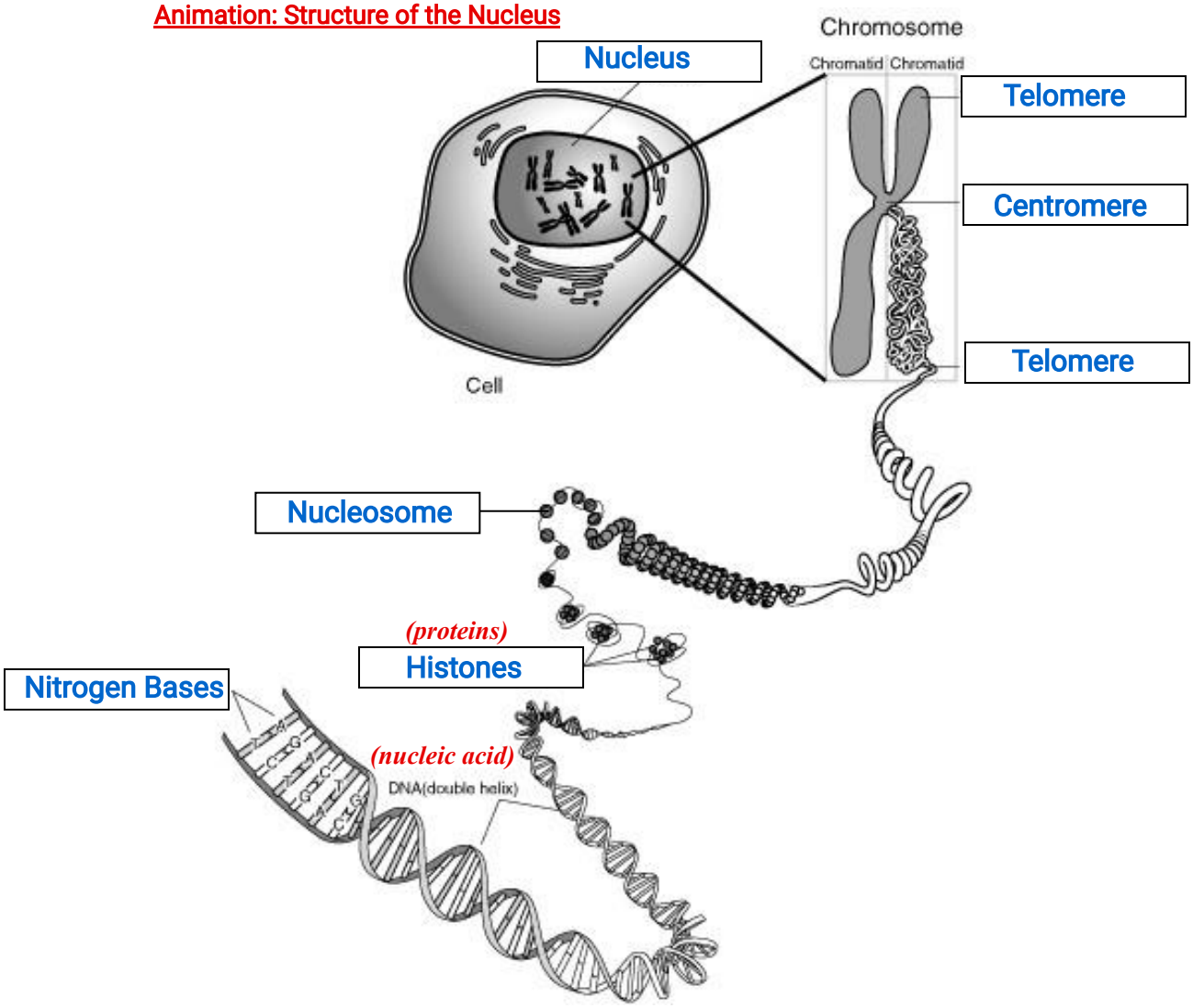
Guided Reading: Chapter 16

Part I. DNA as the Genetic Material (Video: Molecular Visualization of DNA Wrapping)

Animation: Structure of the Nucleus



(p.287)**1.** What are the two chemical components of chromosomes?

The two chemical components of chromosomes are DNA and proteins.

(p.287) **2.** Why did researchers originally think that protein was the genetic material?

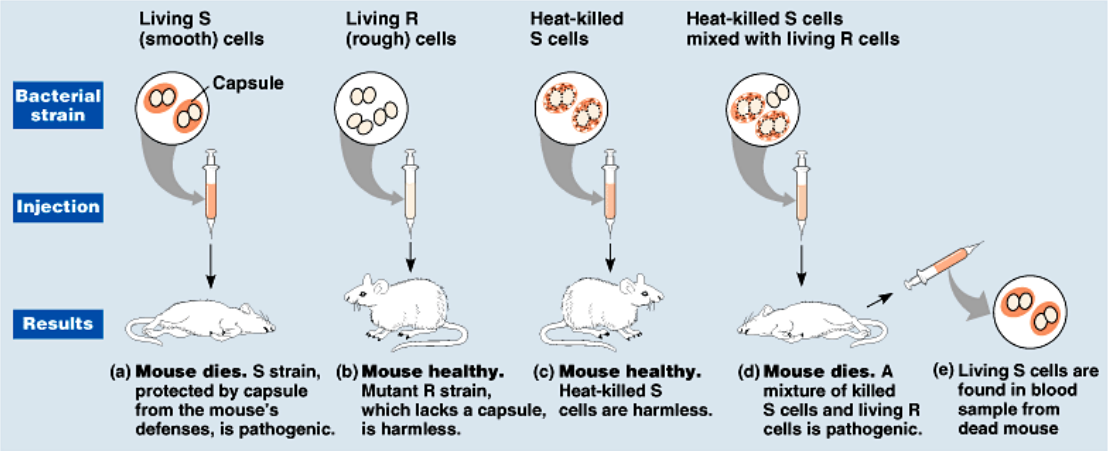
Researchers originally thought that protein was the genetic material since biochemists had already identified them as a class of macromolecules with heterogeneity and specificity, essential requirements for the heredity material. Moreover, little was known about nucleic acids, whose physical and chemical properties seemed far to uniform to account for the multitude of specific inherited traits exhibited by every organism.

They forgot to KEEP IT SIMPLE!!!

(p.288)**3.** Distinguish between the virulent and nonvirulent strains of *Streptococcus pneumoniae* studied by *Frederick Griffith*.

The virulent strain had a protective SMOOTH capsule surrounding it (S-strain) while the nonvirulent (R-strain) did not.

(p.288)**4.** Use this figure to summarize the experiment in which Griffith and Avery became aware that hereditary information could be transmitted from one organism to another. (Animation)



Purpose: To see if a harmless form of bacteria can be changed or transformed into a more deadly form.

Hypothesis: IF the remains of the heat-killed pathogenic (*deadly*) bacteria *Streptococcus pneumonia* are mixed with harmless bacteria, THEN some of the harmless bacteria will be changed into pathogenic bacteria by some "external agent."

Independent Variable: Virulence of Bacteria **Dependent Variable**: Mouse *(live or die)*

Conclusion: A chemical agent "transformed" the harmless bacteria.

(p.288)**5.** Define *transformation* and what did Oswald Avery determine to be the *transforming agent*?

Transformation is a change in the genotype (*genetic makeup*) and phenotype (*physical makeup*) of an organism due to the assimilation (the taking in) of external DNA by a cell. Oswald Avery determines that the transforming agent was DNA.

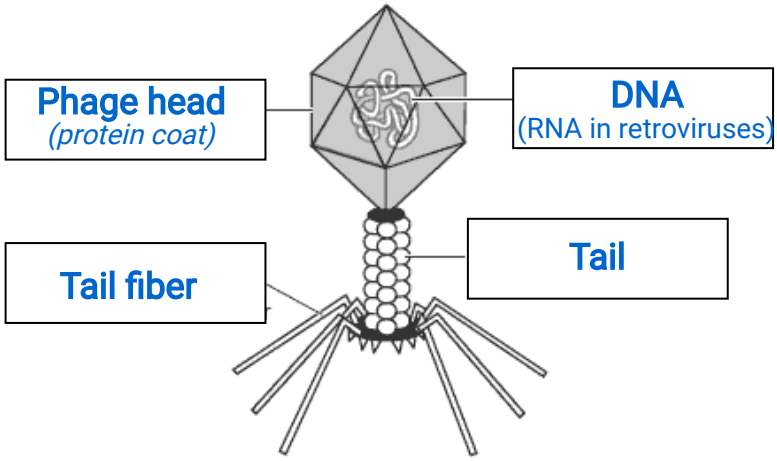
(p.288) **6.** What is a bacteriophage? (Bacteriophage 3D) (Bacteriophage T4 Virus)

A bacteriophage (*phage*) is a virus that infects bacteria.

(p.377) **7.** What are restriction endonucleases or restriction enzymes? (1979 Nobel Prize)

Restriction endonucleases or restriction enzymes are enzymes that protect bacteria against intruding DNA from other organisms, such as phages or other bacteria cells.

(p.289) **8.** Label the *head, tail sheath, tail fiber,* and *DNA* of the diagram of a bacteriophage below,



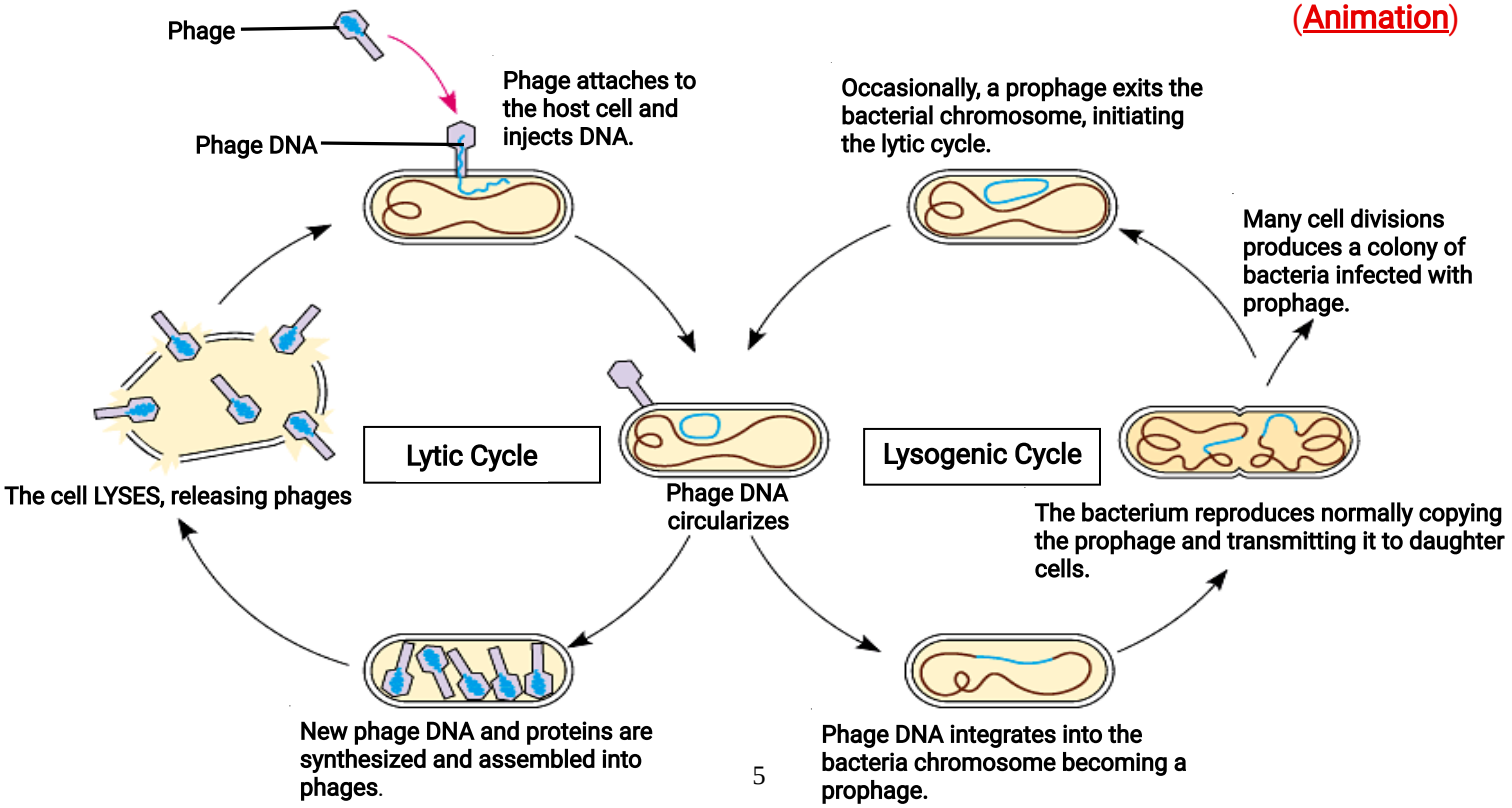
(p.331) **9.** How does a bacteriophage destroy a bacterial cell? (***Look ahead Fig. 18.3***)

A bacteriophage destroys a bacterial cell by by injecting its DNA (*RNA retroviruses*) into the host cell where it is used to produce more viruses.

(1969 Nobel Prize)

(p.333) **10.** Label the diagram below (***Fig.18.5***) and use it to help explain the two methods of viral replication.

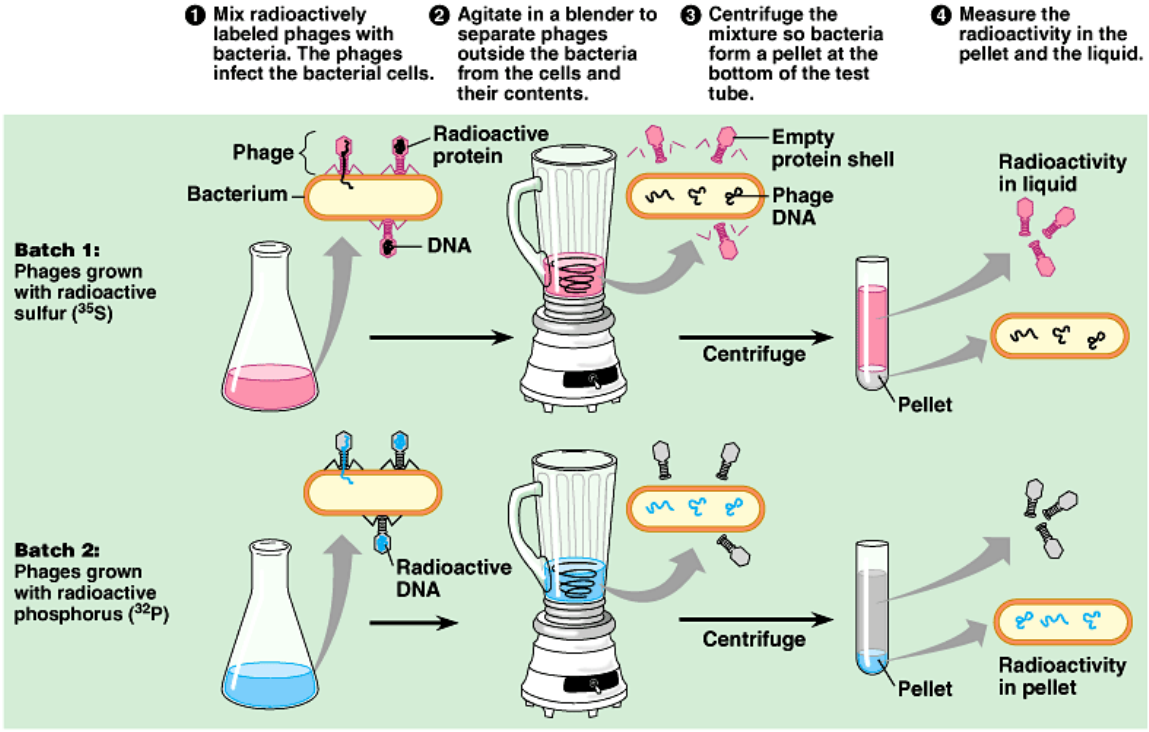
(Animation)



(p.289)**11.** How did Hershey and Chase *label* viral DNA and viral protein so that they could be distinguished?
(Explain why they chose each radioactive tag in light of the chemical composition of DNA and protein.)

Hershey and Chase labeled viral DNA with radioactive phosphorus (^{32}P) because there is no phosphorus in proteins and labeled the viral protein with radioactive sulfur (^{35}S) because there is no sulfur in DNA.

(p.289)**12.** Use this figure to summarize the experiment in which Hershey and Chase became aware that hereditary information could be transmitted between two organisms in an unusual manner. (Animation)



(b) The experiment showed that T2 proteins remain outside the host cell during infection, while T2 DNA enters the cell.

Purpose: To determine which part of a bacteriophage (bacteria-infecting virus) the protein or nucleic acid/DNA is responsible for "reprogramming" or "transforming" the host bacterial cell.

Hypothesis: IF radioactive phosphorus – ^{32}P used to "tag" the viral DNA is found in the more dense pellet containing E.coli bacteria and the radioactive sulfur – ^{35}S used to "tag" the viral protein coat is found in the less dense liquid, THEN the DNA functions as the bacteriophage's genetic material.

Independent Variable: Virus (^{32}P / ^{35}S) **Dependent Variable**: Location of ^{32}P / ^{35}S

Conclusion: ^{32}P found in the pellet – DNA is the genetic material!!!!!

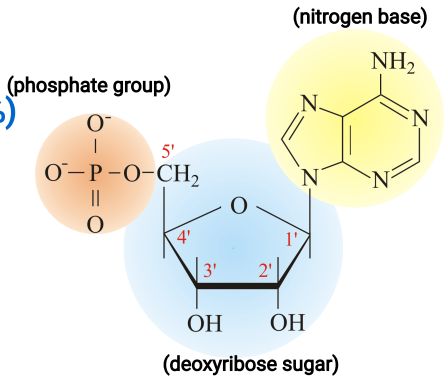
(Greatest Discoveries DNA)

(Antiparallel Nature of DNA)

(p.290)**13.** What are *Chargaff's rules*? How did he arrive at them?

Chargaff's Rule states that in any particular species, the number (%) of Adenines = Thymine and the number (%) Cytosine = Guanine.

BASE PAIR RULE: A binds with T / C binds with G



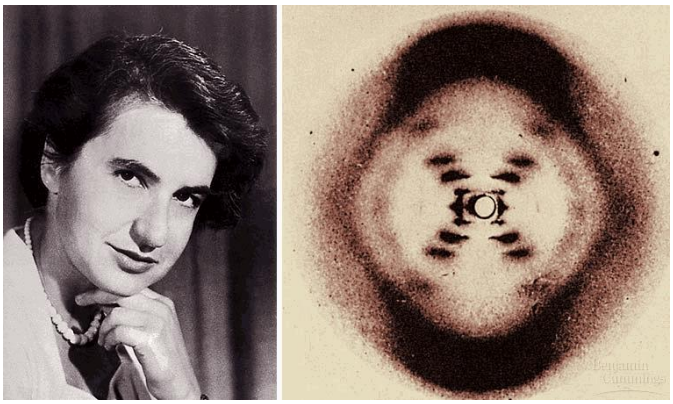
(p.290)**14.** List the three components of a nucleotide.

The three components of a nucleotide are:
a nitrogenous base, deoxyribose sugar and a phosphate group.

(p.287)**15.** Who built the first model of DNA and shared the 1962 Nobel Prize for discovery of its structure?

James Watson and Francis Crick built the first model of DNA and along with Maurice Wilkins shared the 1962 Nobel Prize for their discovery. (1962 Nobel Prize)

(p.291)**16.** What was the role of Rosalind Franklin in the discovery of the *double helix*?



Rosalind Franklin produced an X-ray diffraction picture of DNA that Watson and Crick used to deduce the width of the helix and spacing of the nitrogenous bases leading to discovery of the double-helical structure of DNA.

(X-ray Crystalography)

(X-ray Diffraction)

(p.292)**17.** Distinguish between the structure of *pyrimidines* and *purines*. Explain why adenine bonds only to thymine.

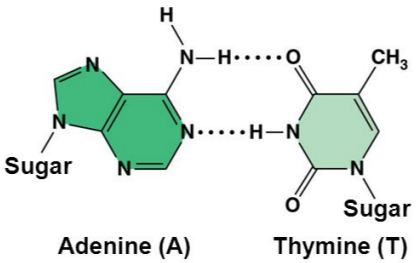
Pyrimidines are nitrogenous bases with a SINGLE ring structure and purine are nitrogenous bases with a DOUBLE ring structure. Adenine can form TWO hydrogen bonds with Thymine and only Thymine.

18. How did Watson and Crick's model explain the basis for Chargaff's rules?

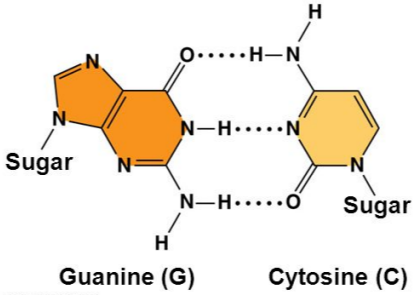
Watson and Crick's model explained the basis for Chargaff's rule that in any particular species, the number (%) of Adenines = Thymine and the number (%) Cytosine = Guanine due to hydrogen bonds between the bases.

19. Given that the DNA of a certain fly species consists of 27.3% adenine Chargaff's rules to deduce the percentages of thymine and cytosine.

$27.3 = A + T$ $\quad \frac{49.8}{2} = 24.9\%$ thymine and cytosine

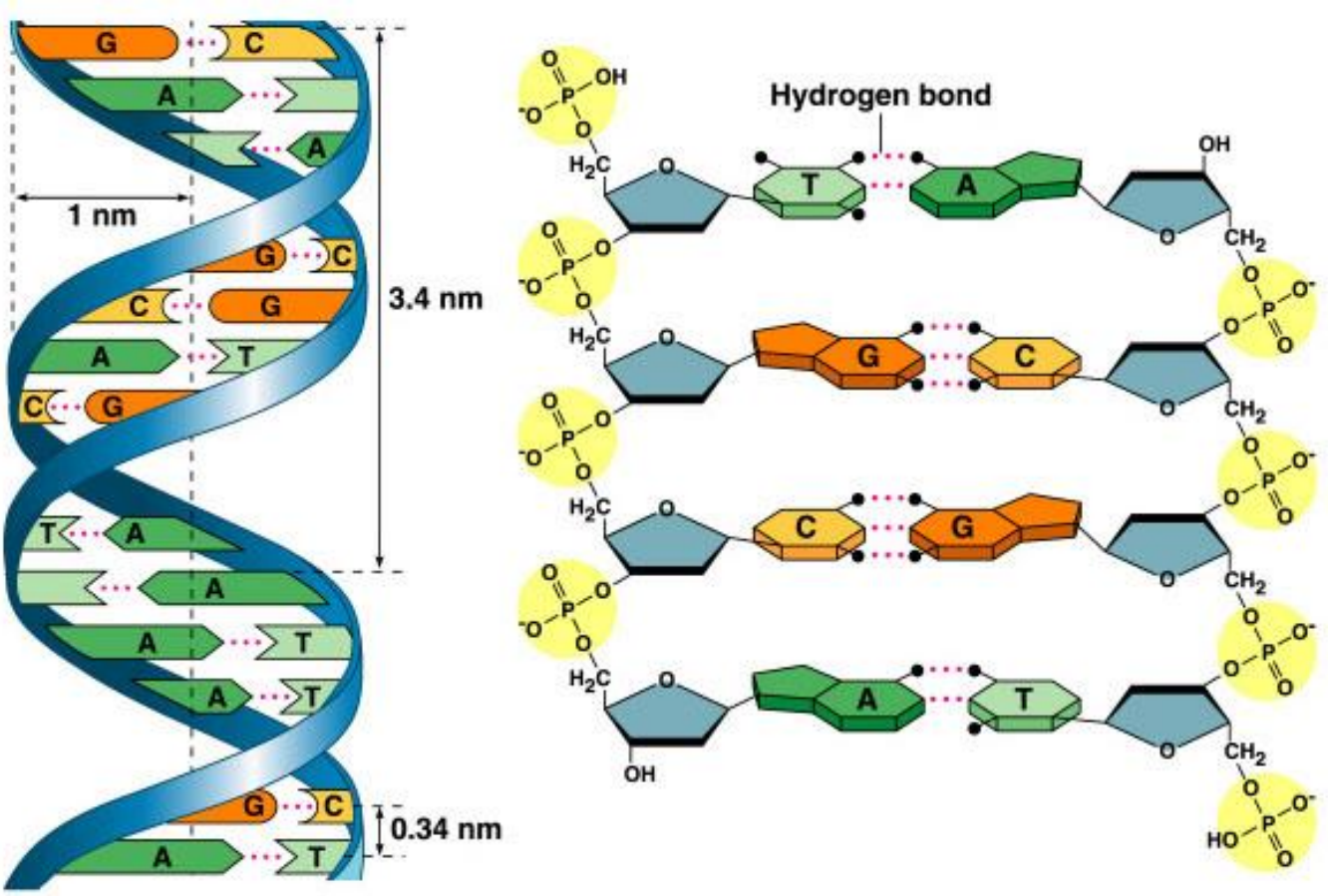


(p.292)**20.** Explain the base-pairing rule. A binds with T
G binds with C



(Animation: Structure of DNA)

(p.291) **21.** Review the structure of DNA by labeling the diagram below and answering the questions that follow.



a. distance across molecule 2.0 nm

b. distance between nucleotides 0.34 nm

c. distance between turns 3.4 nm

d. components of the backbone sugar/phosphate

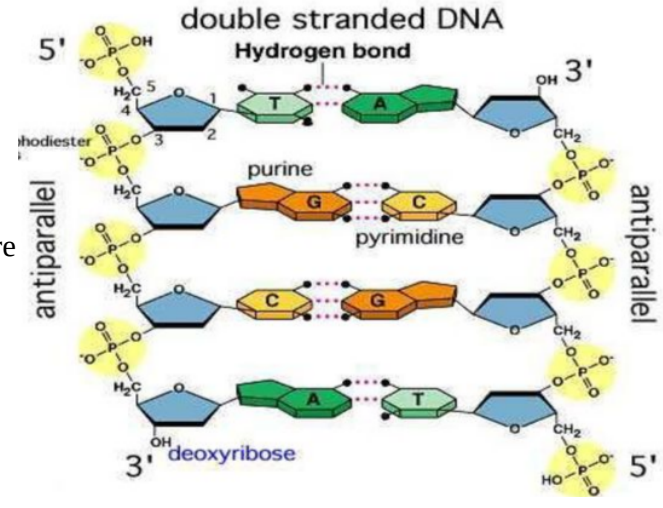
e. components of the "rungs" bases: A-T / G-C

(p.296) **22.** Explain what is meant by 5' and 3' ends of the nucleotide.

The numbers 5 and 3 represent the carbon atoms in the deoxyribose sugar. The prime sign is used to distinguish the carbon atoms in the sugar from the carbon atoms in the nitrogenous bases.

(p.296) **23.** What do we mean when we say the two strands of DNA are

The antiparallel nature of DNA means that the sugar-phosphate backbones of the DNA molecule run in opposite directions and are essentially upside down relative to each other.



Part II. DNA Replication and Repair

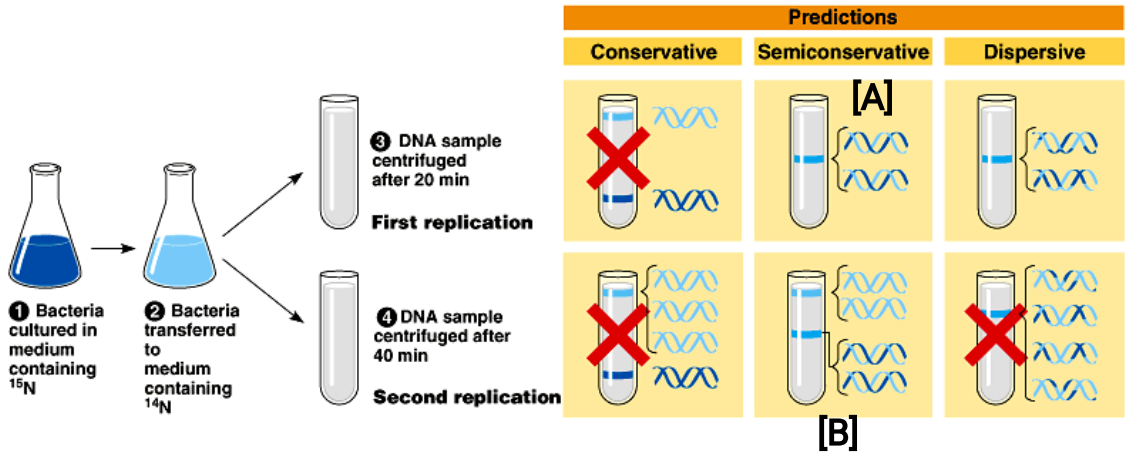
(p.293) **24.** What is the *semiconservative model of replication*?

The semiconservative model of replication states that when DNA replicates, each of the two new daughter molecules will conserve or have one old, original strand.

(p.294) **25.** How did Meselson and Stahl create "heavy" DNA for their experiments?

Meselson and Stahl create "heavy" DNA for their experiments by using a heavy isotope of nitrogen, ^{15}N

(p.294) **26.** Use this figure to summarize the experiment in which Meselson and Stahl confirmed the semiconservative mechanism of DNA replication. (Animation)



Purpose: To determine if DNA replication is conservative, semiconservative or dispersive.

Hypothesis: IF DNA replication is semiconservative (one strand is conserved and acts as template to build the other strand), THEN E.coli bacteria grown first in "heavy" nitrogen (^{15}N) and then grown in "light" nitrogen (^{14}N) will produce ONLY one band of intermediate density ($^{15}N/^{14}N$) [A]. The second replication will produce two bands - one band of intermediate density ($^{15}N/^{14}N$) and one band of light density ($^{14}N/^{14}N$) [B] after centrifugation.

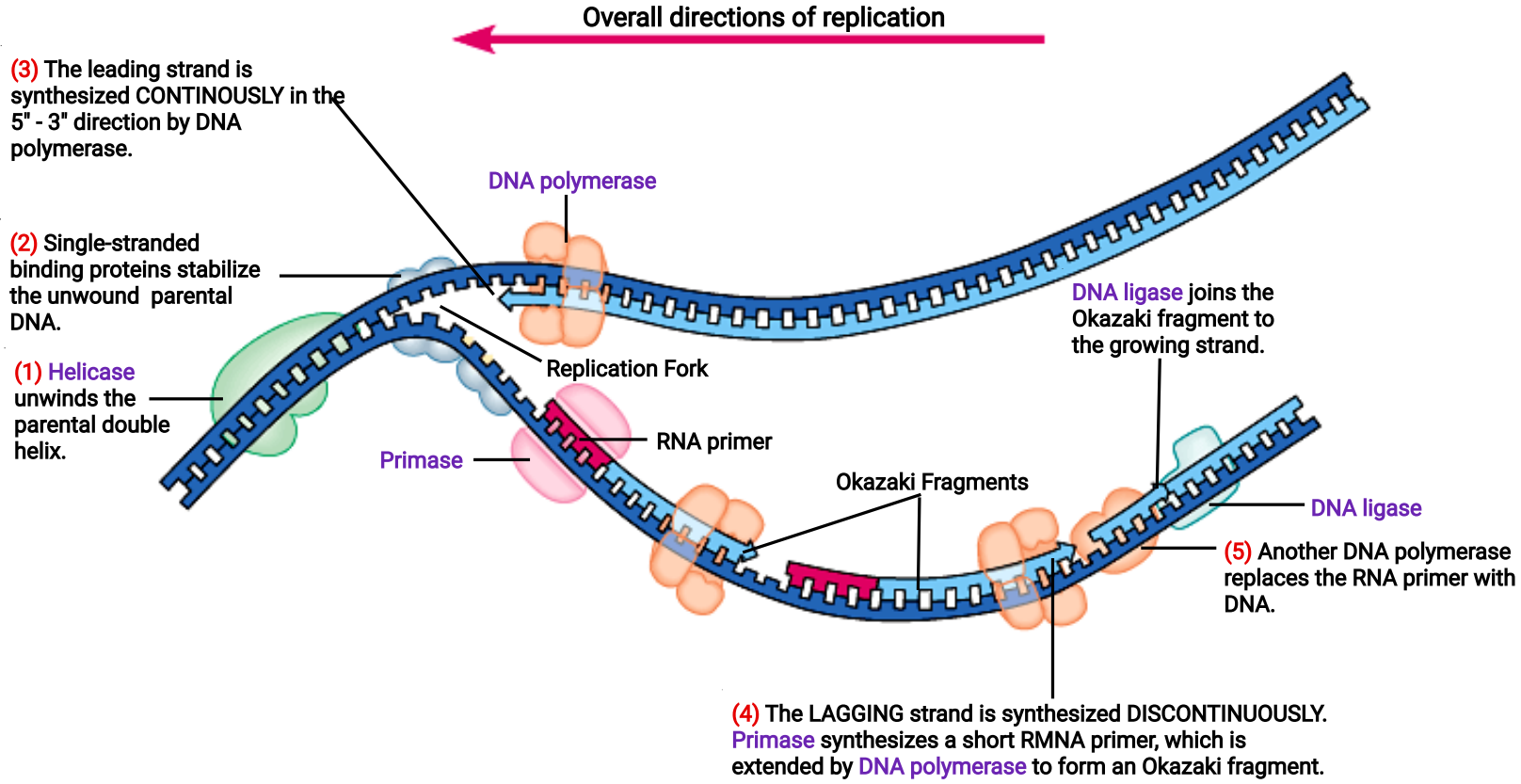
Independent Variable: Bacteria ($^{15}N/^{14}N$) **Dependent Variable**: # of DNA bands & location

Conclusion: DNA replication is semiconservative where one side of the DNA is conserved and acts as a TEMPLATE to construct the new side according to the base pair rule.

(p.295) **27.** Define the *origins of replication*.

The Origins of Replication are special sites where DNA replication begins.
(Eukaryotic cells have multiple Origins of Replication to help speed up the replication process)

(p.297) **28.** Review the process of DNA replication by labeling the diagram below. (Animation) (Ninja Nerd Video)



(p.296-97) **29.** Distinguish between the *leading* and the *lagging strands* during DNA replication.

The leading strand is the one in which DNA polymerase synthesizes a CONTINOUS complementary strand by elongating the new DNA in the mandatory 5' to 3' direction. The lagging strand is synthesized in a DISCONTINUOUS fashion thus following the mandatory 5' to 3' direction of DNA polymerase.

(p.296) **30.** What is the direction of synthesis of the new strand?

The direction of synthesis of the new strand is the mandatory 5' to 3' direction.

(p.297) **31.** What are *Okazaki fragments* and how are they welded together?

Okazaki fragments are the series of segments of DNA used to "backstitch" or synthesize the lagging strand.

(p.297-98) **32.** The enzyme . . .

Helicase _____ untwists and separates the DNA strands.

Single-stranded binding proteins _____ holds the DNA strands apart.

Primase _____ synthesizes RNA primer.

DNA polymerase _____ add DNA nucleotides to the new strand.

Ligase _____ joins DNA fragments together.

DNA polymerase _____ removes the RNA primer and replaces it with DNA.

(p.299) **33.** Explain the roles of each of the following enzymes in DNA proofreading and repair.

a. DNA polymerase – removes any mismatched nucleotides then resumes synthesis

b. Nuclease – DNA-cutting enzyme that removes any damaged DNA

c. Ligase – seals the replaced DNA segments after repair

(p.299) **34.** What is a *thymine dimer*? How might it occur? How is it repaired?

Thymine dimers are the covalent linking of adjacent thymine bases caused by the UV rays of the sun. They are repaired by nucleases that cut out the dimers, DNA polymerase fills the gap and ligase seal the replaced segments.

(p.300) **35.** What are *telomeres*? **Analogy: Telomeres : Chromosomes AS** aglets **:** shoe laces

Telomeres are special, nongenetic nucleotide sequences found at the ends of eukaryotic chromosor

(p.300) **36.** Explain telomere erosion and the role of *telomerase*. (2009 Nobel Prize)

Telomere erosion is the removal of small bits of telomeres after each replication. Telomerase is the enzyme that restores the shortened telomere by catalyzing the lengthening of the telomere.

(p.301) **37.** Why are cancer cells immortal, but most body cells have a limited life span?

Cancer cells are immortal because they contain the enzyme telomerase that restores the shortened telomere by catalyzing the lengthening of the telomere after each replication.