7. a 8. d 9. d 10. d 11. d 12. b 13. b 14. d

Essay: 1. Cancer is uncontrolled cell division. Chemotherapy (and other cancer therapies such as radiation) slows tumor growth by interfering with cell division. Cell division is most rapid in the skin and digestive tract lining, where it replaces lost cells, so the side effects of chemotherapy are greatest on skin and intestinal lining.

2. Cells with between 100 and 200 units were in S phase, in the process of replicating their DNA.

3. These data suggest that prophase is the longest stage of mitosis. Prophase and prometaphase make up about half the process of mitosis. Telophase is also fairly long, lasting about a third of mitosis. Metaphase and anaphase take a relatively short time to occur.

4. There would be 39 different kinds of chromosome—39 homologous pairs. (In female mammals, the two X chromosomes, as well as each pair of autosomes, look alike.)

5. Possible alignments: *ABC* and *abc*, *ABc* and *abC*, *Abc* and *aBC*, and *AbC* and *aBc*. These same eight combinations are possible in eggs or sperm. There are $8 \times 8 = 64$ combinations possible in the zygotes.

6. Parental-type gametes: *QR* and *qr*. Recombinant-type gametes: *Qr* and *qR*.

7. XXY, XYYY, and XXYY would produce male phenotypes, XXXX and X female phenotypes. A single Y chromosome produces "maleness"; the absence of a Y chromosome produces "femaleness."