Chapter 17: from genes to proteins

The **big question** to keep in mind:

How do we get from a gene (a sequence of nucleotides in a DNA strand) to a protein (a molecule made up of a sequence of 20 different amino acids)?

Information flow and the "central dogma"

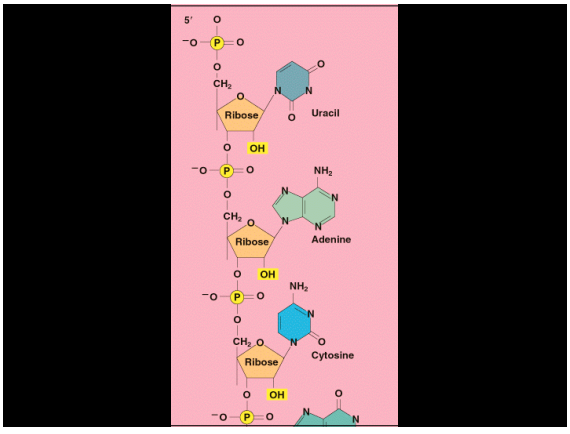
- DNA --> DNA (chapter 16)
- DNA --> RNA
- RNA --> Protein
- RNA is used as an intermediary between DNA and protein
  - Exceptions to the "dogma" - retroviruses

Transcription and Translation

- DNA is *transcribed* into RNA
- RNA is *translated* into protein
  - Analogies…

The structure of RNA

- Like DNA *except*
  - Single stranded
  - Ribose, not deoxyribose
  - Uracil, not Thymine



There are three kinds of RNA molecules in a cell

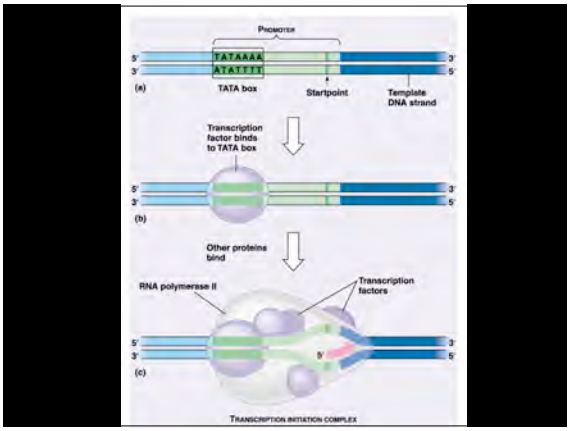
- Messenger RNA or mRNA
  - Carries "message" from DNA to ribosomes, where proteins are made
- Ribosomal RNA or rRNA
  - Structural part of ribosome
- Transfer RNA or tRNA
  - "adapters" that carry the appropriate amino acid to the growing peptide

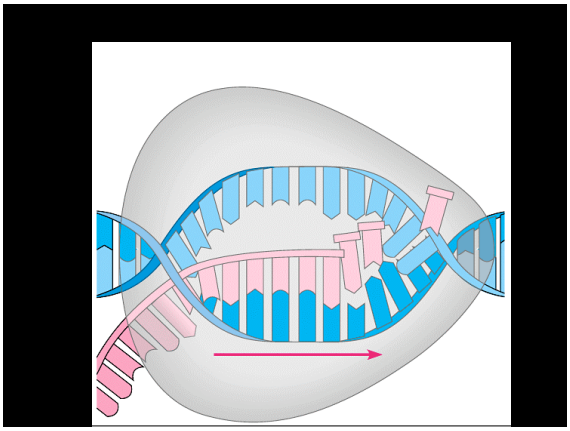
More about mRNA

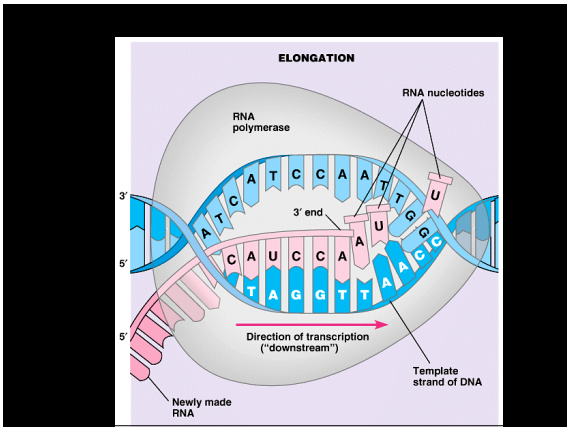
- The information from a specific gene on DNA is transcribed into an mRNA

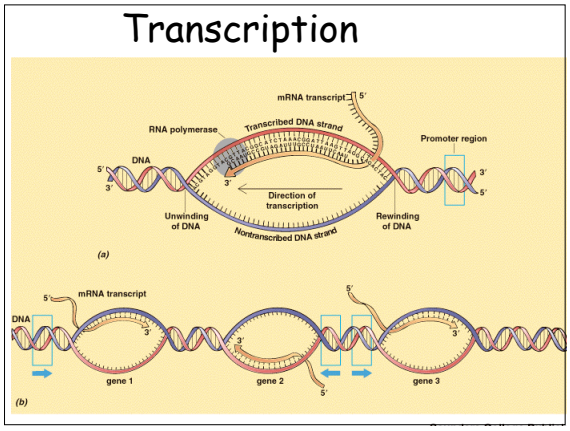
More about mRNA

- The information from a specific gene on DNA is transcribed into an mRNA
- mRNA is a long linear molecule
- In prokaryotes (no nucleus) ribosomes can attach to the mRNA as it is made
- In eukaryotes, mRNA is "processed," then it carries the information out of the nucleus to the ribosomes

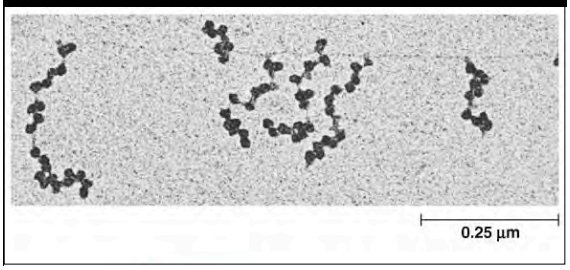


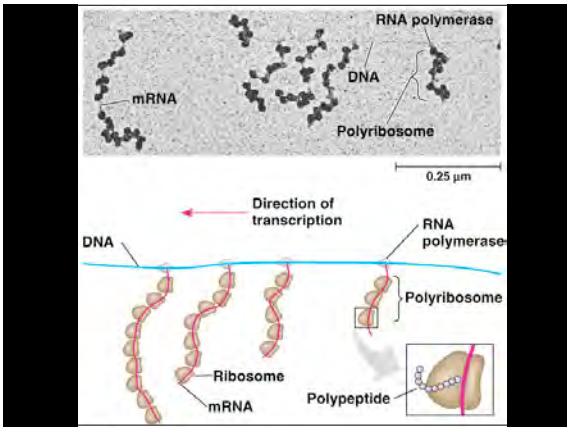






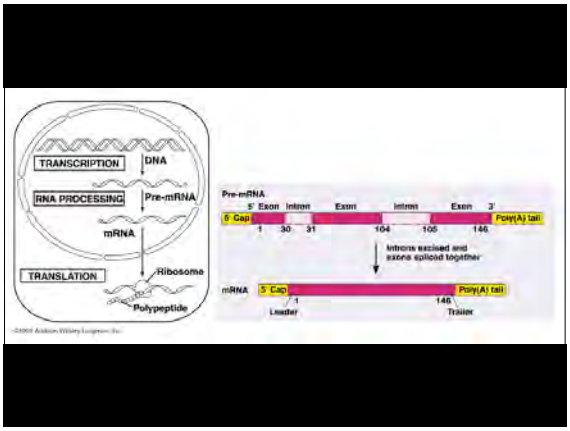
Transcription and translation in a prokaryote





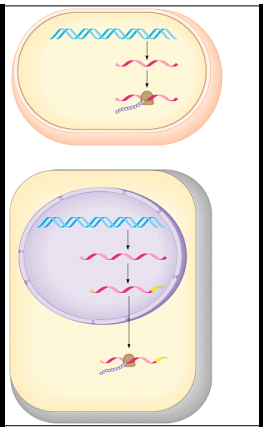
mRNA processing in eukaryotes

- Transcription in eukaryotes produces a "pre-mRNA" or "primary transcript"
- "introns" (regions that do not carry instructions for the final protein) are spliced out, exons are joined
- Addition of 5'cap and polyA tail produces an mRNA that is ready to leave the nucleus



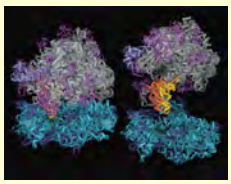
Prokaryote

Eukaryote



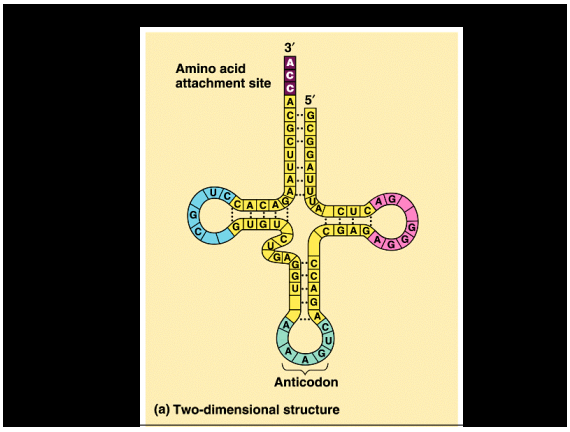
More about rRNA and ribosomes

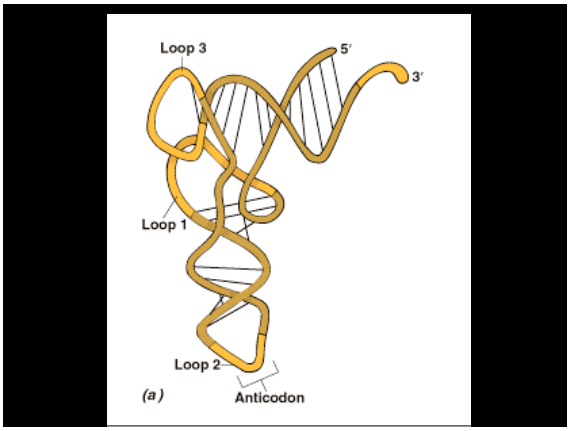
- Several different kinds of rRNA, along with several different proteins, make up a ribosome
  - Ribosomes are protein factories
  - Small and large subunits…



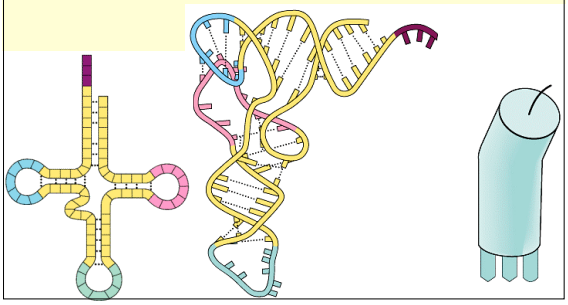
More about tRNA

- There are about 45 types of tRNA
- Every tRNA is about 80 bases long
- They fold and hydrogen bond to form a particular, "three loop" 3D shape
- At the 3′ end, they can carry an amino acid
- On one of the loops has an "anticodon"
- Each type of tRNA carries a specific amino acid, and has a specific anticodon





Three ways to draw a tRNA

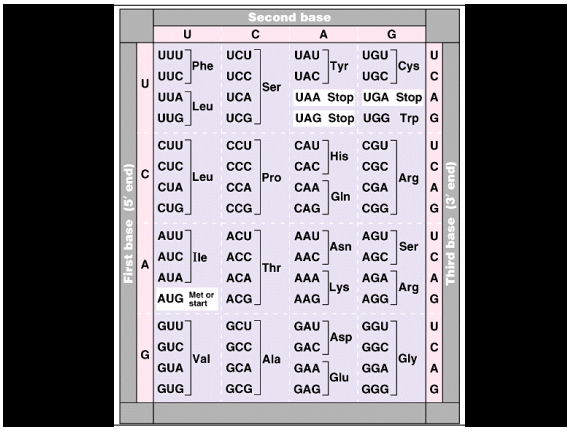


The Genetic Code

- There are four nucleotides in mRNA
- There are twenty possible amino acids in a protein
- How does mRNA specify each A.A.?

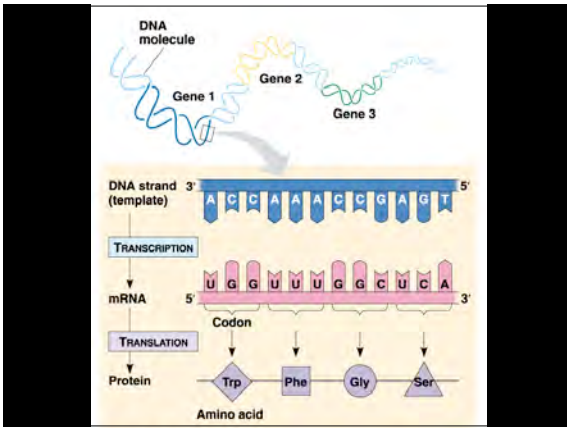
The genetic code: codons

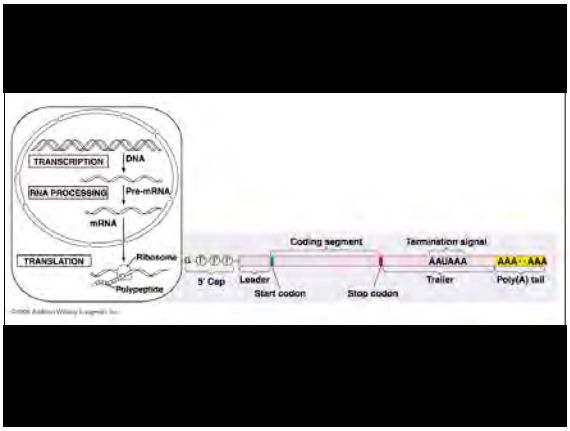
- mRNA is read in 3-base "words" called codons
- Four codons are reserved for "punctuation:"
  - The start codon: AUG (methionine)
  - The stop codons: UAA, UAG, UGA
- The code is "redundant" - there is more than one way to code for many amino acids
- Think - what *reads* the codons?



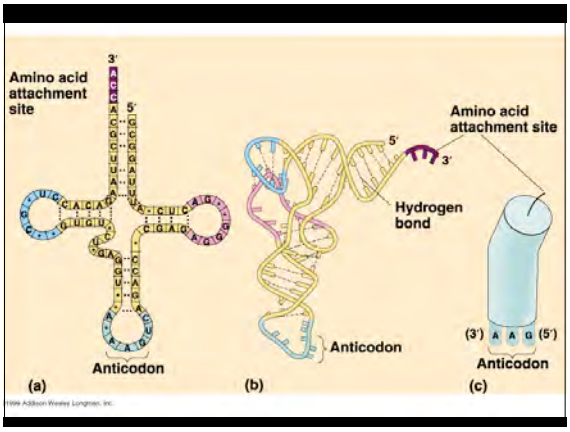
The Genetic Code, cont.

- The genetic code is arbitrary
- The same genetic code is nearly universal
  - Probability
  - Implications
  - Applications

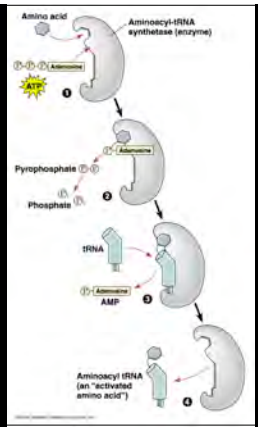


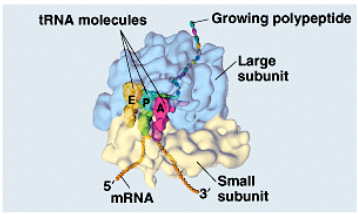


What does translation look like?

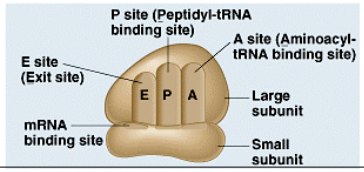


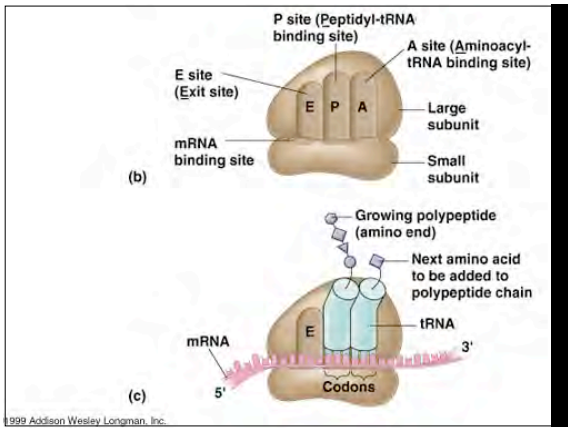
"Charging" a tRNA with the appropriate amino acid





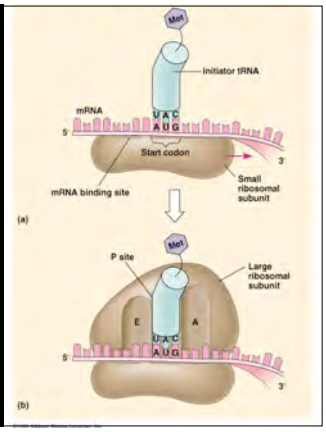
(a) Computer model of functioning ribosome

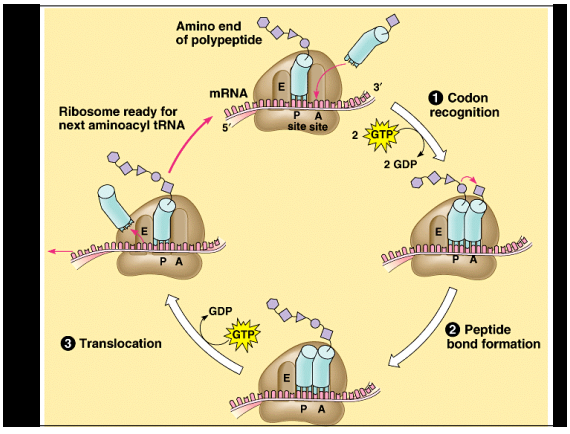


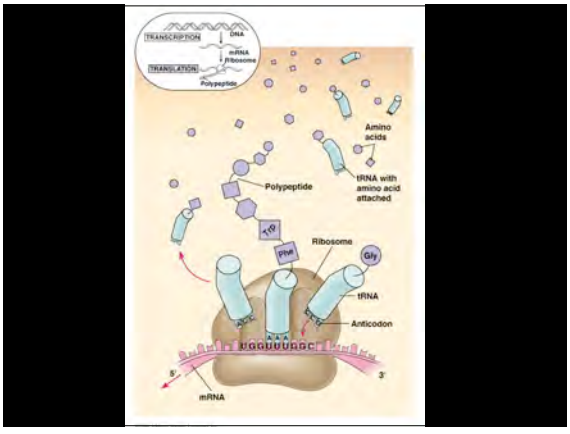


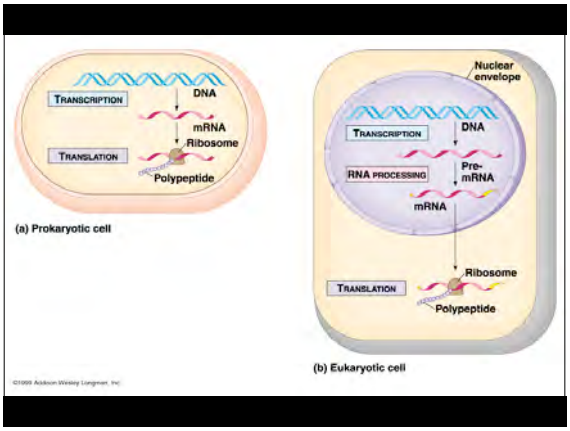
Initiation of translation: mRNA binds to small ribosomal subunit near a start codon.

The initiator tRNA and the large subunit complete the translation complex









Mutations

- A mutation is a change in a DNA molecule
- All genetic variations arise by mutation
- Mutations are random events - there is no mechanism that can produce only *useful* variation

Classifying Mutations I

- How is the DNA changed?
  - Base Substitutions
  - Insertions
  - Deletions
  - Some insertions and deletions are "frameshift" mutations, some are not

Classifying Mutations II

- The effects of mutations:
  - Silent mutations - the resulting protein strand is not changed by the mutation
  - Missense mutations - one or more amino acids are changed by the mutation
  - Nonsense mutations - the mutation creates a new stop codon, and the protein is terminated prematurely

Mutations

- Examples

- ANDTHECATANDTHEDOGEATANDRUN.
- ANDTHERATANDTHEDOGEATANDRUN.
- ANDTHEATANDTHEDOGEATANDRUN.
- ANDTHE.