C1. Self-assembly occurs spontaneously, without the aid of other proteins. Directed assembly involves the aid of proteins that are not found in the mature viral coat.

C2. Viruses also need sequences that enable them to be replicated. These sequences are equivalent to the origins of replication found in bacterial and eukaryotic chromosomes.

C3. The bacterial nucleoid is a region in a bacterial cell that contains a compacted circular chromosome. Unlike eukaryotic nuclei, a nucleoid is not surrounded by a membrane.

C4. A bacterium with two nucleoids is similar to a diploid eukaryotic cell because it would have two copies of each gene. The bacterium is different, however, with regard to alleles. A eukaryotic cell can have two different alleles for the same gene. For example, a cell from a pea plant could be heterozygous, *Tt,* for the gene that affects height. By comparison, a bacterium with two nucleoids has two identical chromosomes. Therefore, a bacterium with two nucleoids is homozygous for its chromosomal genes.

Note: As we will learn in Chapter 14, on rare occasions a bacterium can contain another piece of DNA, called an F′ factor, that can carry a few genes. The alleles on an F′ factor can be different from the alleles on the bacterial chromosome.

C5. One mechanism is DNA looping. Loops of DNA are anchored to DNA-binding proteins. Secondly, the DNA double helix is twisted further to make it more compact, much like twisting a rubber band.

C6. A. One loop is 40,000 bp. One base pair is 0.34 nm, which equals 0.34×10^{-3} μm. If we multiply the two together:

$$(40{,}000)(0.34 \times 10^{-3}) = 13.6\ \mu\text{m}$$

B. Circumference= πD

$13.6\ \mu\text{m} = \pi\text{D}$

$\text{D} = 4.3\ \mu\text{m}$

C. No, it is too big to fit inside of *E. coli.* Supercoiling is needed to make the loops more compact.

C7. DNA is a double helix. The helix is a coiled structure. Supercoiling involves additional coiling to a structure that is already a coil. Positive supercoiling is called overwinding because it adds additional twists in the same direction as the DNA double helix; it is in a right-handed direction. Negative supercoiling is in the opposite direction. Z DNA is a left-handed helix. Positive supercoiling in Z DNA is in a left-handed direction while negative supercoiling is in the right-handed direction. This is opposite to the meaning of positive and negative supercoiling in B DNA.

C8. These drugs would diminish the amount of negative supercoiling. Negative supercoiling is needed to compact the chromosomal DNA, and it also aids in strand separation. Bacteria might not be able to survive and/or transmit their chromosomes to daughter cells if their DNA was not compacted properly. Also, since negative supercoiling aids in strand separation, these drugs would make it more difficult for the DNA strands to separate. Therefore, the bacteria would have a difficult time transcribing their genes and replicating their DNA, since both processes require strand separation. As discussed in Chapter 11, DNA replication is needed to make new copies of the genetic material to transmit from mother to daughter cells. If DNA replication was inhibited, the bacteria could not grow and divide into new daughter cells. As discussed in Chapters 12–15, gene transcription is necessary for cells to make proteins. If gene transcription was inhibited, the bacteria could not make many proteins that are necessary for survival.

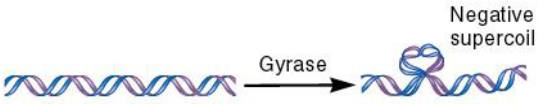
C9. A. The three turns would create either three fewer or three more turns for a total of seven or thirteen, respectively.

B. If the helix now has seven turns, it was left-handed. The three right-handed turns you made would cause three fewer turns in a left-handed helix. If the helix now has thirteen turns, it was right-handed. The three right-handed turns you made would add three more turns to a right-handed helix (compare Figures 10.7a and e).

C. The turning motion would probably not make supercoils because the two strings are not tightly interacting with each other. It's easy for the two strings to change the number of coils.

D. If you glued the two strings together with rubber cement, the three additional turns would probably make supercoils. A glued pair of strings is more like the DNA double helix. In a double helix, the two strands are hydrogen bonding to each other. The hydrogen bonding is like the glue. Additional turning motions tend to create supercoils rather than alter the number of coils.

C10.



C11. Topoisomers are different with regard to the number of supercoils they contain. They are identical with regard to the number of base pairs in the double helix.

C12. The centromere is the attachment site for the kinetochore, which attaches to the spindle. If a chromosome is not attached to the spindle, it is free to "float around" within the cell, and it may not be near a pole when the nuclear membrane re-forms during telophase. If a chromosome is left outside of the nucleus, it is degraded during interphase. That is why the chromosome without a centromere is not likely to be found in daughter cells.

C13. Centromeres are found in eukaryotic chromosomes. They provide an attachment site for kinetochore proteins so that the chromosomes are sorted (i.e., segregated) during mitosis and meiosis. They are most important during M phase.

C14. Highly repetitive DNA, as its name suggests, is a DNA sequence that is repeated many times. It can be tandemly repeated or interspersed. Tandemly repeated DNA often has a base content that is significantly different from the rest of the chromosomal DNA so it sediments as a satellite band. In DNA renaturation studies, highly repetitive DNA renatures at a much faster rate because it is found at a higher concentration.

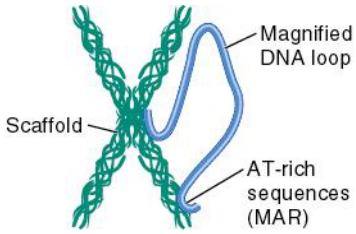
C15. A nucleosome is composed of double-stranded DNA wrapped 1.65 times around an octamer of histones. In the 30 nm fiber, histone H1 helps to compact the nucleosomes. The three-dimensional zigzag model is a current model that describes how this compaction occurs. It looks like a somewhat random (zigzagging) of the nucleosomes within the 30 nm fiber.

C16. During interphase (i.e., G_1, S, and G_2), the euchromatin is found primarily as a 30 nm fiber in a radial loop configuration. Most interphase chromosomes also have some heterochromatic regions where the radial loops are more highly compacted. During M phase, each chromosome becomes entirely heterochromatic. This is needed for the proper sorting of the chromosomes during nuclear division.

C17. Assuming a size of 3 billion bp, and if we assume that 146 bp wrap around a histone octamer, with 50 bp in the intervening region:

3,000,000,000/196 = 15,306,122, or about 15.3 million

C18.



C19. Heterochromatin is more tightly packed. This is due to a greater compaction of the radial loop domains. Functionally, euchromatin can be transcribed into RNA, while heterochromatin is inactive.

C20. During interphase, the chromosomes are found within the cell nucleus. They are less tightly packed and are transcriptionally active. Segments of chromosomes are anchored to the nuclear matrix. During M phase, the chromosomes become highly condensed and the nuclear membrane is fragmented into vesicles. The chromosomal DNA remains anchored to a scaffold, formed from the nuclear matrix. The chromosomes eventually become attached to the spindle apparatus via microtubules that attach to the kinetochore, which is attached to the centromere.

C21. The main activities that can occur during interphase are transcription and DNA replication. For these activities to occur, the DNA must be in a relatively loose conformation. During M phase, there is relatively little genetic activity, although there is evidence that a few genes are transcribed. However, most genes are transcriptionally inactive during M phase.

C22. There are 146 bp around the core histones. If the linker region is 54 bp, we expect 200 bp of DNA (i.e., 146 + 54) for each nucleosome and linker region. If we divide 46,000 bp by 200 bp we get 230. Since there are two molecules of H2A for each nucleosome, there would be 460 molecules of H2A in a 46,000 bp sample of DNA.

C23. We are looking at a 30 nm fiber. This is the predominant form of DNA found in the radial loops of a cell that is in interphase.

C24. The role of the core histones is to form the nucleosomes. In a nucleosome, the DNA is wrapped 1.65 times around the core histones. Histone H1 binds to the linker region. It may play a role in compacting the DNA into a 30 nm fiber.

C25. A. There are 10^8 bp in this chromosome. In a double helix, a single nucleotide traverses about 0.34 nm, which equals 0.34×10^{-3} μm. If we multiply the two values together:

$$10^8 (0.34 \times 10^{-3}) = 0.34 \times 10^5 \ \mu\text{m, or } 34{,}000 \ \mu\text{m.}$$

B. The 30 nm fiber is about 49 times shorter than a linear double helix. (Note: The 11 nm fiber compacts the DNA about seven times. The 30 nm structure compacts the DNA an additional seven times compared to the 11 nm fiber. Therefore, compared to linear DNA, the 30 nm fiber is $7 \times 7 = 49$ times more compact.)

If we divide 34,000 μm by 49 we get 694 μm.

C. This would not fit inside the nucleus if it were stretched out in a linear manner because a typical nucleus is much smaller. However, the 30 nm fiber is very thin and is compacted into many radial loop domains.

C26. The answer is B and E. A Barr body is composed of a type of chromatin called heterochromatin. Heterochromatin is highly compacted. Euchromatin is not so compacted. A Barr body is not composed of euchromatin. The term *genome* refers to all the types of chromosomes that make up the genetic composition of an individual. A Barr body is just one chromosome, the X chromosome.

C27. During interphase, much of the chromosomal DNA is in the form of the 30 nm fiber, and some of it is more highly compacted heterochromatin. During metaphase, all of the DNA is highly compacted, as shown in Figure 10.21*d*. A high level of compaction prevents gene transcription and DNA replication from taking place. Therefore, these events occur during interphase.