Chapter 8
Microbial Genetics

Terminology

- Genetics: The study of what genes are, how they carry information, how information is expressed, and how genes are replicated
- Gene: A segment of DNA that encodes a functional product, usually a protein
- Chromosome: Structure containing DNA that physically carries hereditary information; the chromosomes contain the genes
- Genome: All the genetic information in a cell

Terminology

- Genomics: The molecular study of genomes
- Genotype: The genes of an organism
- Phenotype: Expression of the genes

Determine Relatedness

Which strain is more closely related to the Uganda strain?

Genetic Map of the Chromosome of *E. coli*

The Flow of Genetic Information

DNA

- Polymer of nucleotides: Adenine, thymine, cytosine, and guanine
- Double helix associated with proteins
- "Backbone" is deoxyribose-phosphate
- Strands are held together by hydrogen bonds between AT and CG
- Strands are antiparallel

Semiconservative Replication

DNA Synthesis

DNA Synthesis

- DNA is copied by DNA polymerase
  - In the 5' → 3' direction
  - Initiated by an RNA primer
  - Leading strand is synthesized continuously
  - Lagging strand is synthesized discontinuously
  - Okazaki fragments
  - RNA primers are removed and Okazaki fragments joined by a DNA polymerase and DNA ligase
✓ Give a clinical application of genomics. 8-1
✓ Why is the base pairing in DNA important? 8-2
✓ Describe DNA replication, including the functions of DNA gyrase, DNA ligase, and DNA polymerase. 8-3
✓

Transcription

DNA is transcribed to make RNA (mRNA, tRNA, and rRNA)
- Transcription begins when RNA polymerase binds to the promoter sequence
- Transcription proceeds in the 5' → 3' direction
- Transcription stops when it reaches the terminator sequence

Translation

- mRNA is translated in codons (three nucleotides)
- Translation of mRNA begins at the start codon: AUG
- Translation ends at nonsense codons: UAA, UAG, UGA

The Genetic Code

- 64 sense codons on mRNA encode the 20 amino acids
- The genetic code is degenerate
- tRNA carries the complementary anticodon

Simultaneous Transcription & Translation

- What is the role of the promoter, terminator, and mRNA in transcription? 8-4
- How does mRNA production in eukaryotes differ from the process in prokaryotes? 8-5
37 Regulation
- Constitutive genes are expressed at a fixed rate
- Other genes are expressed only as needed
  - Repressible genes
  - Inducible genes
  - Catabolite repression

38 Operon

39 Induction: process that turns on the transcription of a gene.

40 Induction

41 Repression: regulatory mechanism to meant to stop gene expression

42 Repression

43 Catabolite Repression: form of positive regulation designed to control intracellular molecular levels.

44

1. Lactose present, no glucose
2. Lactose + glucose present

45 ✓ What is an operon? 8-6
 ✓ What is the role of cAMP in catabolite repression? 8-7
 ✓

46 Mutation
- A change in the genetic material
- Mutations may be neutral, beneficial, or harmful
- Mutagen: Agent that causes mutations
- Spontaneous mutations: Occur in the absence of a mutagen

47 Mutation
1. Base substitution (point mutation)
   - Missense mutation
2. Change in one base
   - Result in change in amino acid

48 Mutation
1. Nonsense mutation
2. Results in a nonsense codon

49 Mutation
1. Frameshift mutation
2. Insertion or deletion of one or more nucleotide pairs

50 The Frequency of Mutation
- Spontaneous mutation rate = 1 in $10^9$ replicated base pairs or 1 in $10^6$ replicated genes
- Mutagens increase to $10^{-5}$ or $10^{-3}$ per replicated gene

Chemical Mutagens

Radiation
- Ionizing radiation (X rays and gamma rays) causes the formation of ions that can react with nucleotides and the deoxyribose-phosphate backbone

Repair
- Photolyases separate thymine dimers
- Nucleotide excision repair

Selection
- Positive (direct) selection detects mutant cells because they grow or appear different
- Negative (indirect) selection detects mutant cells because they do not grow
  - Replica plating

- How can a mutation be beneficial? 8-8
- How are mutations caused by chemicals? By radiation? 8-9
- How can mutations be repaired? 8-10
- How do mutagens affect the mutation rate? 8-11
- How would you isolate an antibiotic-resistant bacterium? An antibiotic-sensitive bacterium? 8-12

Genetic Recombination
- Vertical gene transfer: Occurs during reproduction between generations of cells.
- Horizontal gene transfer: The transfer of genes between cells of the same generation.

Genetic Recombination
- Exchange of genes between two DNA molecules
  - Crossing over occurs when two chromosomes break and rejoin

Genetic Recombination

Genetic Transformation

Bacterial Conjugation

Conjugation in \textit{E. coli}

Conjugation in \textit{E. coli}

Conjugation in \textit{E. coli}

Transduction by a Bacteriophage

Plasmids
- Conjugative plasmid: Carries genes for sex pili and transfer of the plasmid
- Dissimilation plasmids: Encode enzymes for catabolism of unusual compounds
- R factors: Encode antibiotic resistance
R Factor, a Type of Plasmid

Transposons
- Segments of DNA that can move from one region of DNA to another
- Contain insertion sequences for cutting and resealing DNA (transposase)
- Complex transposons carry other genes

Transposons

Transposons

- Differentiate horizontal and vertical gene transfer. 8-14
- Compare conjugation between the following pairs: F⁺ × F⁻, Hfr × F⁻. 8-15
- What types of genes do plasmids carry? 8-16
  ✓
  ✓
  ✓
  ✓