# Advanced Cell Biology. Lecture 21

Alexey Shipunov

Minot State University

March 9th, 2011

# Outline

# Outline

Questions and answers

From RNA to protein

# Previous final question: the answer

How RNA polymerase recognizes the “proper” strand of DNA?

# Previous final question: the answer

How RNA polymerase recognizes the “proper” strand of DNA?

- Asymmetric promoter

# Introns and exons

- Non-coding sequences are introns (vary from 1 to 10,000 bp)
- Other are exons

# Introns and exons

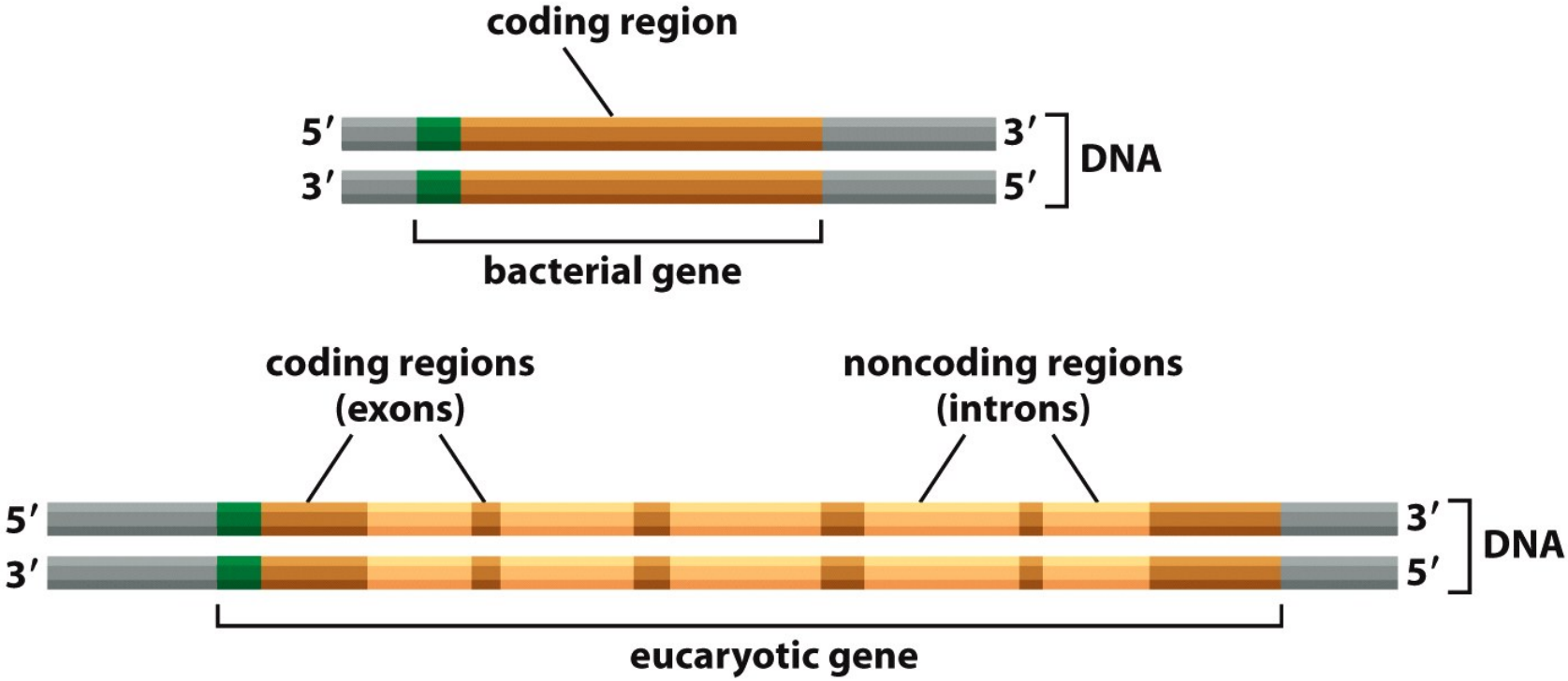



Figure 7-17 Essential Cell Biology 3/e (© Garland Science 2010)

# RNA splicing

- Introns should be removed from RNA: this is splicing
- RNA-protein complexes snRPNS (“snurps”) recognize the starts and ends of introns
- Snuprs are core part of spliceosome
- Introns form lariat structures when spliced

# RNA splicing

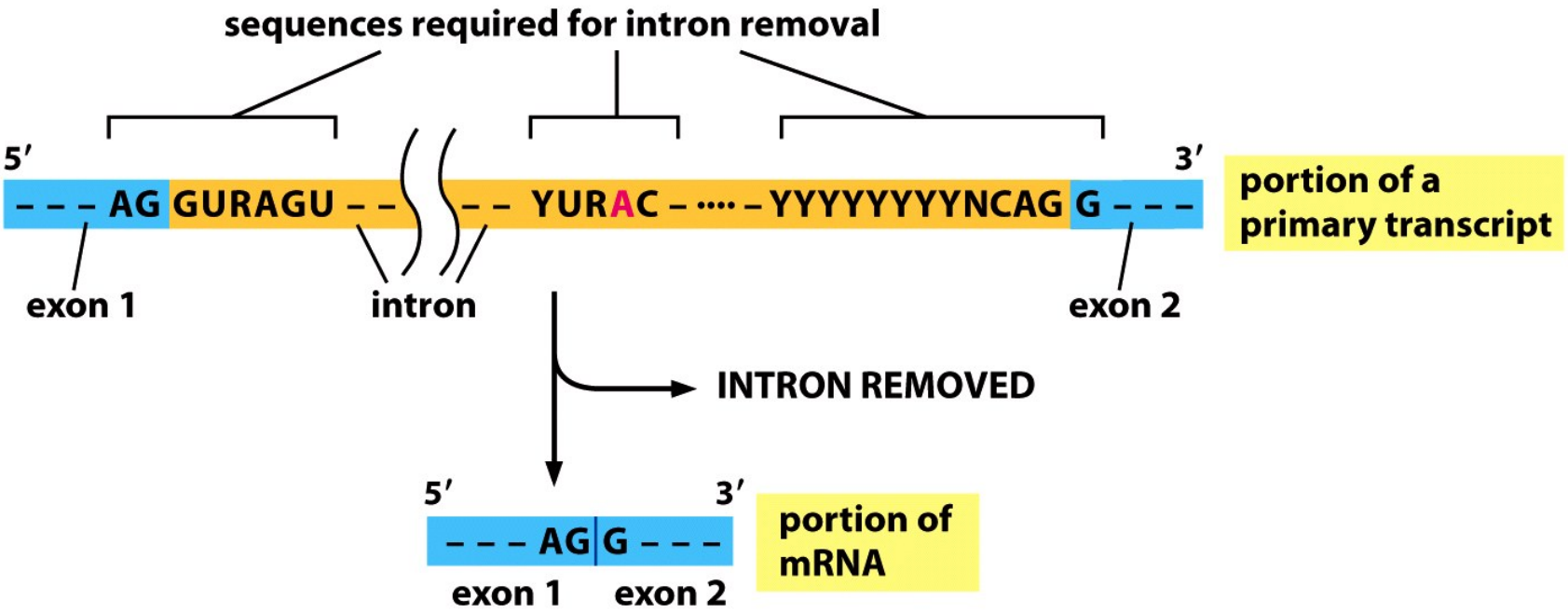



Figure 7-19 Essential Cell Biology 3/e (© Garland Science 2010)

RNA splicing movie

# Alternative splicing

- One RNA may be spliced differently
- Every single result of splicing will be the different protein

# Alternative splicing

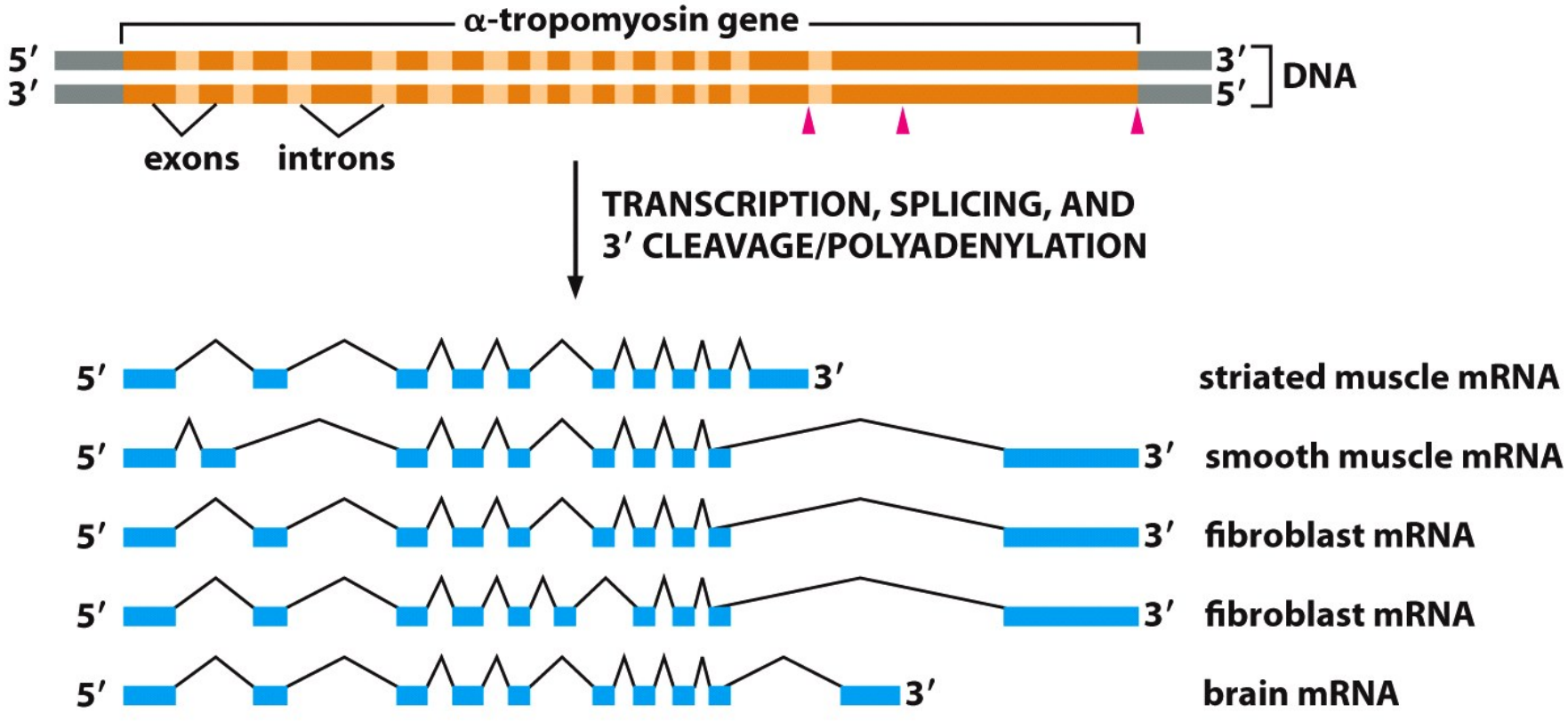



Figure 7-21 Essential Cell Biology 3/e (© Garland Science 2010)

# Selective export of RNA

- Nuclear pore will allow only “ready” mRNA to be exported into cytoplasm
- That will not allow the unprocessed RNA to be translated into protein

# RNA export from nucleus

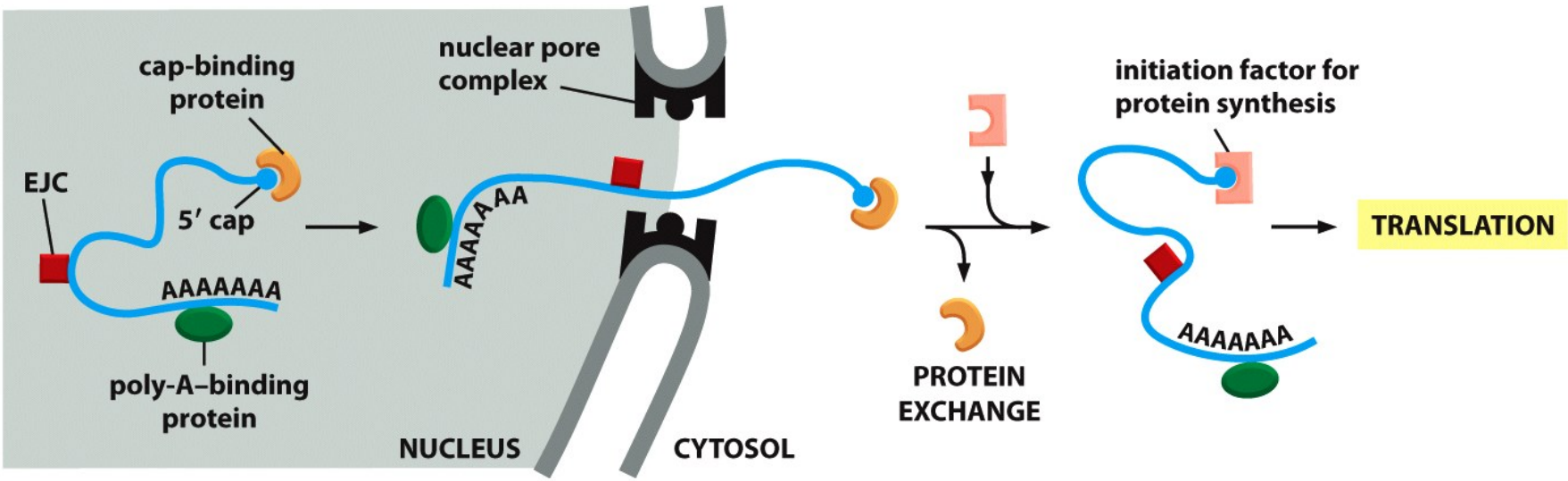



Figure 7-22 Essential Cell Biology 3/e (© Garland Science 2010)

# Degrading of RNA

- Bacterial mRNAs live $\approx$3 min
- In eukaryotes, mRNA lives longer, and the lifespan depends on how RNA was processed

# Origin of introns

- Introns will increase the flexibility of genome, but lower the speed of cell replication
- It is therefore possible that prokaryotes are secondary intronless
- Introns were found in some Archaea

# Transcription: eukaryotes vs. prokaryotes

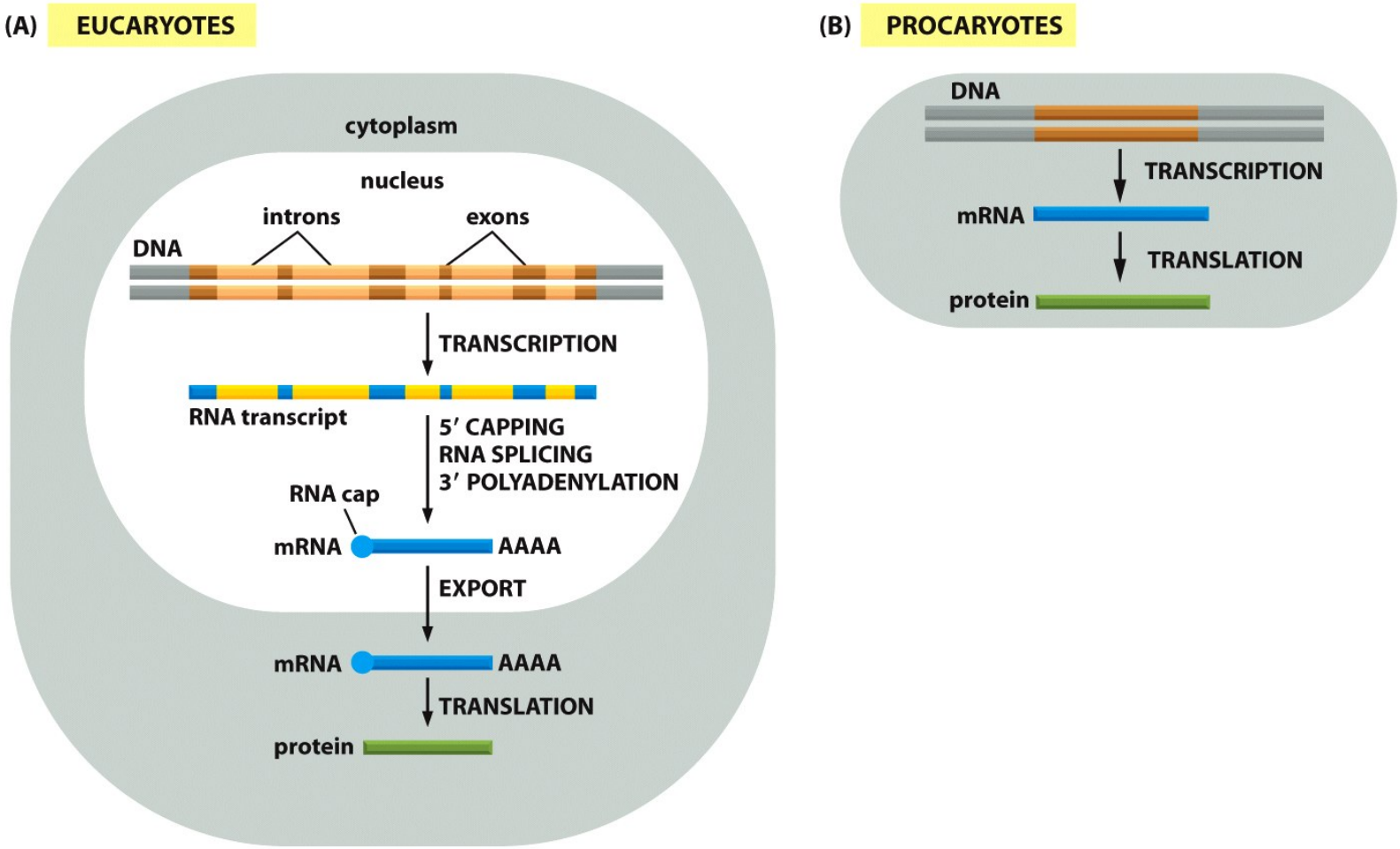



Figure 7-23 Essential Cell Biology 3/e (© Garland Science 2010)

# Redundance of genetic code

- Translation is decoding of codons into amino acids
- Four nucleotides may encode 64 amino acids
- As a result, the 3rd position may vary without change of amino acid

# Codons vs. amino acids

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GCA GCC GCG GCU | AGA AGG CGA CGC CGG CGU | GAC GAU | AAC AAU | UGC UGU | GAA GAG | CAA CAG | GGA GGC GGG GGU | CAC CAU | AUA AUC AUU | UUA UUG CUA CUC CUG CUU | AAA AAG | AUG | UUC UUU | CCA CCC CCG CCU | AGC AGU UCA UCC UCG UCU | ACA ACC ACG ACU | UGG | UAC UAU | GUA GUC GUG GUU | UAA UAG UGA |
| Ala | Arg | Asp | Asn | Cys | Glu | Gln | Gly | His | Ile | Leu | Lys | Met | Phe | Pro | Ser | Thr | Trp | Tyr | Val | stop |
| A | R | D | N | C | E | Q | G | H | I | L | K | M | F | P | S | T | W | Y | V | |

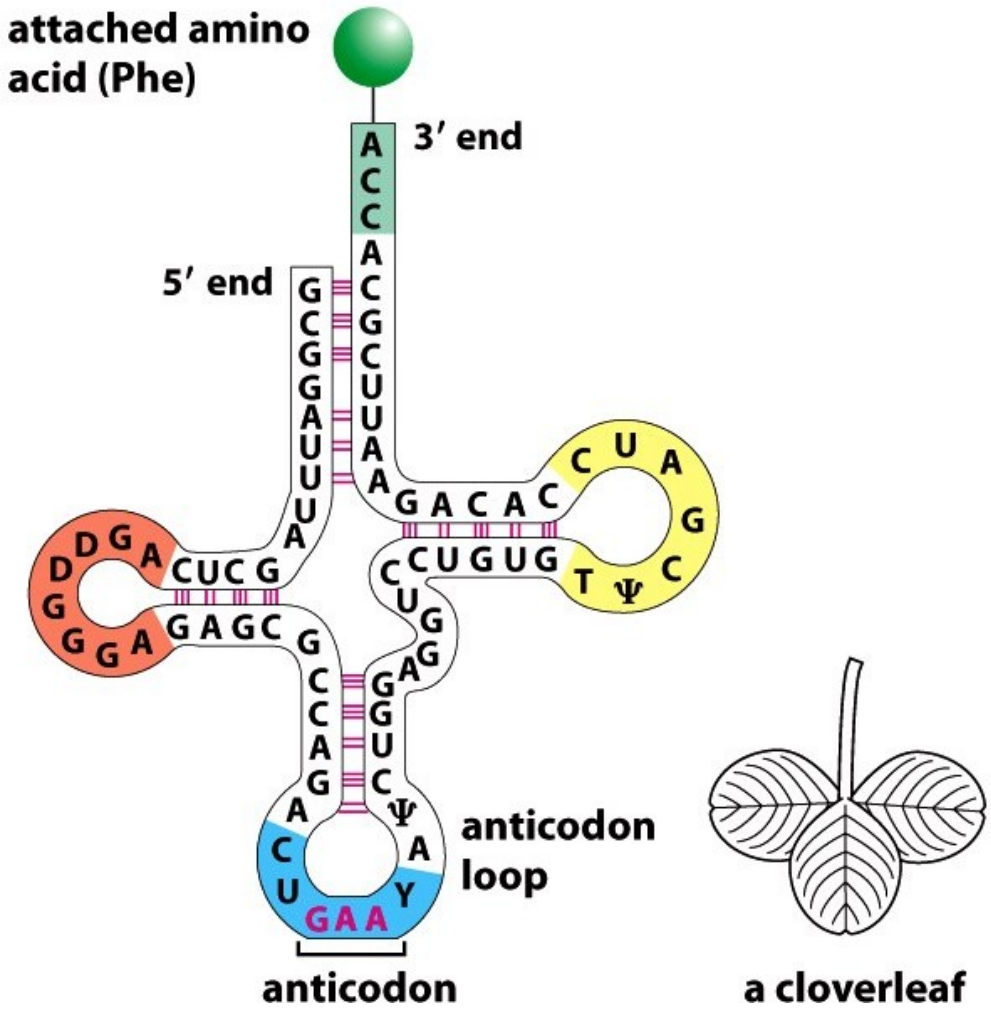
# Decifering the code

- First, artificial translation systems (taken from *E. coli* RNAs and enzymes) were created
- In 1960s, Nirenberg and Leder discovered that trinucleotides may be attached to ribosome and activate the transfer RNAs
- They produced big amounts of same codons and then analyzed complexes of ribosome-trinucleotide-aminoacyl-tRNAs.

# Transfer RNAs

- "Cloverleaf" of ≈80 nucleotides
- Three loops and (optionally) amino acid on 3' end (the arm, which also contains specific nucleotides)
- Top loop contain anticodon
- There are 31 kinds of tRNAs because many of them can tolerate a mismatch in 3rd position (wobble)

# Cloverleaf and tRNA



# Transfer RNA movie

# Linkage between amino acid and tRNA

- Aminoacyl-tRNA-synthetase is specific to every kind of amino acid
- Aminoacyl-tRNA-synthetase can recognize tRNA arm and anticodon
- Bond between amino acid and tRNA is highly-energetic

# amynoacyl-tRNA-synthetase

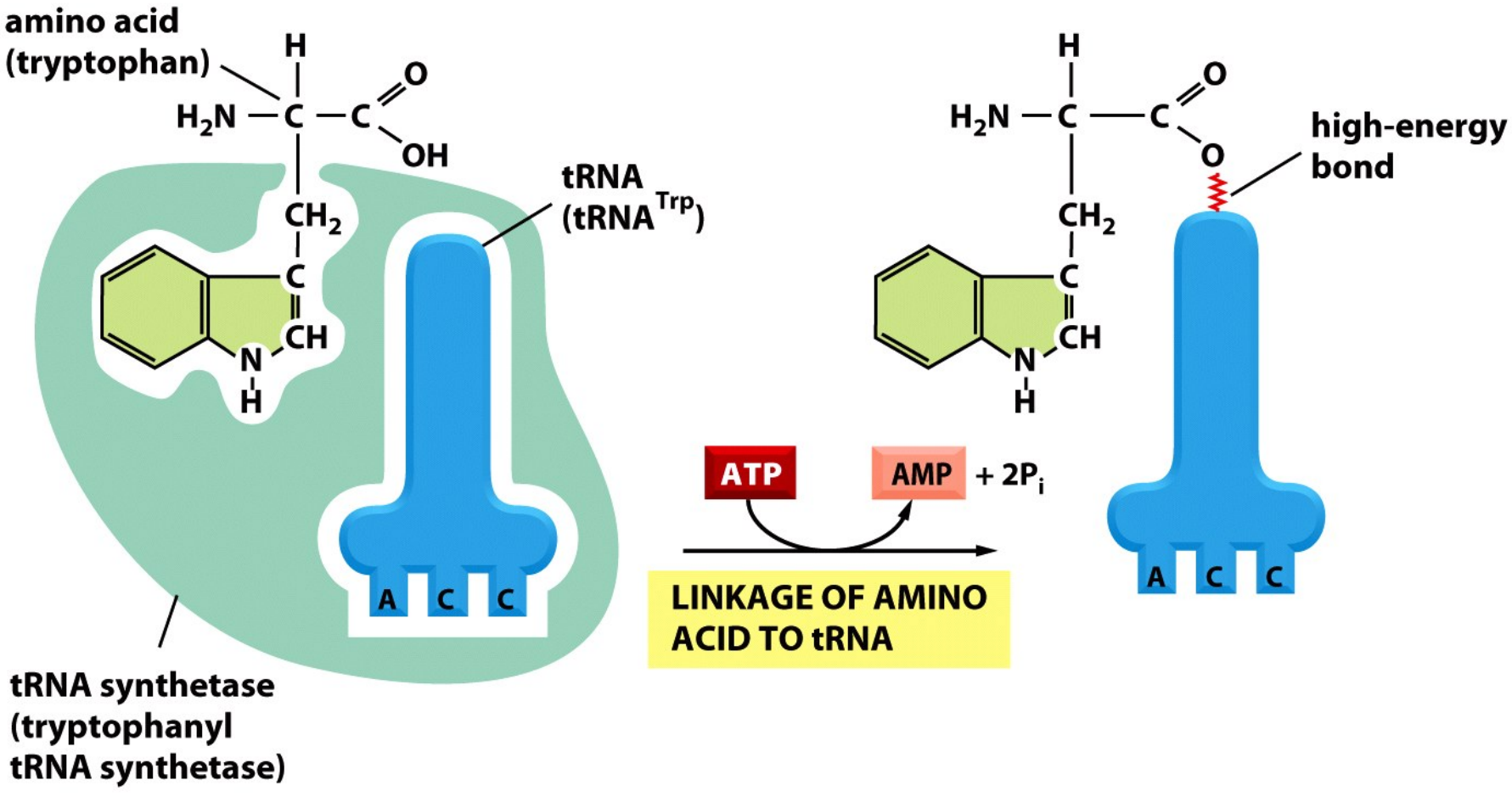



Figure 7-29 part 1 of 2 Essential Cell Biology 3/e (© Garland Science 2010)

# Ribosome

- Prokaryotes: 70S ribosomes
  - Small subunit: 30S
    - 16S RNA
    - 21 proteins
  - Large subunit: 50S
    - 5S RNA + 23S RNA
    - 34 proteins
- Eukaryotes: 80S ribosomes
  - Small subunit: 40S
    - 18S RNA
    - 33 proteins
  - Large subunit: 60S
    - 5S RNA + 28S RNA + 5.8S RNA
    - 49 proteins

# Structure of eukaryotic ribosome

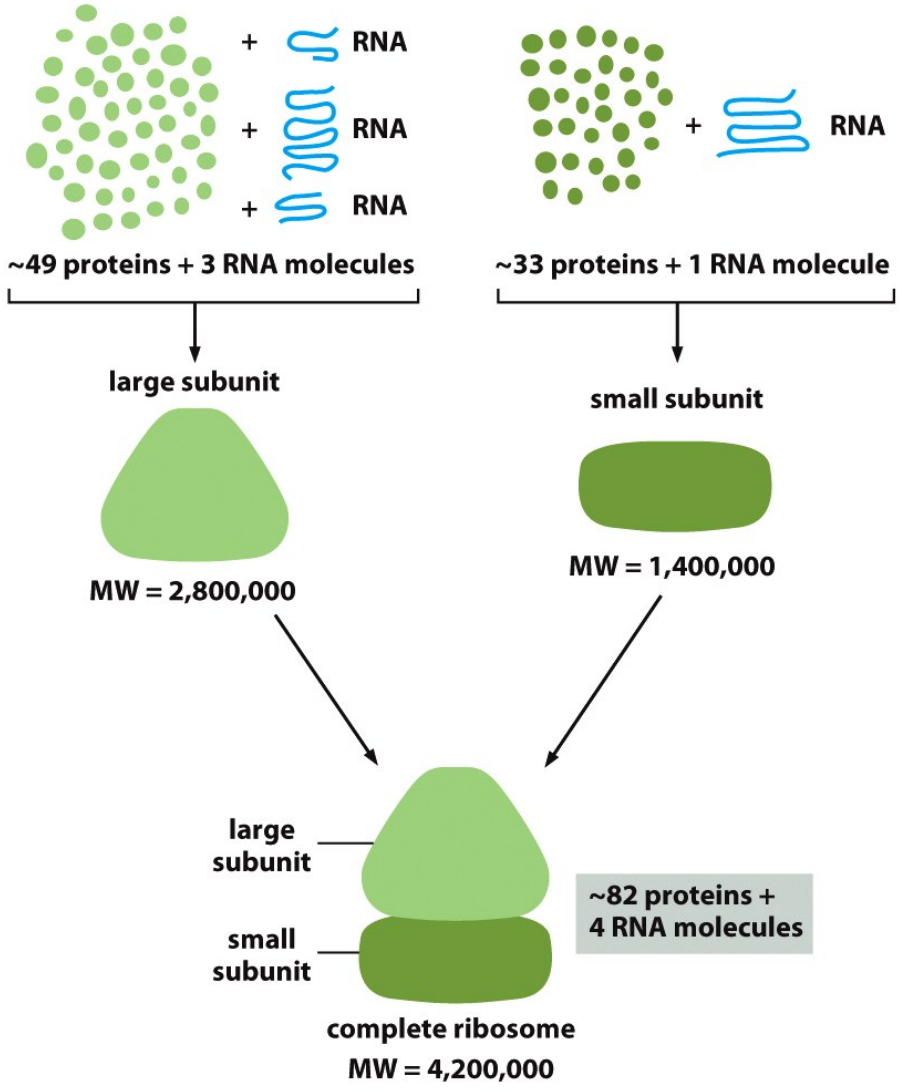



Figure 7-31 Essential Cell Biology 3/e (© Garland Science 2010)

# Ribozyme

- Has three binding sites, A, P and E (for aminoacyl-tRNA, peptidyl-tRNA ans exit)
- RNAs, not proteins are responsible for ribosome conformation and activity
- Ribosome is a RNA-enzyme, ribozyme

# A-P-E binding sites of ribosome in work

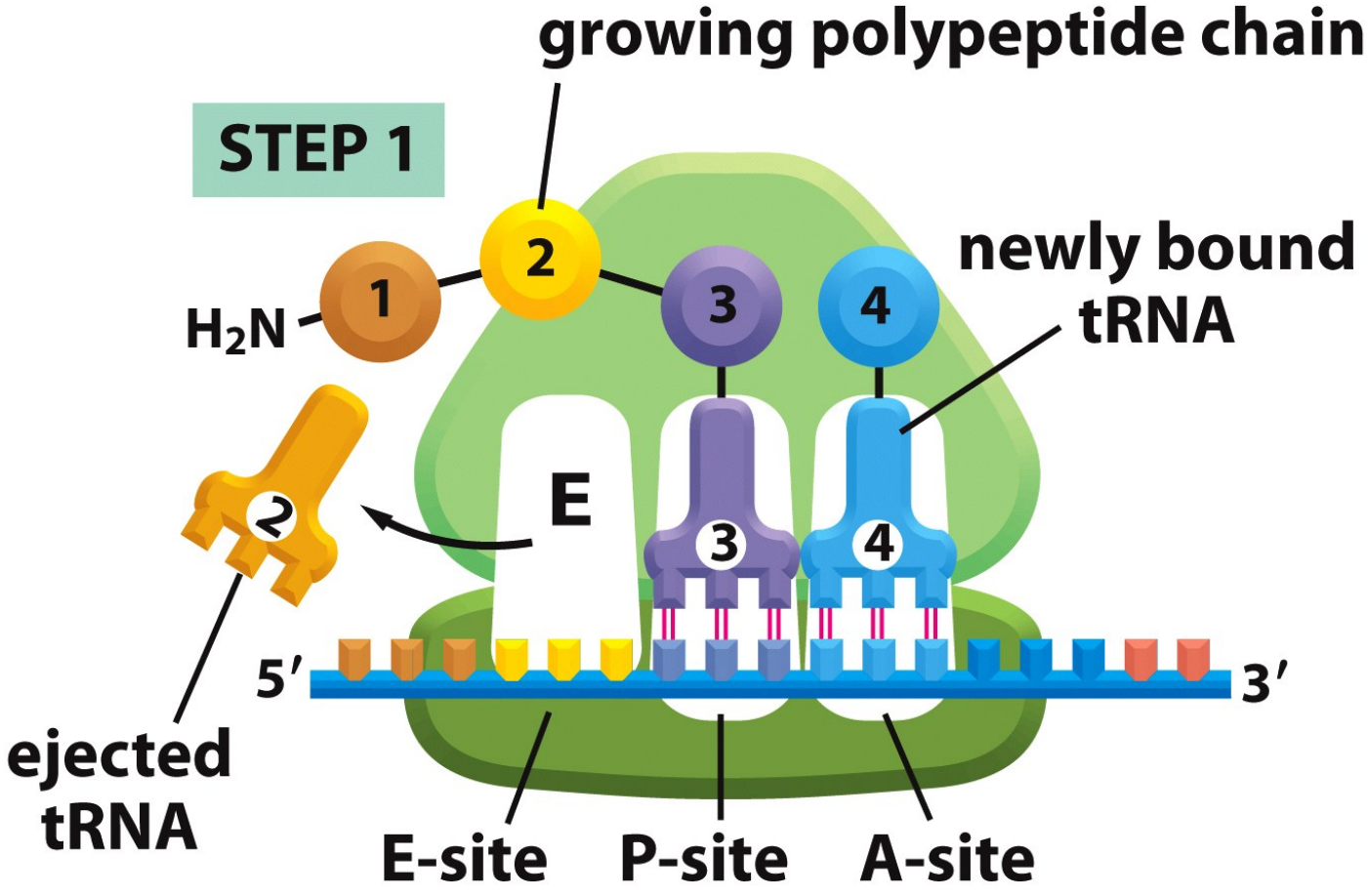



Figure 7-33 part 1 of 5 Essential Cell Biology 3/e (© Garland Science 2010)

# Final question (1 point)

# Final question (1 point)

What is bigger, eukaryotic or prokaryotic ribosome?

# Summary

- Transcription processes are seriously different between prokaryotes and eukaryotes
- Transcription factors, RNA splicing, and exporting from the nucleus are key features of eukaryotic transcription
- For 61 meaningful codons, there are 31 tRNAs and 20 amino acids
- Ribosome is a ribozyme

# For Further Reading

A. Shipunov.
*Advanced Cell Biology* [Electronic resource].
2011—onwards.
Mode of access: `http://ashipunov.info/shipunov/school/biol_250`.

B. Alberts et al.
*Essential Cell Biology*. 3rd edition.
Garland Science, 2009.
*Chapter 7*: 231–254.