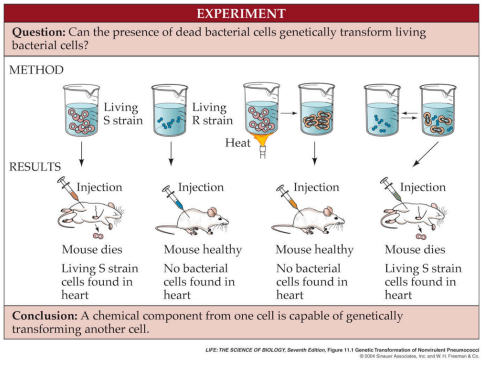
MOLECULAR BIOLOGY: REPLICATION, TRANSCIPTION, AND TRANSLATION

Honors Biology
2012

1

IMPORTANT EXPERIMENTS

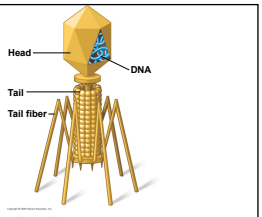
- Frederick Griffith
  - Described a "transforming factor" that could be transferred into a bacterial cell
  - Process is called transformation

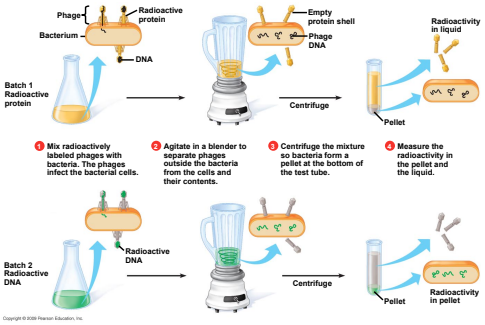


2

IMPORTANT EXPERIMENTS

- Hershey-Chase
  - Used bacteriophages to show that DNA is the genetic material
  - Phages were labeled with radioactive sulfur (labels proteins) and radioactive phosphorus (labels DNA)
    - Sulfur-labeled protein stayed outside the cell
    - Phosphorus-labeled DNA was inside the cell

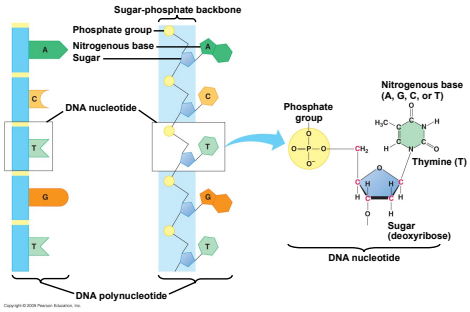


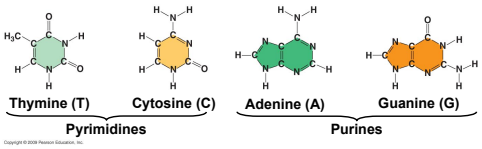


3

NUCLEOTIDES

- Monomer of DNA and RNA is called a nucleotide
  - Contains three parts: nitrogenous base, 5-carbon sugar, and phosphate group
- DNA and RNA are called polynucleotides
  - Composed of a sugar-phosphate backbone
  - Nitrogenous bases point inward
    - Four DNA bases: thymine, cytosine, adenine, and guanine

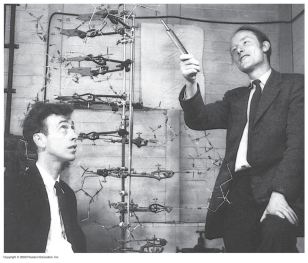


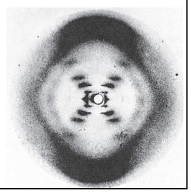


4

WATSON AND CRICK

- Credited with discovering the structure of DNA
  - Really took ideas from others and were the first to publish
  - Took X-ray crystallography data from Rosalind Franklin without her knowledge

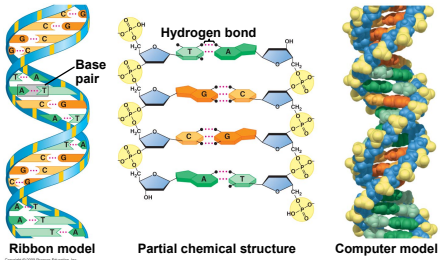


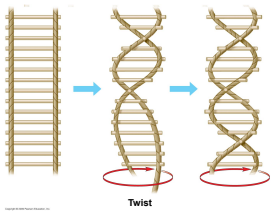


5

DNA STRUCTURE

- Composed of two polynucleotide chains joined together by hydrogen bonds between bases
  - A pairs with T, forming two hydrogen bonds
  - G pairs with C, forming three hydrogen bonds
- Twisted as a helical shape

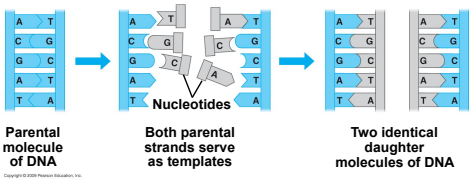




6

DNA REPLICATION

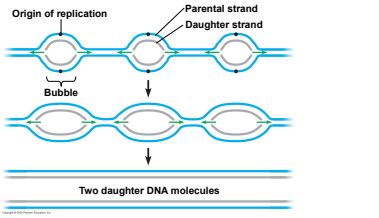
- Semiconservative model
  - Two DNA strands separate
  - Each strand is used as a pattern to produce a complimentary strand
  - Each new DNA helix has one old strand and one new strand

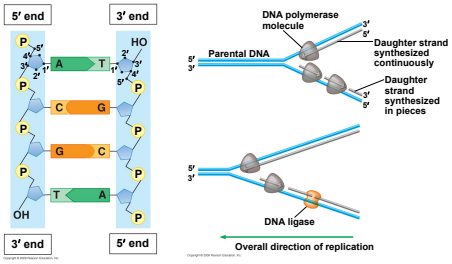


7

DNA REPLICATION

- Replication occurs in the 5' → 3' direction
  - Leading strand = continuous replication
  - Lagging strand = segmented replication
- Enzymes important for replication
  - DNA helicase binds to unwind the DNA
  - DNA polymerase adds new base pairs
  - DNA ligase joins fragments together

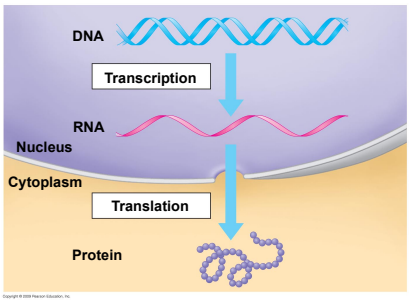


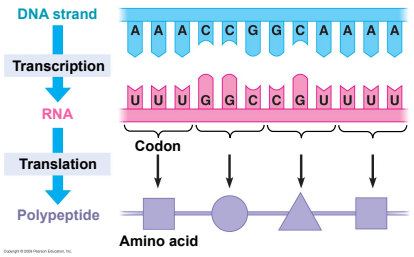


8

FROM DNA TO PROTEIN

- Gene sequence of DNA directs for the synthesis of a protein
  - DNA is **transcribed** into RNA
  - RNA is **translated** into protein

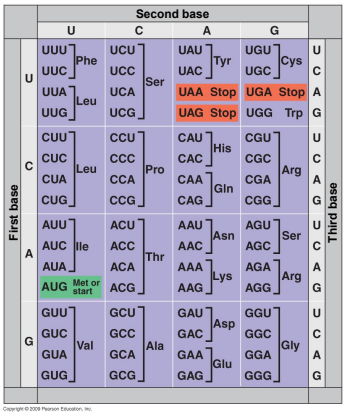




9

GENETIC CODE

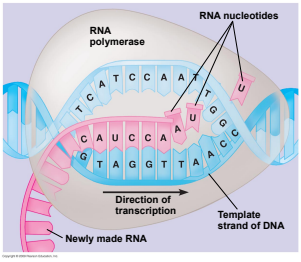
- Codons - three nucleotide sequences that correspond to a particular amino acid
  - 61 codons code for an amino acid (more than one codon can code for an amino acid)
  - AUG - start codon (codes for the amino acid methionine)
  - Three stop codons (UAA, UAG, and UGA)

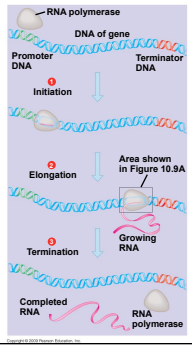


10

TRANSCRIPTION

- DNA strands separate
- One strand is used as a patter to produce RNA
  - Important change: In RNA thymine (T) is not used; uracil (U) is used instead.
- RNA polymerase is the enzyme that complete transcription
- Three stages:
  - Initiation: RNA polymerase binds to a promoter to unwind the helix
  - Elongation: RNA nucleotides are added to the chain
  - Termination: RNA polymerase reaches a terminator sequence and detaches

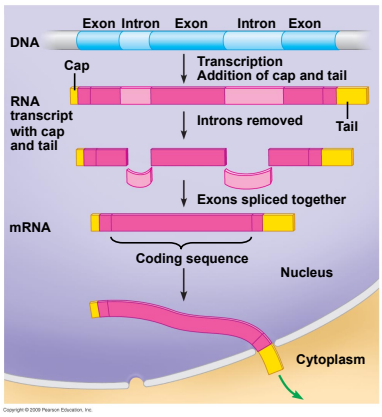




11

RNA PROCESSING

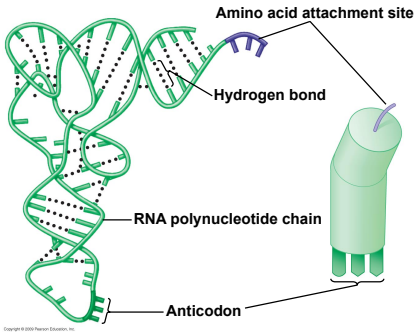
- Messenger RNA (mRNA) - contains codons for protein sequences
  - Introns - interrupting segments
  - Exons - coding segments
- Processing
  - Cap added to the 5' end (guanine nucleotides)
  - Tail added to the 3' end (Poly-A tail - 50-250 adenines)
  - RNA Splicing - removal of introns and joining of exons



12

TRANSLATION

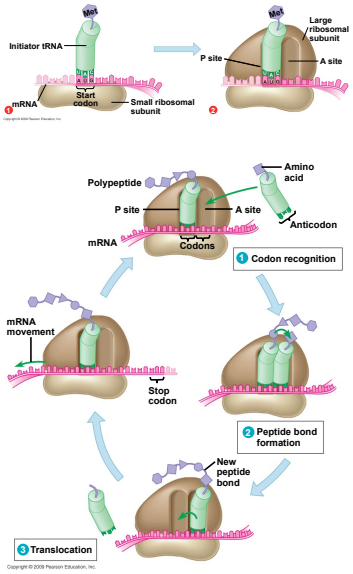
- Transfer RNA (tRNA) - match amino acids with the mRNA codon
  - Each tRNA carries a specific amino acid
  - Anticodon allows tRNA to bind to the complimentary codon on mRNA (A pairs with U; G pairs with C)



13

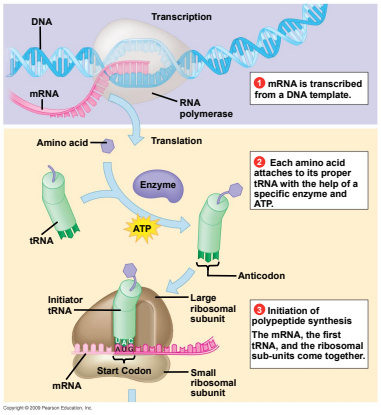
TRANSLATION

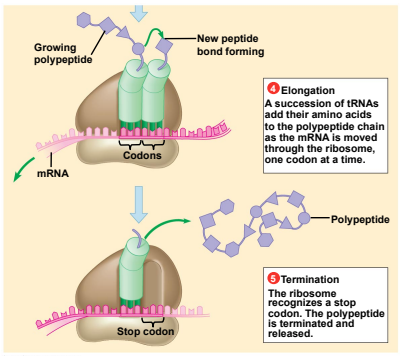
- Occurs at the ribosome (rRNA) in the cytoplasm
- Three stages:
  - Initiation: mRNA binds to ribosome and first tRNA at the start codon (P site)
  - Elongation: next tRNA binds to mRNA at the A site and the two amino acids are joined as the ribosomes moves the molecules over to the next site
  - Termination: stop codon is reached, all of the components are released



14

OVERVIEW OF TRANSCRIPTION AND TRANSLATION



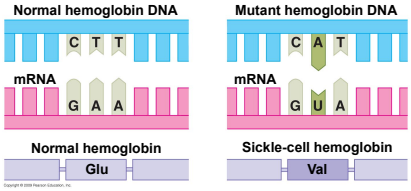


15

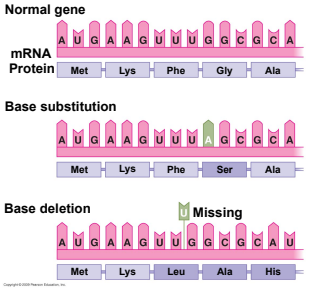
MUTATIONS

- Mutation - change in nucleotide sequence
  - Base substitutions: replacement of one nucleotide with another
    - Could have no effect or would effect only one amino acid
  - Deletions or insertions
    - Can alter the reading frame and thus have significant impacts downstream
- Can be spontaneous (due to errors in replication or recombination) or induced by mutagens (radiation or chemicals)

Substitutions



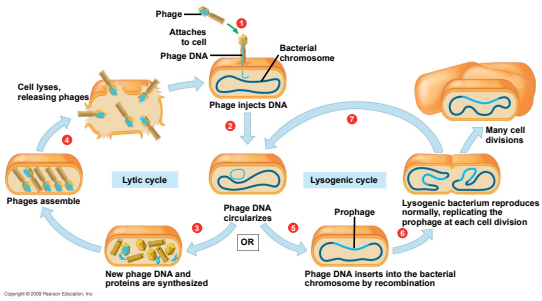
Insertions or Deletions



16

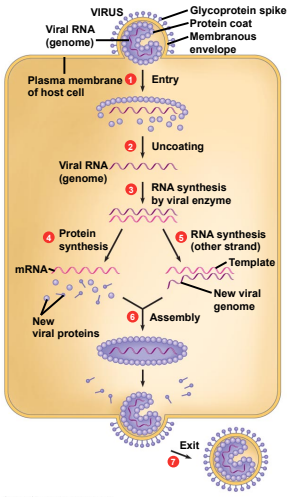
MICROBIAL GENETICS: VIRUSES

- Two types of reproductive cycles:
  - Lytic: viral particles are produced using host cell components and the host cell dies when the viruses are released
  - Lysogenic: viral DNA is inserted into the host by recombination



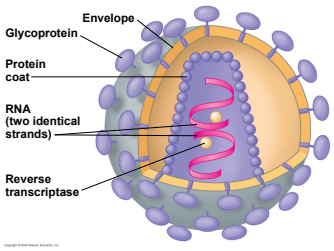
17

ENVELOPED VIRUSES

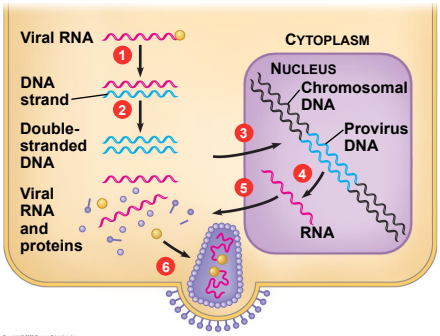


18

RETROVIRUSES



- HIV (human immunodeficiency virus)
  - Contains two copies of its RNA genome and an enzyme, reverse transcriptase, which can produce DNA from an RNA template



19

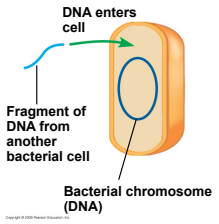
VIROIDS AND PRIONS

- Viroid - circular RNA that infects plants
- Prions - infectious proteins that cause nervous system disorders in animals
  - Misfolded forms of normal proteins that can convert other proteins

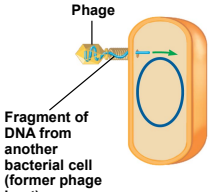
20

BACTERIA

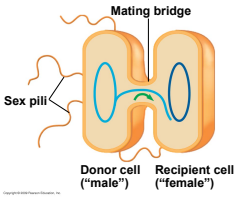
- Three ways they transfer DNA
  - Transformation - uptake of DNA from the environment
  - Transduction - gene transfer through bacteriophages
  - Conjugation - transfer of DNA from a donor to a recipient through a cytoplasmic bridge



Transformation



Transduction



Conjugation

21

PLASMIDS

- Small circular DNA molecules that are separate from the bacterial chromosome