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Chapter 17

From Gene to Protein

PowerPoint® Lecture Presentations for

Biology

Eighth Edition

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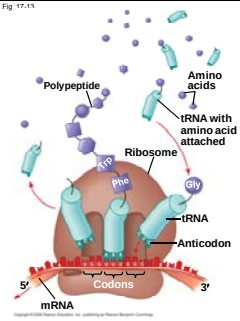

Key Players in:

Translation
- mRNA
- tRNA
- ribosome
- amino acids

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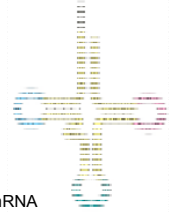
tRNA

On this model of a tRNA molecule, identify each of the following:



– 5′ and 3′ ends
– hydrogen bonds
– unpaired regions
– anticodon loop
– binding site for amino acid
– sequence that pairs with mRNA

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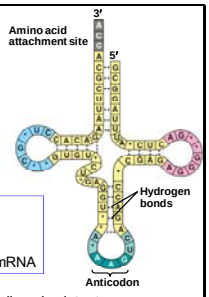
Fig. 17-14a

The Structure of Transfer RNA



- Single RNA strand (~80 nt)
- Different tRNAs carry different amino acids (on 3' end)
- Anticodon pairs with codon on mRNA

(a) Two-dimensional structure

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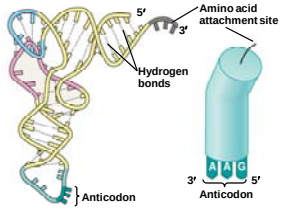
Fig. 17-14b

Because of hydrogen bonds, tRNA actually twists and folds into a three-dimensional molecule - tRNA is roughly L-shaped



(b) Three-dimensional structure

(c) Symbol used in this book

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Fig. 17-15-4

Two Basic Steps of Translation:

1.A correct match between a tRNA and an amino acid, done by the enzyme **aminoacyl-tRNA synthetase (called "tRNA charging")**

1.A correct match between the tRNA anticodon and an mRNA codon

Some tRNAs bind more than one codon – why?

Be able to describe the steps of tRNA charging

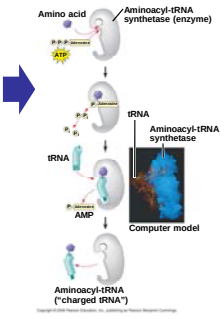

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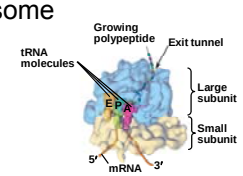
Fig. 17-16a

Ribosome



(a) Computer model of functioning ribosome

- Ribosomes facilitate specific coupling of tRNA anticodons with mRNA codons in protein synthesis
- The two ribosomal subunits (large and small) are made of proteins and **ribosomal RNA (rRNA)**

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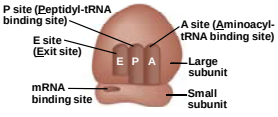
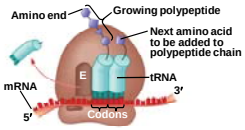


(b) Schematic model showing binding sites



(c) Schematic model with mRNA and tRNA

3 sites on Ribosome

APE:

A site
- holds tRNA with next *amino acid*

P site
- holds tRNA with growing *polypeptide*

E site
- *exit* site where tRNAs leave

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Building a Polypeptide

- The three stages of translation:
  - Initiation
  - Elongation
  - Termination
- All three stages require protein “factors” that aid in the translation process

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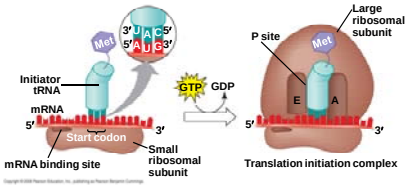
Fig. 17-17

Initiation of Translation

Initiation complex assembles:

1. mRNA, small ribosomal subunit, initiation factors, "initiator" tRNA (charged with MET) assemble first
2. Complex scans mRNA for start codon (AUG)
3. Large ribosomal subunit binds to complete complex



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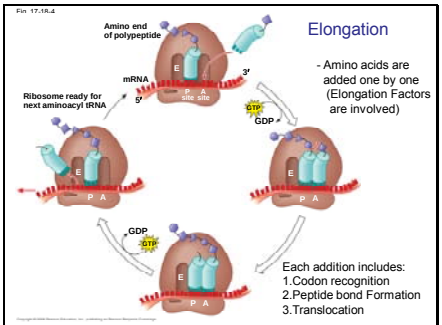

Elongation

- Amino acids are added one by one (Elongation Factors are involved)

Each addition includes:
1.Codon recognition
2.Peptide bond Formation
3.Translocation

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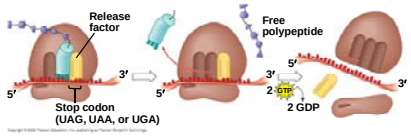
Fig. 17-19-3

Termination



Termination occurs when a stop codon in the mRNA reaches the A site

The A site accepts a protein called a release factor

The release factor causes the addition of a water molecule instead of an amino acid

This reaction releases the polypeptide, and the translation assembly then comes apart

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The final product of an expressed gene can be which of the following?

Find all of the correct choices.

a. mRNA
b. tRNA
c. rRNA
d. polypeptide

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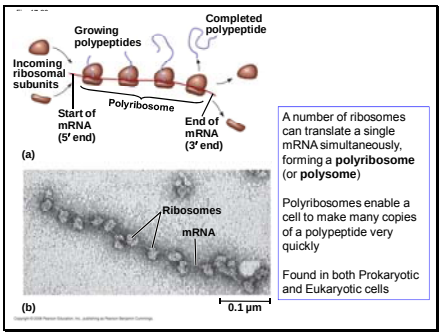

A number of ribosomes can translate a single mRNA simultaneously, forming a **polyribosome** (or **polysome**)

Polyribosomes enable a cell to make many copies of a polypeptide very quickly

Found in both Prokaryotic and Eukaryotic cells

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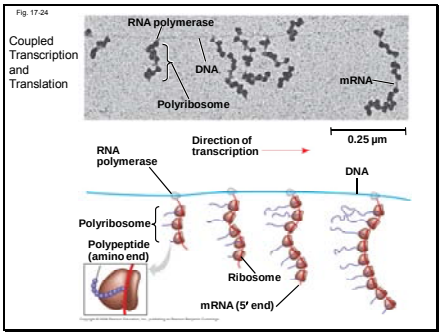

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Completing and Targeting the Functional Protein

Often translation is not sufficient to make a functional protein

- What events happen after translation?

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Protein Folding and Post-Translational Modifications

- During and after synthesis, a polypeptide chain spontaneously (or with help) coils and folds into its three-dimensional shape
- Proteins may also require post-translational modifications before doing their job
  - What are some modifications?
- Some polypeptides are activated by enzymes that cleave them – "pro- or pre- or pre-proproteins"
- Other polypeptides come together (interact) to form the subunits of a protein
- Proteins have to be targeted to their proper location

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Targeting Polypeptides to Specific Locations

- Two populations of ribosomes are evident in cells: free ribsomes (in the cytosol) and bound ribosomes (attached to the ER)
- Free ribosomes mostly synthesize proteins that function in the cytosol
- Bound ribosomes make proteins of the endomembrane system and proteins that are secreted from the cell
- Ribosomes are identical and can switch from free to bound

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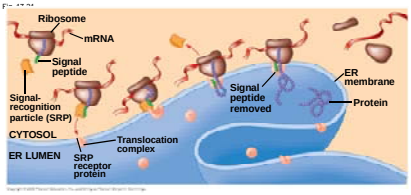

- Polypeptide synthesis begins in the cytosol
- Synthesis finishes in the cytosol *unless* the polypeptide signals the ribosome to attach to the ER
- Polypeptides destined for the ER or for secretion are marked by a **signal peptide**
- A **signal-recognition particle (SRP)** binds to the signal peptide
- The SRP brings the signal peptide and its ribosome to the ER

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Transcription and Translation

Of the following, which pertain to transcription, post-transcriptional modification, or translation?

- stop codon
- peptide bond
- P site
- GTP
- amino-acid synthetase
- Poly A tail
- ribosome
- anticodon
- promoter
- terminator sequence
- tRNA
- 5' cap
- Spliceosome
- 5' and 3' UTR
- RNA pol

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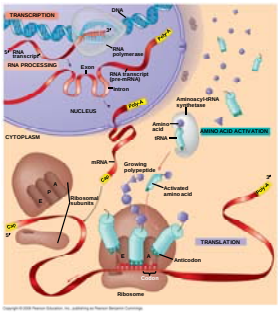
Fig. 17-25



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Comparing Gene Expression in Bacteria, Archaea, and Eukarya

- While gene expression differs among the domains of life, the concept of a gene is universal
- Bacteria and eukarya differ in their RNA polymerases, termination of transcription and ribosomes; archaea tend to resemble eukarya in these respects
- Bacteria can simultaneously transcribe and translate the same gene
- In eukarya, transcription and translation are separated by the nuclear envelope
- In archaea, transcription and translation are likely coupled

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What Is a Gene? *Revisiting the Question*

- The idea of the gene itself is a unifying concept of life
- We have considered a gene as:
  - A discrete unit of inheritance (coming soon…)
  - A region of specific nucleotide sequence in a chromosome
  - A DNA sequence that codes for a specific polypeptide chain
- In summary, a gene can be defined as a region of DNA that can be expressed to produce a final functional product, either a polypeptide or an RNA molecule

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The Effect of Mutations on Protein Function

- **Mutations** are changes in the genetic material of a cell or virus (due to spontaneous mutations during replication or physical/chemical agents)
- **Point mutations** are changes in just one nucleotide/base pair of a gene
- The change of a single nucleotide in a DNA template strand can lead to the production of an abnormal protein (but might not)

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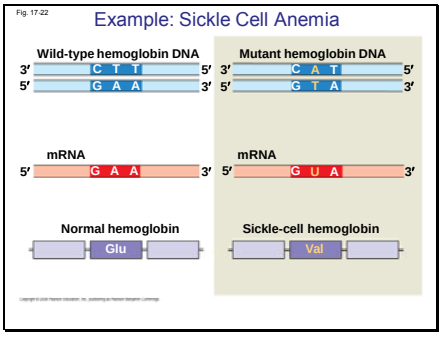

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Types of Point Mutations

Point mutations within a gene can be divided into two general categories

1. Base-pair substitutions

1. Base-pair insertions or deletions

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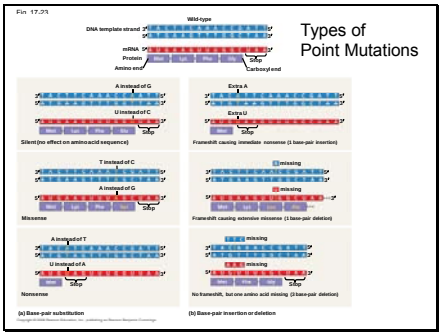

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Substitutions

- A **base-pair substitution** replaces one nucleotide and its complimentary base with another pair of nucleotides
- **Silent mutations** have no effect on the amino acid produced by a codon because of redundancy in the genetic code
- **Missense mutations** still code for an amino acid, but not necessarily the right amino acid
- **Nonsense mutations** change an amino acid codon into a stop codon, nearly always leading to a nonfunctional protein (early termination)

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Insertions and Deletions

- **Insertions** and **deletions** are additions or losses of nucleotide pairs in a gene
- These mutations have a disastrous effect on the resulting protein more often than substitutions do
- Insertion or deletion of nucleotides may alter the reading frame, producing a **frameshift mutation** (change in reading frame)