Module 1: Introduction to Proteins and mRNAs
Summary

Proteins and their roles in human health

- Protein is an essential component of every life form on earth
  - Proteins are the machinery that make your body tick and keep you healthy
- Proteins are extremely abundant
  - They make up ~1/6 of the human body weight
  - Billions can fit inside each human cell
- Proteins come in all shapes and sizes
- Different cell types make different sets of proteins
- Mistakes in protein synthesis can lead to a variety of human diseases
- Viruses also contain proteins, but must use the molecular machinery in humans to replicate and manufacture them

Protein structure

- Proteins are long chains composed of amino acids
  - There are 20 different amino acids, each with a unique side chain
  - Amino acids connect via peptide bonds to form long chains known as polypeptides
  - These polypeptide chains then fold up into unique 3D shapes
- A protein's 3D shape determines its function
- Some proteins function independently; others self-assemble to form larger multiprotein complexes

mRNA structure

- mRNAs are the blueprints for proteins, carrying messages for how to make them
- mRNAs are long chains composed of nucleotides
  - There are 4 nucleotides, each with a unique side chain called a nitrogenous base
- The 4 nitrogenous bases are adenine (A), cytosine (C), guanine (G), and uracil (U)
- Nucleotides are joined together by chemical bonds called phosphodiesters to create a sugar-phosphate backbone
  - These phosphate groups are negatively charged, preventing mRNA from freely crossing cell and nuclear membranes

How cells make proteins and know what proteins to make

- Translation is the biological process of making proteins from mRNA
- Ribosomes are tiny molecular machines that move along the mRNA, translating the genetic code into a protein
  - The genetic code consists of 64 three-letter words called codons made from all possible combinations of the 4 nucleotides
    - 61 combinations each code for a specific amino acid
    - AUG, which codes for methionine, signals where to initiate protein synthesis
    - UAA, UGA, and UAG signal where to stop protein synthesis
  - First, the small subunit of a ribosome scans mRNA for the initiation codon AUG
  - Then, the large subunit of a ribosome joins and protein synthesis begins

  - The ribosome rachets along the mRNA one codon at a time, adding the corresponding amino acid to the end of the polypeptide chain
  - Finally, once a stop codon is reached:
    - The full-length polypeptide is released and folds into a functional protein
    - The 2 ribosome subunits dissociate and the process can begin again
- Each mRNA molecule is translated hundreds to thousands of times

Where do mRNAs come from?

- Transcription is the biological process of making RNA from DNA
- DNA is the permanent repository of genetic information in our cells
  - It is made up of long chains of nucleotides tightly packed into chromosomes
  - DNA is located in the cell nucleus
- When a cell needs to make a particular protein, that portion of DNA is copied into RNA
  - Once the initial RNA transcript matures into mRNA, it is transported out of the nucleus into the cytoplasm, where translation occurs
- The flow of information from DNA to mRNA to protein is known as the Central Dogma of Biology