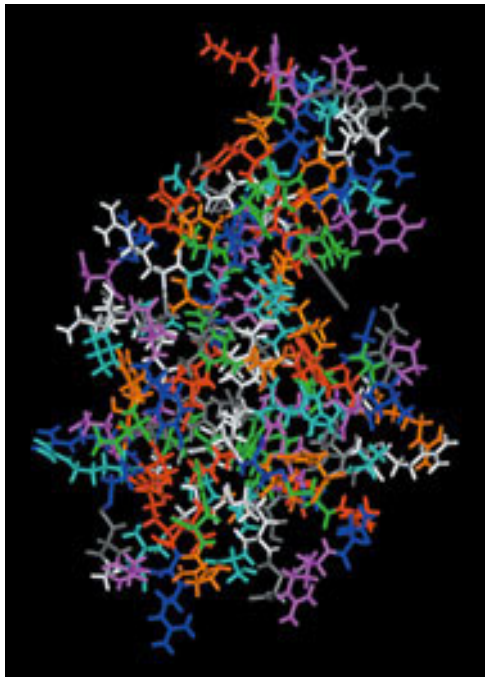
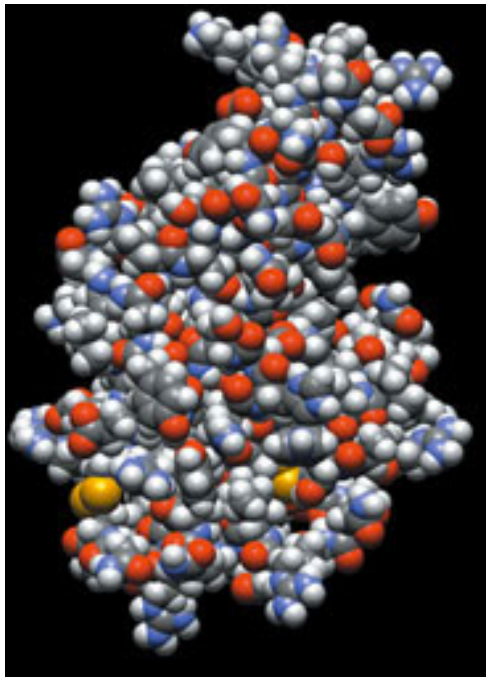
# Proteins and signal transduction

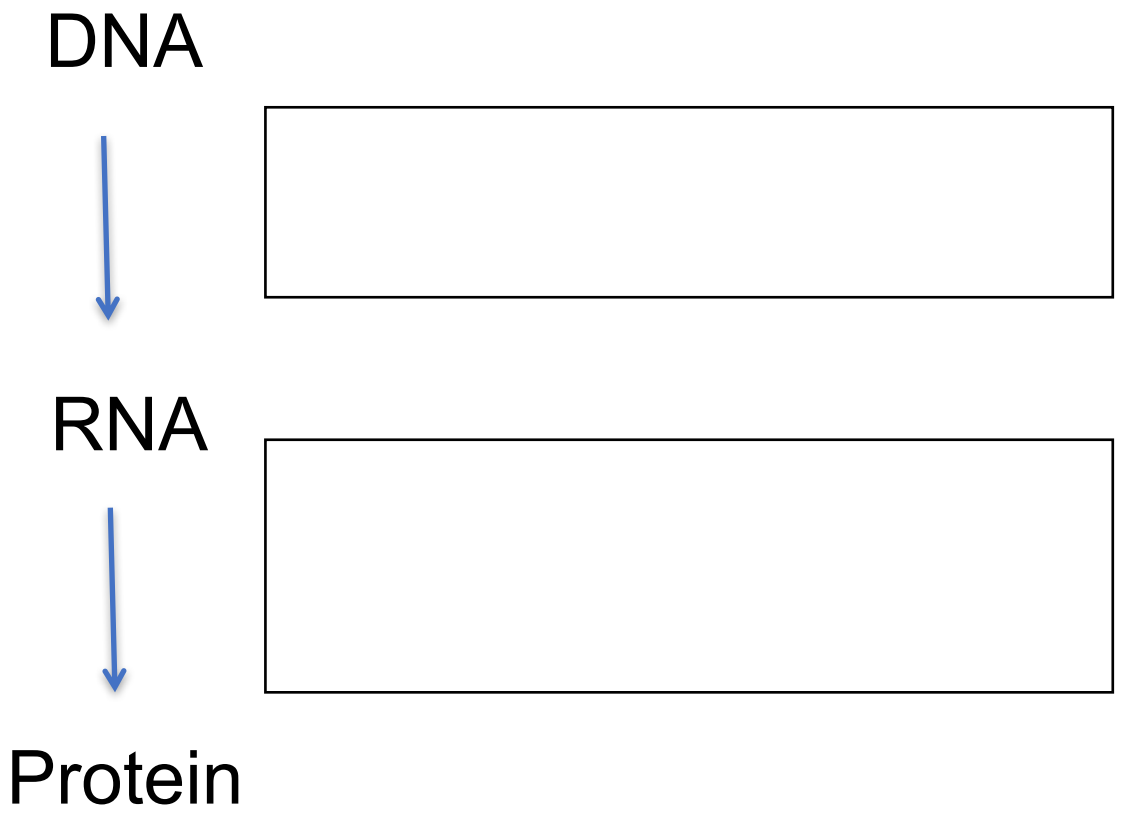
BIO311

01.17.2017





# Protein Synthesis



# Proteins

- Majority of the dry weight of the cell
- Variety of functions:
  - _____proteins – cytoskeleton (microtubules, actin), chromosome scaffolds
  - _____– catalyze chemical reactions (metabolism). Synthesize molecules (_____).
  - Transfer information (TFs, _____)
  - Molecular Machines. _____

# How can one class of biomolecules give rise to so many diverse functions?

They can adopt many different structures (_____)

# Structural variety in proteins

- Made up of _____aa, not just 4 residues like in RNA or DNA – computational possibilities
- Flexible about the C-N _____bond

Structure → _____

# Making proteins

Watch the translational machine, the ribosome, in action

# Translation: how proteins are made

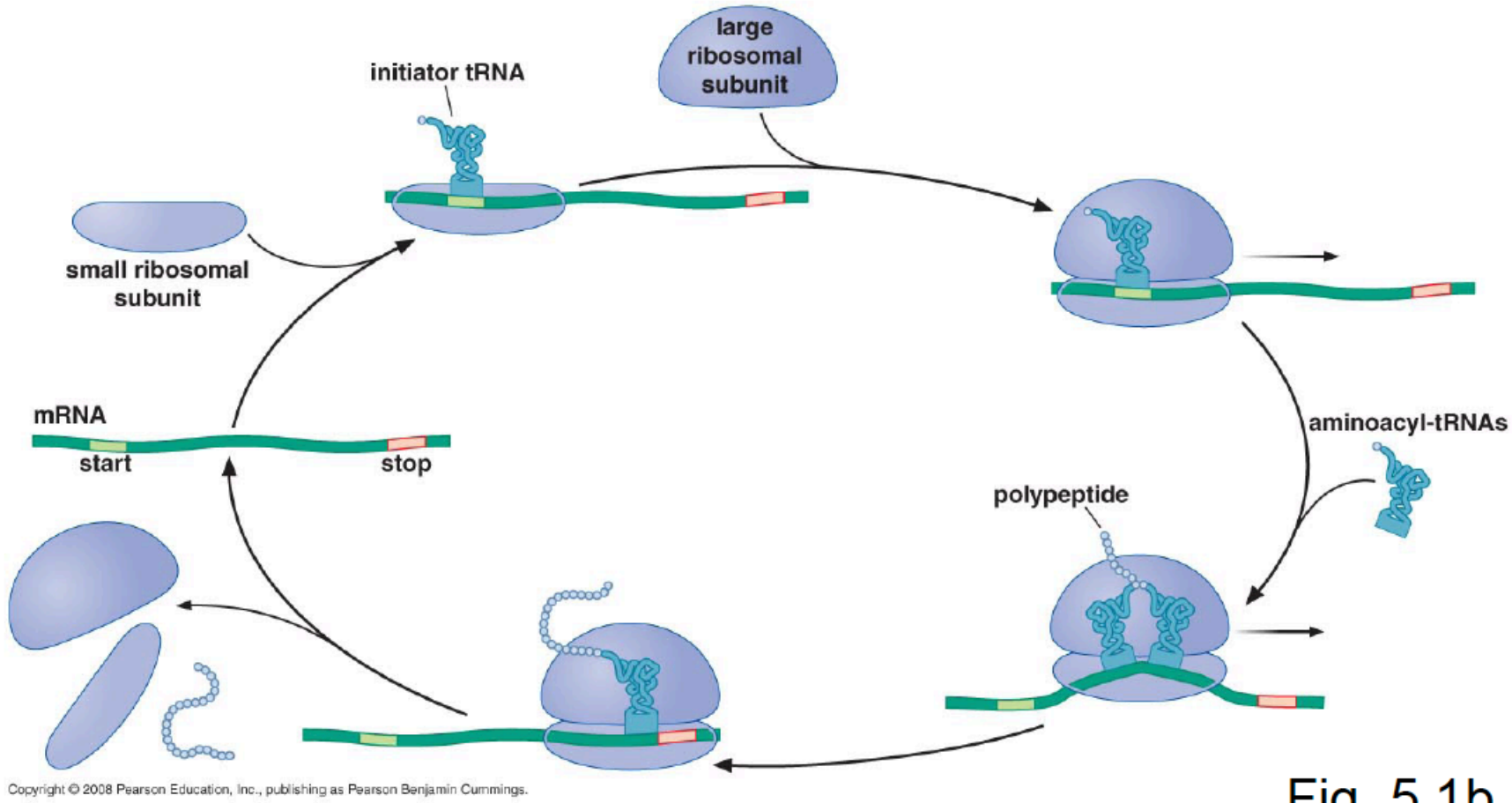
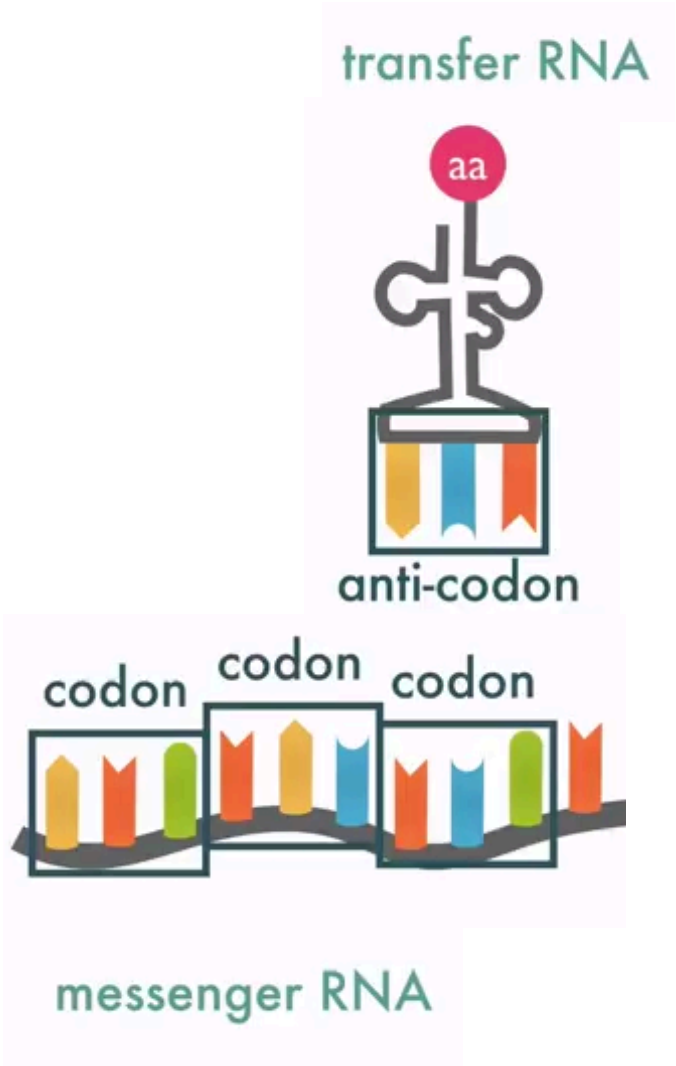




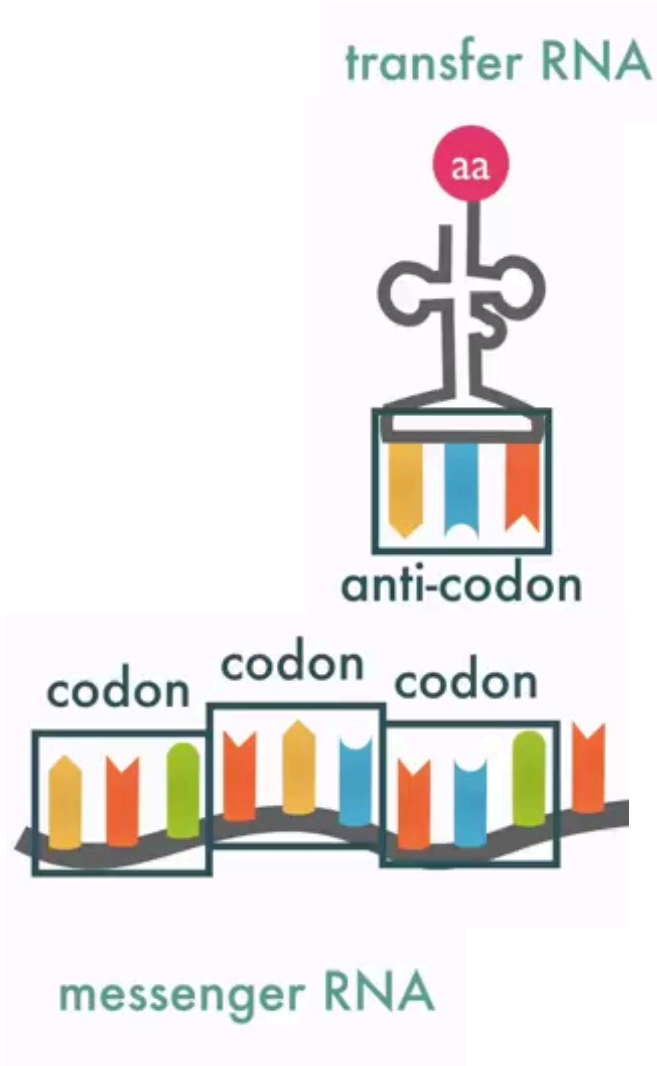

Fig. 5.1b

# From the Genetic Code to the aa seq




- _____: a set of 3 nucleotides in the mRNA seq that codes for 1 aa.
- _____: corresponding triplete seqon the tRNA that brings the specific aa to the ribosome during the translation.

# The genetic code




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

# The Genetic Code

- 4 unique bases so $4^3$= 64 potential codons
- 20 amino acids
- What do the other 44 codons code for?

# The Genetic Code

- 4 unique bases = _____potential codons
- _____amino acids
- What do the other 44 codons code for?
- Genetic code is redundant (several codons for 1 amino acid)
- Punctuation

# The Genetic Code

- Punctuation

- Start codon is _____ = _____
  - Translational _____

- Stop codons: UAA, UAG, UGA
  - Translational stop

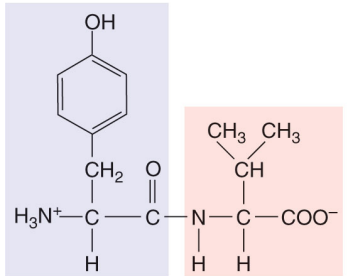
# Terminology: coding vs non-coding DNA

# 4 levels of protein structure

Primary 1°
Secondary 2°
Tertiary 3°
Quarternary 4°

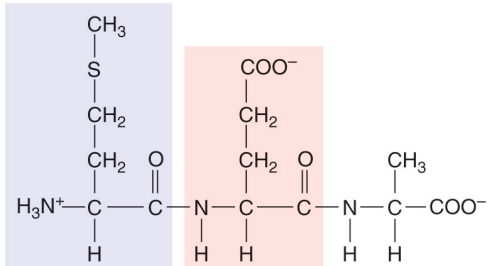
# Primary Structure of proteins

Dipeptide



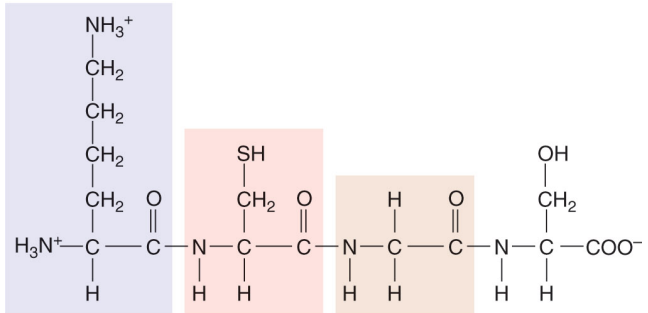
Tyrosylvaline
(Tyr-Val or YV)

Tripeptide



Methionylglutamylalanine
(Met-Glu-Ala or MEA)

Tetrapeptide



Lysylcysteinylglycylserine
(Lys-Cys-Gly-Ser or KCGS)

Linear sequence of amino acids
in the polymer (_____)

# PROTEIN STRUCTURE

- Proteins don’t exist in the cell as extended chains
- They fold into _____and _____structures (Globular)
- Primary structure determines these structures

# Strong chemical bonds

- _____– peptide bond = strong
- _____– reversible, weaker

# Weak chemical bonds (noncovalent) stabilize protein structure

- **Ionic bond**
- **Hydrogen bond**
- **van der Waals interaction**
- **Hydrophobic interaction**
  - **clustering of side chains**

# Secondary structures

**3 flavors**

_____helix

_____sheet

_____coil

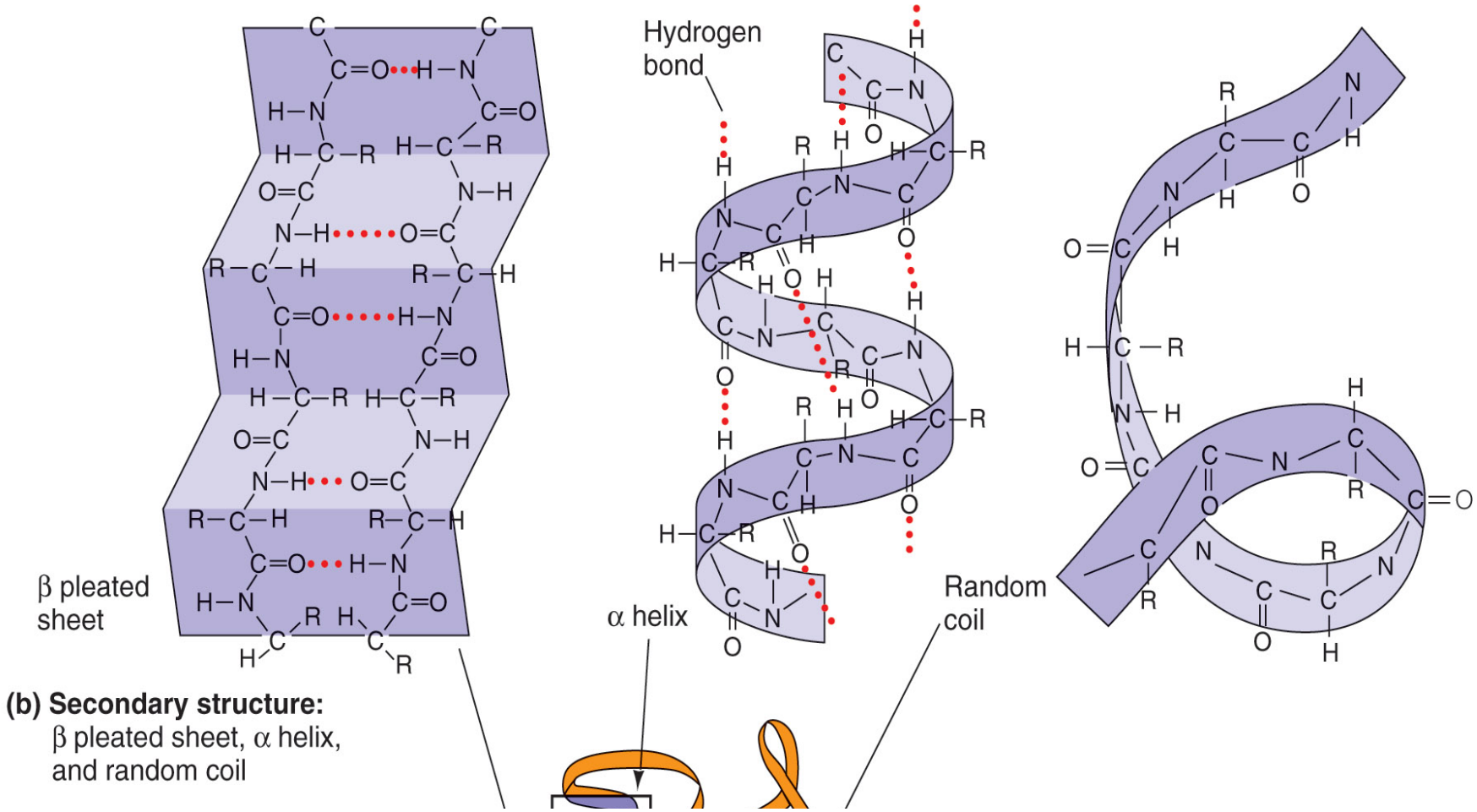



Figure 2.23b

Adapted from Tropp, B. E. Biochemistry: Concepts and Applications. Brooks/Cole Publishing Company, 1997.

# Tertiary structure

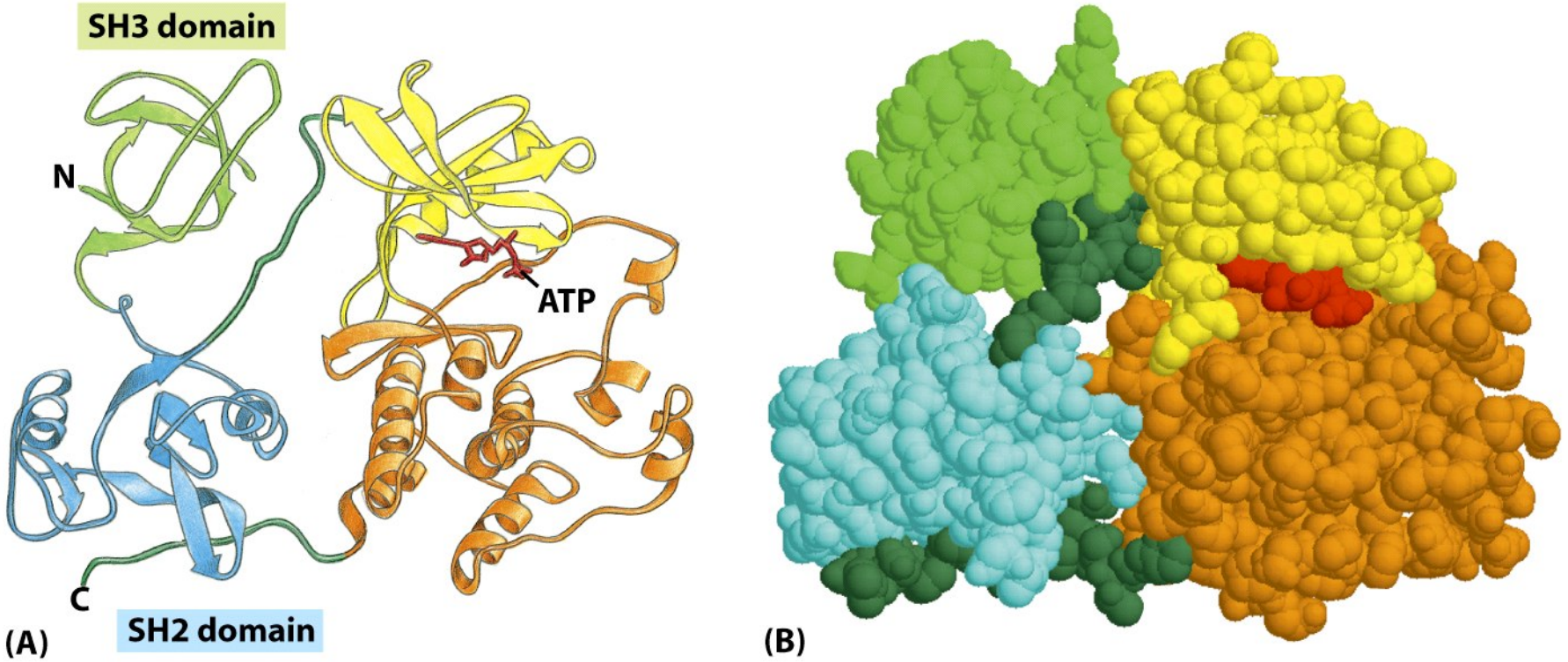
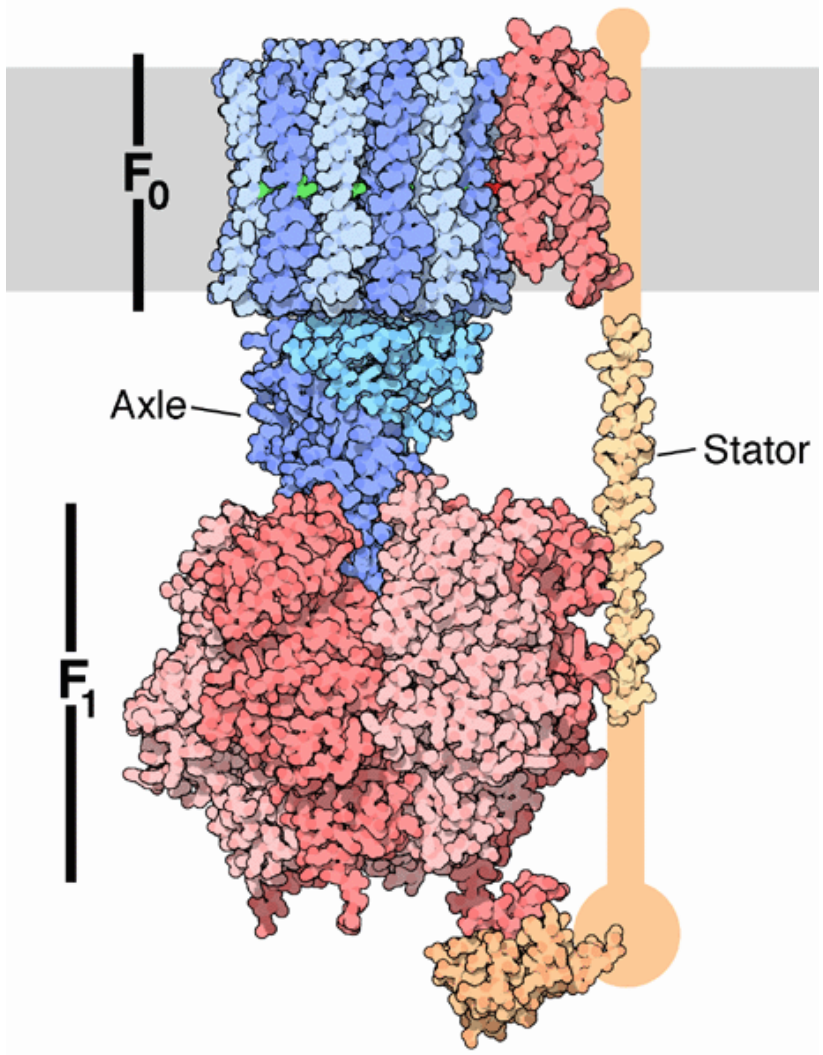



Figure 3-10 *Molecular Biology of the Cell* (© Garland Science 2008)

# Quaternary structure



# Quaternary structure in action

- ATP synthase: a molecular machine in motion

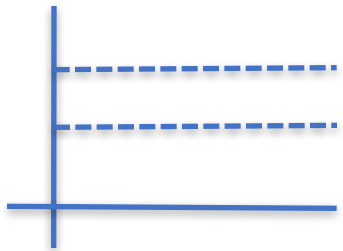
# Think/pair/share

- Design a protein for a cellular function of your choice. How would you make it? (Hint: consider tertiary and/or quaternary structure).
- “Break” your engineered protein. How would you do it? (Hint: think about the genetic code).

# PROTEIN FUNCTIONS

- Enzymes: biological catalysts

# Activation energy

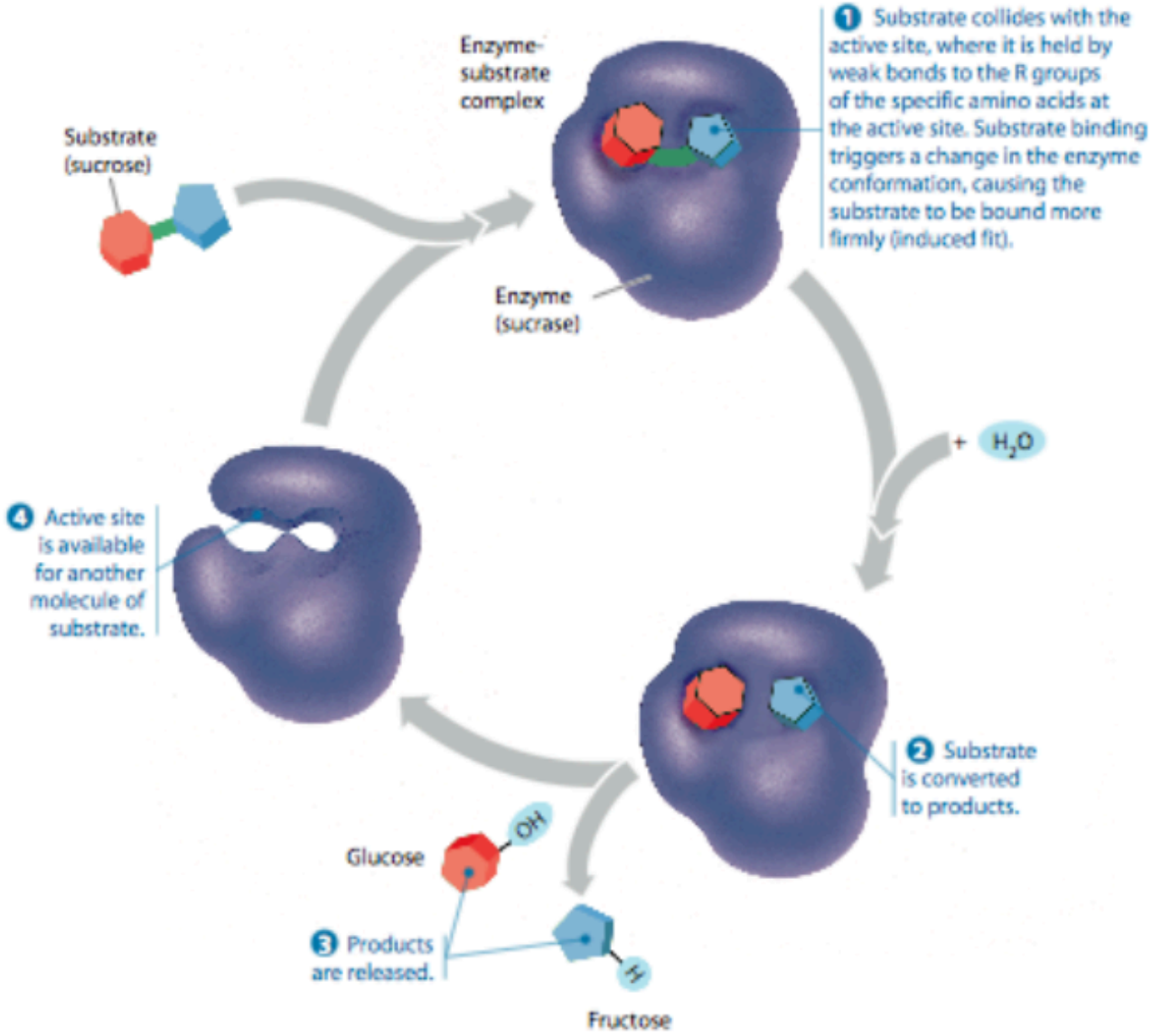


In biological systems,

- _____facilitates getting over the _____to move the reaction forward.

- _____effectively _____the activation energy.

# Active sites



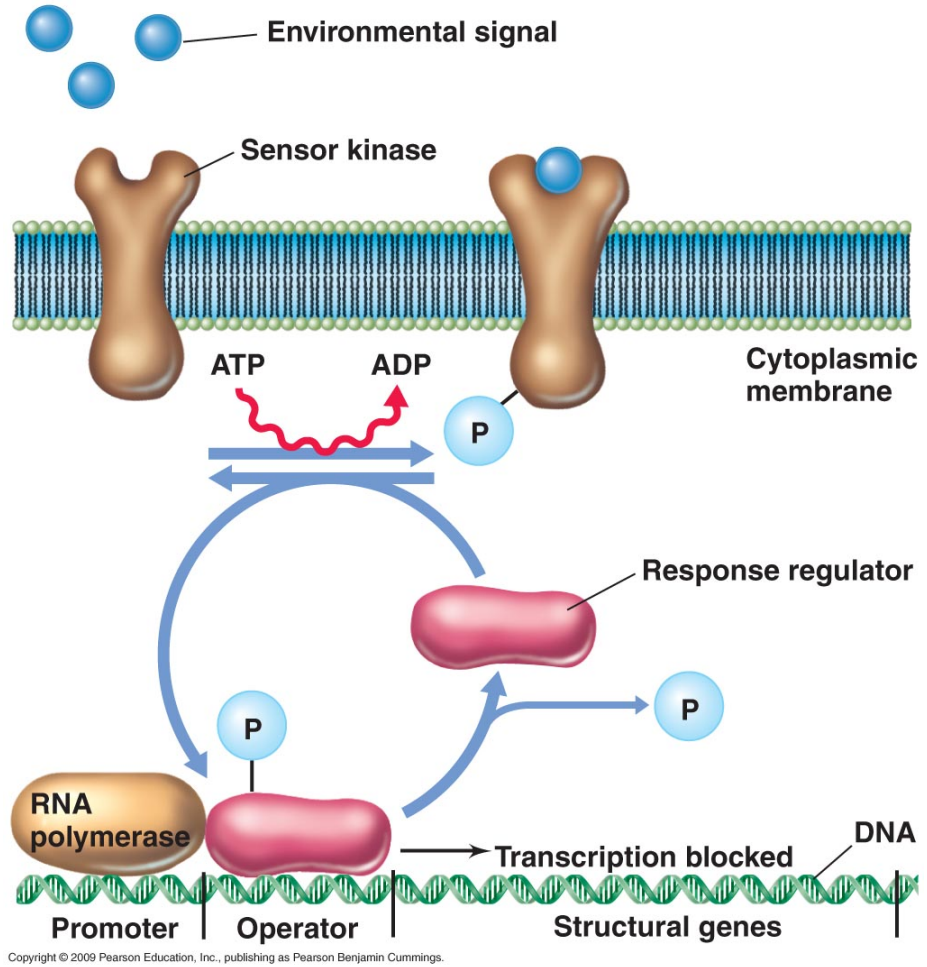
# Kinases

- Bind a _____group onto another protein
- Phosphate group _____the other protein

# What is signal transduction?

1. Signal (small molecule, light, hormone, sugar, salt…..)
2. Signal gets inside cell (_____)
3. Signal transfer and _____
4. Change in cell behavior (_____,_____,_____...)

# Two-component systems



# Many types of two-component systems

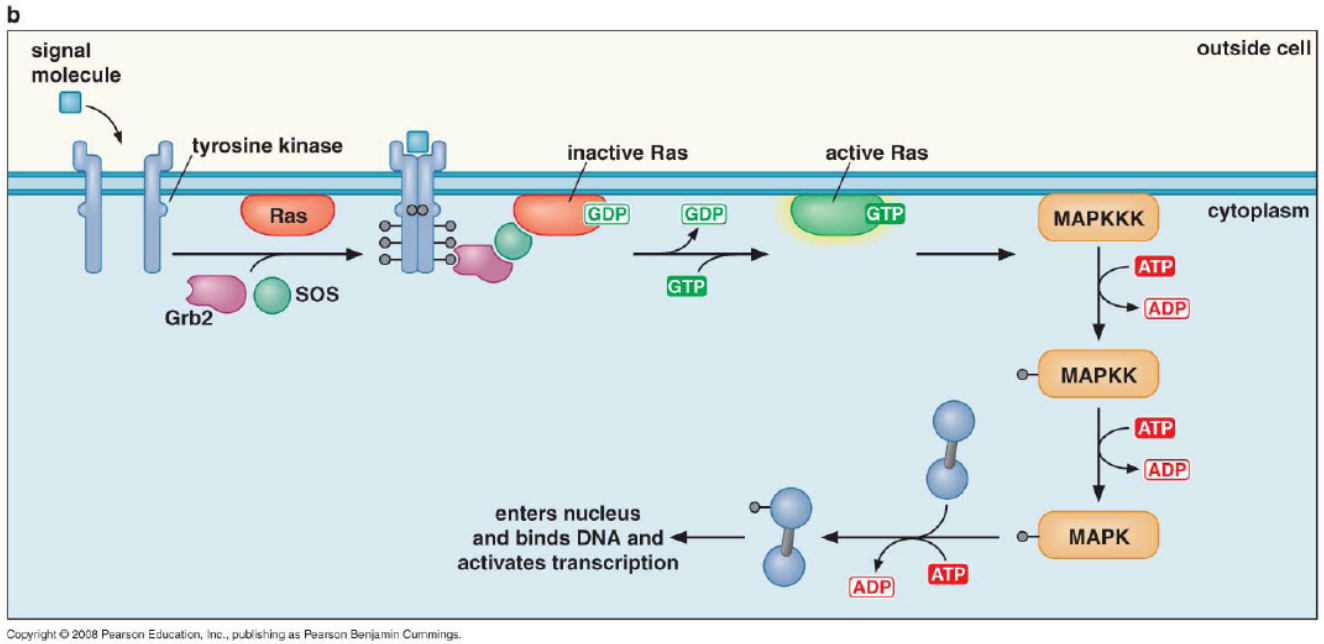
- Nitrate and nitrite utilization
- Inorganic phosphate utilization
- Oxygen
- Cell cycle (e.g. *Caulobacter crescentus*)

# Eukaryotic signal transduction

- Allows for _____ _____of a stimulus
- _____the signal coming from the stimulus.

# Information transfer

## RAS pathway




https://www.youtube.com/watch?v=oDjDUUhGVsI

Fig. 5.20