Information Transfer and Protein Synthesis

The DNA-RNA Connection

- A. Transcription
  - 1. mRNA (messenger RNA) is made from the DNA template
    - a. Carries information for making a specific protein
    - b. mRNA is transcribed in the nucleus where the DNA is found
- B. Translation
  - 1. Protein is made from the mRNA template
    - a. Sequence of bases on mRNA determines which amino acids will be found in the protein
    - b. Translation takes place in the ribosomes, not the nucleus

Coding Genetic Information

- A. The Genetic Code
  - 1. Order of nucleotides in DNA determines amino acid sequence of the protein product
    - a. There are 20 amino acids in animal proteins
    - b. The code must have at least twenty different forms
- B. Possible Codes
  - 1. Each nucleotide codes for a single amino acid
    - a. The four nucleotides could code only four amino acids ($4^1 = 4$)
  - 2. Pairs of nucleotides code for a single amino acid
    - a. Pairs of nucleotides could code for 16 amino acids ($4^2 = 16$)
  - 3. Triplets of nucleotides code for a single amino acid
    - a. Triplets could code for 64 amino acids ($4^3 = 64$)

Cracking the Genetic Code

- A. Marshall Nirenberg's Experiments
  - 1. Synthesized mRNA that had nothing but Uracil
    - a. Uracil is the RNA equivalent of Thymine
  - 2. Used Radioactively labeled amino acids
    - a. Each tube contained all twenty amino acids
    - b. Each tube had only one of the twenty labeled
  - 3.Result
    - a. Only Phenylalanine was incorporated into the protein
      - (1) UUU codes for phenylalanine
- B. Codons
  - 1. Sequences of three nucleotides that code for a particular amino acid
    - a. With 64 possible codons, there are more than one codon for each amino acid
  - 2. There are "punctuation" codons
    - a. "Start" to begin protein synthesis
    - b. "Stop" to end protein synthesis

RNA Synthesis

A. Types of RNA
1. tRNA - transfer RNA
2. rRNA - ribosomal RNA
3. mRNA - messenger RNA

B. RNA Synthesis
1. Coding Strand
a. "Sense" strand - only one strand of DNA is used as a template for transcription to RNA
2. Transcription takes place in the nucleus

C. Three stages of transcription
1. Initiation
a. RNA polymerase attaches to the promoter region of the DNA coding strand
(1) Promoter is just before segment to be transcribed
2. Elongation
a. RNA polymerase moves along the DNA, building a complementary RNA strand
3. Termination
a. Polymerase reaches the end of the DNA sequence to be transcribed
(1) polymersase and RNA are released

RNA Processing

A. Additions
1. Methyl-guanine cap placed on starting end of the mRNA
a. methylation protects against enzyme degradation
b. helps mRNA attach to the ribosome
2. Poly-A tail
a. 100-200 adenine nucleotides added to terminal end
b. Aids in transport through nuclear membrane

B. Splicing
1. Introns
a. Areas of RNA that correspond to non-coding DNA regions
b. Introns are removed before the RNA leaves the nucleus
2. Exons
a. Regions that will be translated into protein

Formation of tRNA, r RNA, and Ribosomes

- A. tRNA
  1. Transcribed from DNA
  2. Nucleotides are chemically modified
  3. Molecule folds to form a three dimensional structure
     a. tRNA binds to itself in areas that are “self complementary”
  4. Amino acids attach at one end
  5. Opposite end (anti-codon) binds to the mRNA
- B. Ribosomes and rRNA
  1. rRNA molecules and proteins combine to make the large and small ribosomal subunits
     a. Transported through the nuclear envelope to the cytosol
  2. In the cytosol, the subunits are assembled into complete ribosomes

Transfer RNA Charging

- A. Step One
  1. Enzyme binds a specific amino acid to a molecule of ATP
     a. ATP loses two phosphates, joins as AMP
- B. Step Two
  1. Appropriate tRNA binds to the amino acid
     a. AMP is displaced
  2. Enzyme releases completed tRNA

Protein Synthesis

- A. Initiation
  1. Methyl-guanine cap attaches to the ribosome
  2. Start codon AUG is positioned in the P site on the ribosome
     a. Methionine binds to start codon at P site
- B. Elongation
  1. Ribosome moves one codon at a time
     a. lengthening peptide (protein) chain is at the P site
     b. incoming amino acid is at the A site
- C. Termination
  1. Special protein binds to the Stop codon
  2. Peptide chain is released
  3. Ribosome falls apart into two subunits

Translation Errors

- A. Reading Frame Error
  1. Initiation does not start reading at the correct codon
  2. Incorrect amino acids are used as the translation continues out of frame
- B. DNA Errors
  1. Errors will be passed on to the RNA and then on to the protein

Tranport and Modification of Proteins

A. Processing of Protein Products
    1. Ribosomes are attached to the endoplasmic reticulum (ER)
    2. Signal sequence
        a. First amino acids - signal ultimate destination of protein
    3. At termination, the protein is released to the inside of the ER

B. Packaging of Protein
    1. Proteins may be cut and spliced before becoming active
    2. Sugar may be added to form a glycoprotein

C. Destination
    1. Protein may be used within the cell
    2. Protein may be shipped out of the cell (secretion)