Week 6
Genetics: BIO-2306

The concepts this resource covers are the topics typically covered during this week of the semester. If you do not see the topics your particular section of class is learning this week, please take a look at other weekly resources listed on our website for additional topics throughout the semester.

We also invite you to look at the group tutoring chart on our website to see if this course has a group tutoring session offered this semester.

If you have any questions about these study guides, group tutoring sessions, private 30 minute tutoring appointments, the Baylor Tutoring YouTube channel or any tutoring services we offer, please visit our website www.baylor.edu/tutoring or call our drop in center during open business hours. M-Th 9am-8pm on class days 254-710-4135.

Keywords: Nucleic Acid, Bacteria, Chromosome, Nucleosome

Topic of the Week: ***Discovering DNA is Heritable Material*** (10.2)

Deoxyribonucleic Acid: **DNA** is the coiled (helical) polymer of nucleotides that encodes and stores genetic information in organisms.
Ribonucleic Acid: **RNA** is another type of nucleic acid with encoding, structural and enzymatic capabilities → for this reason, the first organisms on earth had RNA genomes!

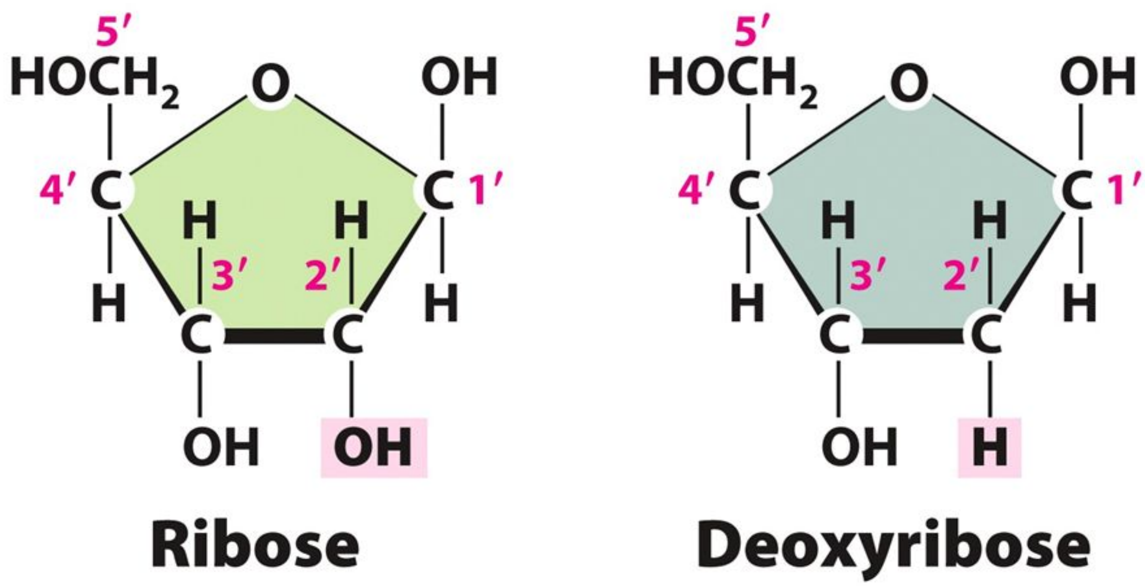

Figure 10.9
Genetics: A Conceptual Approach, Fifth Edition
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Above: the structures of the ribose (5 carbon) sugar of DNA and RNA are considered above. It is most important to note that *Deoxy*ribose sugars lack a 2' hydroxyl group, hence "deoxy."

Chargaff's Rules: the proportion of A&T and G&C are ***equivalent*** in **DNA** and the total proportions add up to 100%

Griffith's Experiment: virulent (**S**) *S. pneumoniae* was known to be deadly and non-virulent (**R**) was not when injected into mice.

→ Griffith "heat killed" virulent *S. pneumoniae* and mixed them with live non-virulent *S. pneumoniae*.

→ The mixture of the "heat killed"(**S**) and live (**R**) *S. pneumoniae* ***kills the mice*** it is injected into

Transforming Principle: some "transforming substance" had to have caused the change from the non-virulent to virulent *S. pneumoniae*… we now know this is **DNA**

Avery, MacLeod and McCarty Experiment: proved that DNA is the "transforming substance"

Used a modified version of Griffith's experiment where digestive enzymes were applied to transformed bacteria, showing what could or could *not* be the transforming substance:

A. 	**B.** 	**C.** 
DNase	**X**	**DNase**
RNase	**RNase**	**X**
X	**Protease**	**Protease**
H_0: proteins are the transforming substance	H_0: DNA is the transforming substance	H_0: RNA is the transforming substance
Results: Mouse Survives	**Results:** Mouse **DIES**	**Results:** Mouse survives
Not-Valid	**Valid!!!**	Not-Valid

Hershey Chase Experiment: confirm that DNA can be genetic information (T_2*Bacteriophages*)

Using radioactive molecules in the media of infected *E. coli*, showed phages had a DNA genome (the radioactivity of phage 'offspring' revealed the nature of heritable factor)

→ ^{32}**P:** integrates to DNA → **P**-labeled phage produces radioactive offspring

→ ^{35}**S:** integrates to proteins → offspring of **S**-labeled phage is not radioactive

Watson and Crick's Discovery of DNA's 3D Structure: Watson, Crick and Franklin discovered DNA's structure in 1953

X-ray Crystallography: an electron beam is reflected in different ways when it passes through molecules → Rosiland Franklin used this to visualize the helical structure of DNA

click the links in the underlined titles to find out more information!

Watson & Crick's Discovery: using only what they could study or build - models, X-ray diffraction patterns (from Franklin), or structural chemistry - they concluded the **Double Helical** structure of DNA

Fraenkel-Conrat/Singer Experiment: showed that RNA, but not DNA, could be genetic material of viruses (model → **TMV**)

Highlight #1: DNA Structure (10.3-4)

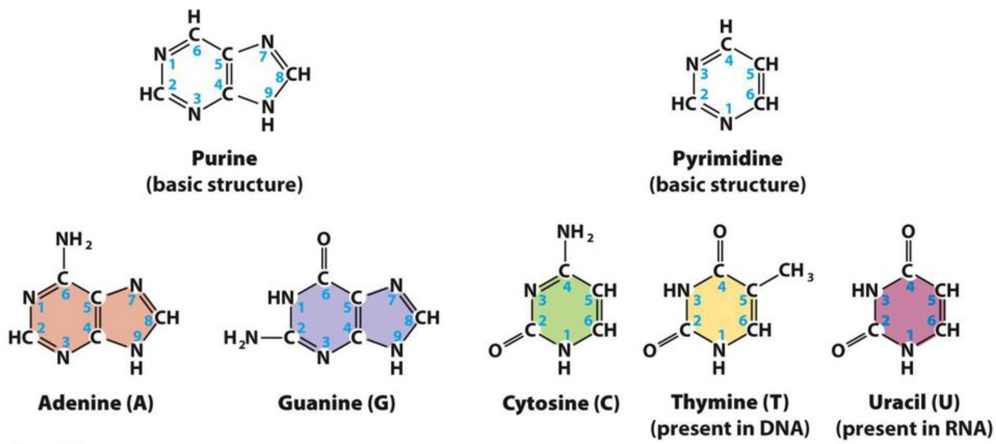

Figure 10.11
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Nitrogenous Bases: structures bound to the ribose sugar which confer genetic code (above)

- **Purines:** Adenine, Guanine
- **Pyrimidines:** Cytosine, Thymine (*DNA*), Uracil (*RNA*)

Primary (linear) **Structure of DNA:**

Nucleoside: the *5 carbon* sugar and the nitrogenous base (on the 1' carbon)

Nucleotide: the nucleoside + a phosphate (**-OPO$_3^{2-}$**) group bound to the 5' carbon

- **NTP:** nucleoside triphosphate (RNA nucleotide)
- **dNTP:** deoxy-nucleoside triphosphate (DNA nucleotide)
- *2 **P**hosphate groups are broken off during polymerization (T**P** → M**P**)*
  - **Adenosine:** dAMP (deoxy**adenosine** monophosphate)
  - **Guanine:** dGMP (deoxy**guanosine** monophosphate)
  - **Thymine:** dTMP (deoxy**thymidine** monophosphate)
  - **Cytosine:** dCMP (deoxy**cytidine** monophosphate)

Table 10.2 Names of DNA Bases, Nucleotides and Nucleosides

	Adenine	Guanine	Thymine	Cytosine
Base symbol	A	G	T	C
Nucleotide	deoxyadenosine 5' monophosphate	deoxyguanosine 5' monophosphate	deoxythymidine 5' monophosphate	deoxycytidine 5' monophosphate
Nucleotide symbol	dAMP	dGMP	dTMP	dCMP
Nucleoside	deoxyadenosine	deoxyguanosine	deoxythymidine	deoxycytidine
Nucleoside symbol	dA	dG	dT	dC

Table 10.2
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Secondary (helical) **Structure of DNA:**

DNA Double Helix: the helical structure of two DNA strands bound by **hydrogen bonds** between bases stabilized by **steric effects** between adjacent nucleosides (like stacked plates)

Phosphodiester bond: a free 3' **-OH** group binds with a 5' [**-OPO$_3$**]$^{2-}$ via condensation reaction (loss of H_2O)

Antiparallel: one DNA strand runs in the **5' → 3'** direction, while the one it is bound to is **3' → 5'**

Complementary: this describes Chargaff's rules, where A's bind to T's and G's to C's on opposing strands

NOTE: A and T have 2 H-bonds; C and G have 3 H-bonds

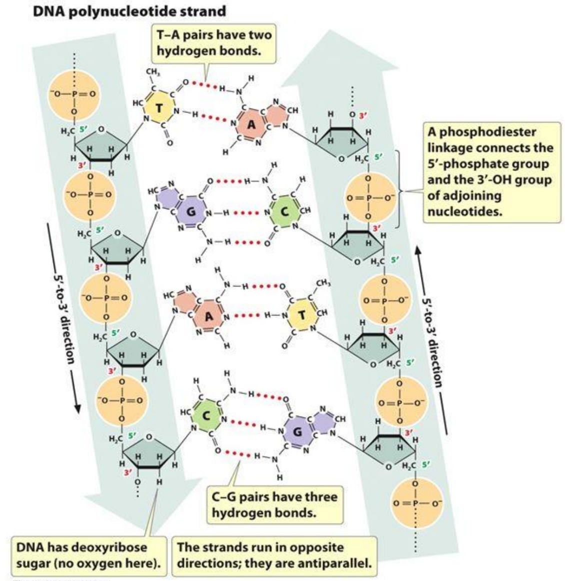

Figure 10.13 part 1
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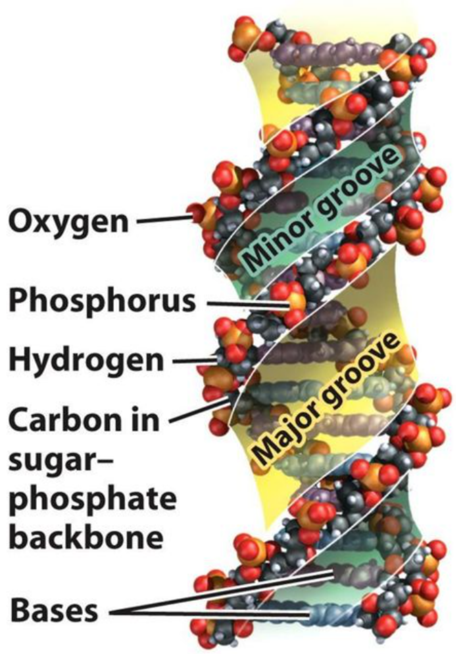

Figure 10.14a
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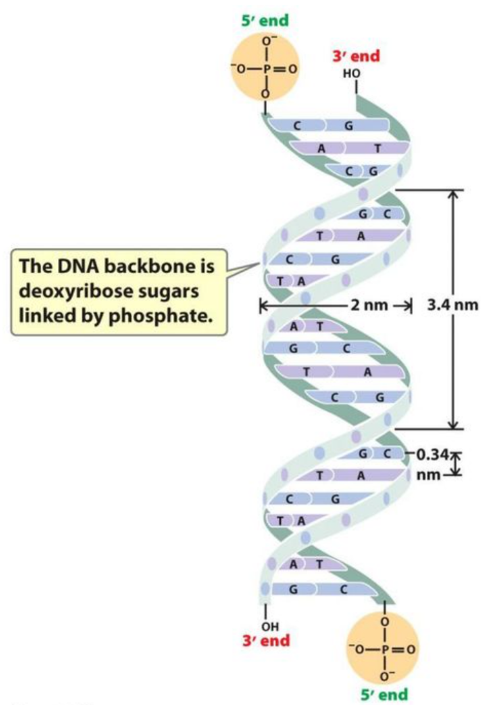

Figure 10.14b
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Highlight #2: **Chromosomal Structure** (11)

DNA Coiling: generally ~10bp per rotation

Positive Supercoiling → **more than** 10bp per rotations

Negative Supercoiling → **less than** 10bp per rotations

***Topoisomerase*:** enzyme that makes double-stranded cuts to relieve tension on DNA helices

Chromatin: the complex of DNA and proteins

Heterochromatin: highly condensed form of chromatin throughout the cell cycle; likely ***not*** actively transcribed (*note:* if observed on a stained slide, this would appear DARK)

Euchromatin: loosely condensed chromatin which changes binding tightness throughout the cell cycle (*note:* if observed on a stained slide, this would appear LIGHT)

***DNase* Hypersensitive Site:** sites where DNA is less tightly bound

Histones: proteins which associate with DNA (only in eukaryotes and some archaea)

Five Types: H1, $H2_A$, $H2_B$, H2, H4

Nucleosome: A DNA-histone complex which DNA wraps around (~150bp)

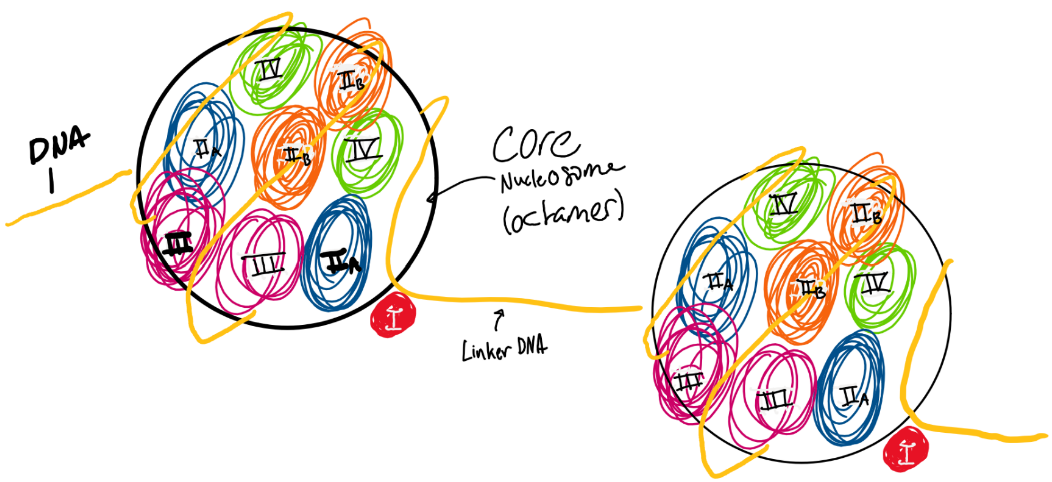
Core Nucleosome: an octamer (2 sets of) $H2_A$, $H2_B$, H3, H4

H1 + Linker DNA: H1 holds the DNA in place on the nucleosome and linker DNA (~50 bp) joins adjacent nucleosomes

Histones generally tend to express (+) charged residues **(His**, **Lys**, **Arg)** to attract the (-) charged phosphate backbone of DNA

→ adding methyl or acetyl groups decreases affinity of DNA for a histone

Below: a drawing of two Nucleosomes surrounded by DNA molecules (yellow)



Highlight #3: **Bacteria** (9)

Bacteria: *prokaryotic* organisms characterized by a peptidoglycan cell wall and lack of a nucleus with circular DNA

Conjugation: bacteria may share/interchange genetic information with one another
DNA from a *donor* may be incorporated into the genome of a recipient
Transformation: bacteria may pick up free bits of DNA and incorporate them into their own genome (**NOTE:** this is very important to the discovery of DNA as the genetic material of a cell → see *Griffith Experimen*t in ch. 10)

CHECK YOUR LEARNING

Concept Check: *(Answers found on last page)*

1. If a strand of DNA is 34% Guanine, what is the percentage of Adenosine nucleotides?
    a. 32%
    b. 34%
    c. 16%
    d. 68%
2. A which of these histones would you *not* expect to be part of the core nucleosome
    a. $H2_A$
    b. H3
    c. H5
    d. $H2_B$
3. DNA is complementary and antiparallel. If one strand is 5'-ATGCATGTCA-3' what would the other strand of DNA be?
    a. 5'-TACGTACAGT- 3'
    b. 5'-GATCATGAGA- 3
    c. 5'-ATGCATGTCA- 3'
    d. 5'-TGACATGCAT- 3'
4. What would happen if DNA-associated Histones in a particular region associated with gene **A** were acetylated?
    a. The number of DNase hypersensitive sites would decrease
    b. More transcription of gene **A** would occur
    c. Post translational modifications would modify gene **A** products to inhibit its transcription
    d. DNA would associate more tightly with histones
5. Why would Hershey and Chase use radioactive sulfur instead of nitrogen to identify proteins?
    a. Nitrogen is present only in amino groups, but they wanted to be extra
    b. Nitrogen exists only in DNA nucleosides, so it couldn't label proteins
    c. Sulfur destabilizes DNA strands, so it removes DNA strands from the sample
    d. Nitrogen is present in amino acid side chains and backbones, along with DNA nucleosides; Sulfur is present only amino acids Methionine and Cysteine

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THINGS YOU MAY STRUGGLE WITH:

1. Chargaff's rule is awesome, but what about in RNA? The base U replaces T, so we'd expect A=U and C=G… right? However, Chargaff's rule *doesn't necessarily* apply; RNA is often single stranded (which may have looped sections), so if bases are not paired we can't apply *base pairing* rules!
2. Tip for remembering purines and pyrimidines:
    a. Purines: A and G → Pretend that aggies are 'pure'
    b. Pyrimidines: T, C, U (obviously, we do not like TCU -sic 'em- so we would say they are "not pure," hence *not* purines)
3. What is a *DNase* Hypersensitive site? It is a place where DNA-protein association is weak, meaning DNA is very exposed so that Transcription machinery can access it to express genes. Thus, DNA digesting enzymes would degrade this far easier than if it was tightly associated with proteins → hence, *DNase* hypersensitivity!

CONGRATS: You made it to the end of the resource! Thanks for checking out these weekly resources! Don't forget to check out our website for group tutoring times, video tutorials and lots of other resources: www.baylor.edu/tutoring!

Answers to check your learning questions are below!

Answers:

1. **C**
2. **C**
3. **D**
4. **B**
5. **D**