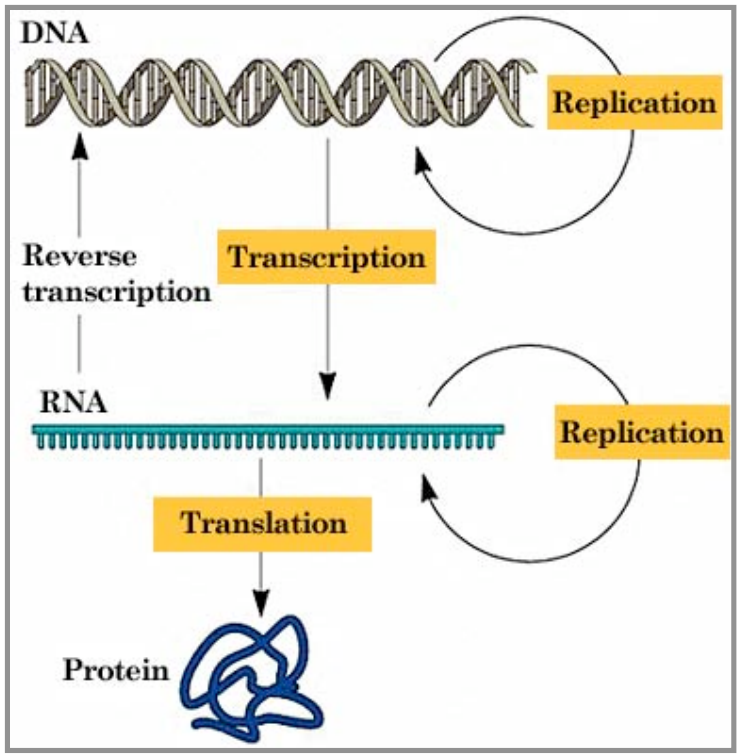
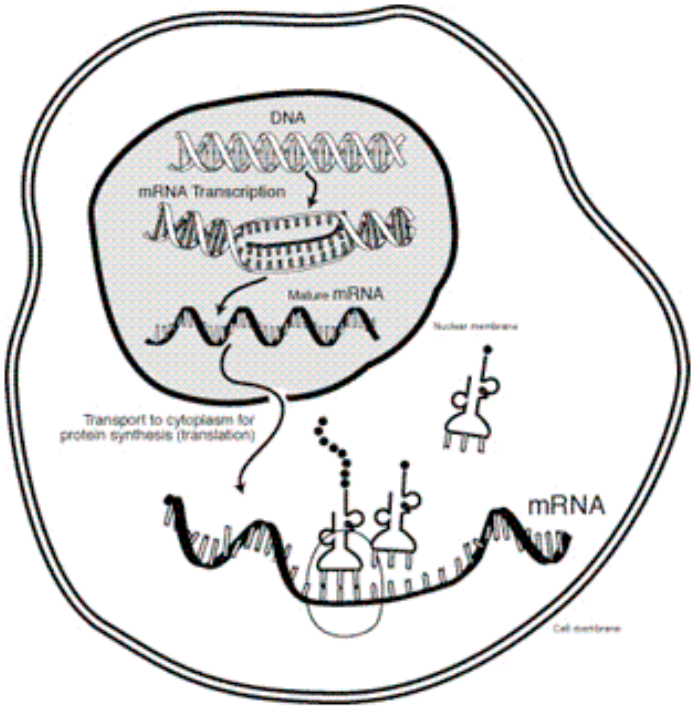
# Intro to Biology

BMI 214 section

4/14/06

# The Central Dogma





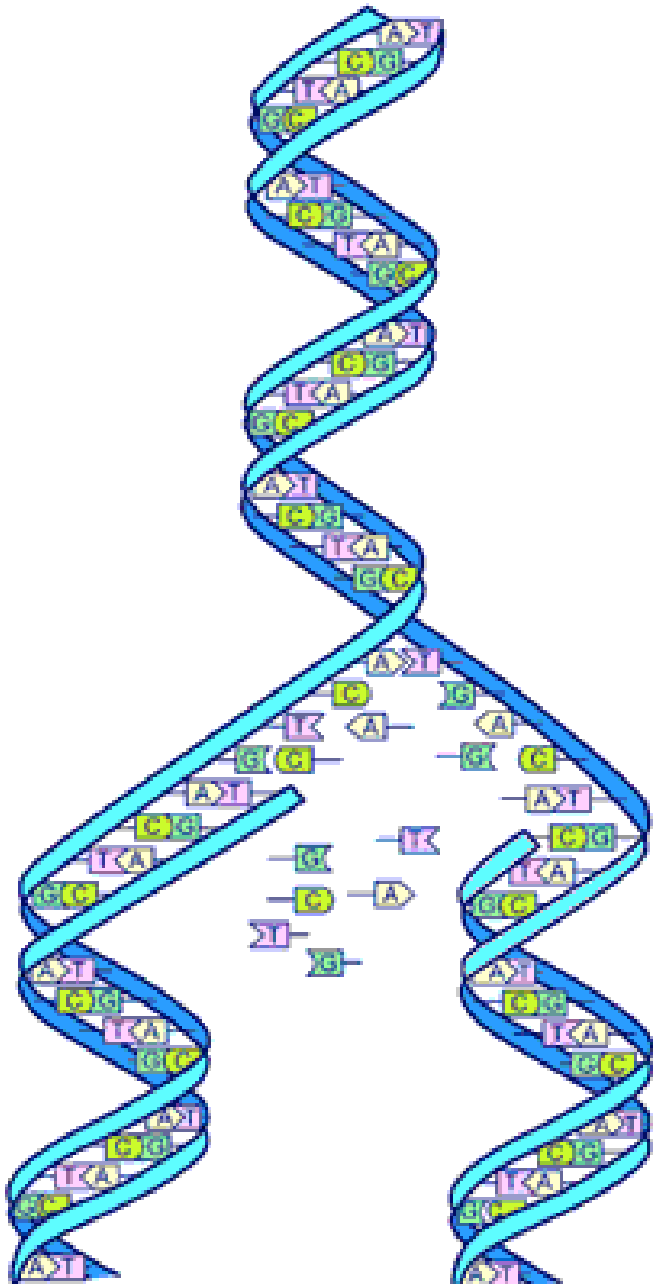
- Analogies: DNA = set of blueprints for an organism, genes = instructions for individual components, nucleus = library that holds all the blueprints, mRNA = copy of parts of blueprint, ribosome = contractor/factory, tRNA = factory workers, protein = objects made by contractors from blueprints

http://www.ncbi.nlm.nih.gov, http://cats.med.uvm.edu

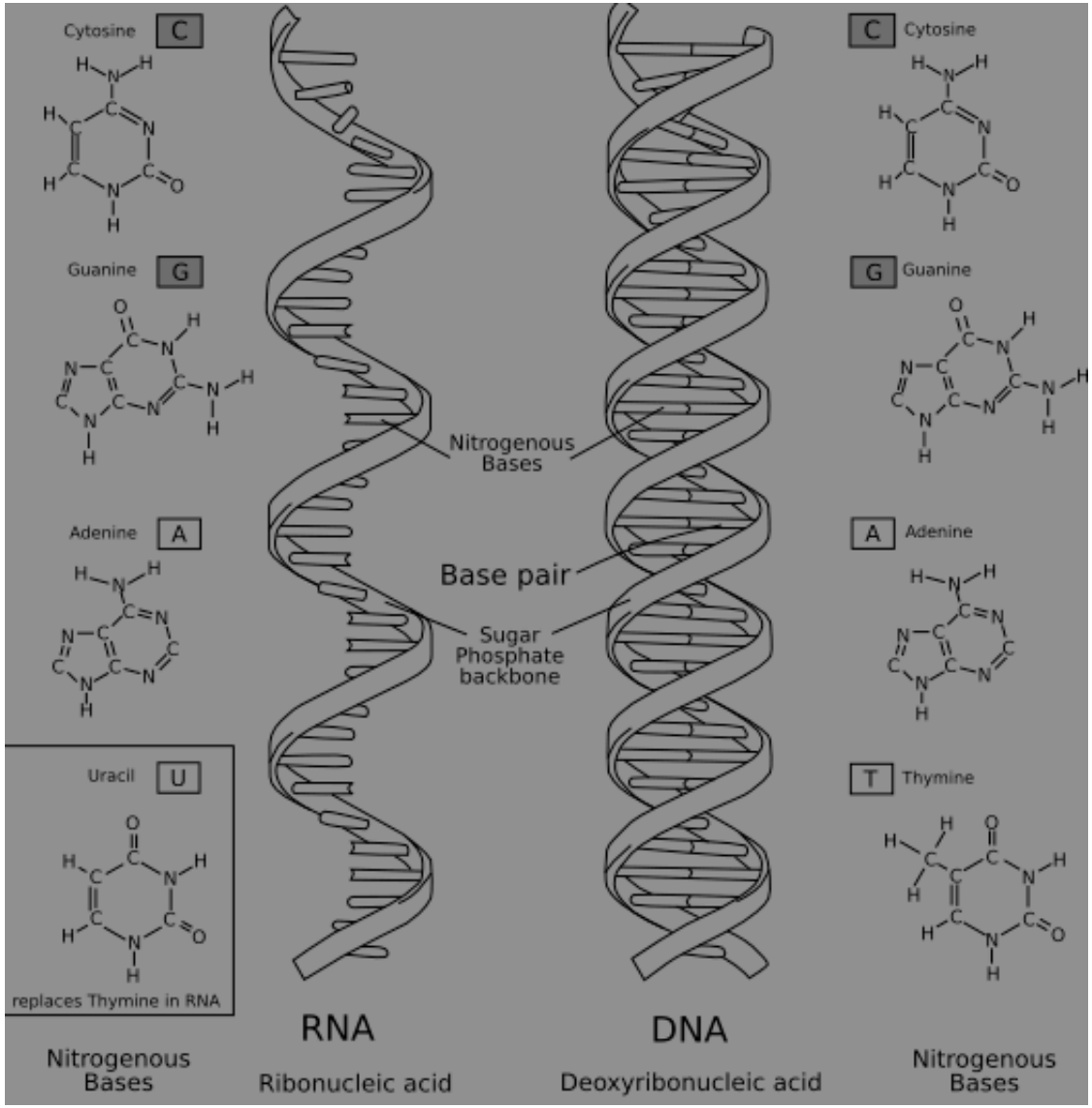
# DNA

- Consists of 4 bases
  - A = adenine
  - T = thymine
  - G = guanine
  - C = cytosine
- A pairs with T and G pairs with C
- Long, linear molecule composed of 2 complementary strands (from base pairing) that form a double helix
- DNA replication: strands separate and new complementary strand synthesized onto each (figure at right)

http://en.wikipedia.org



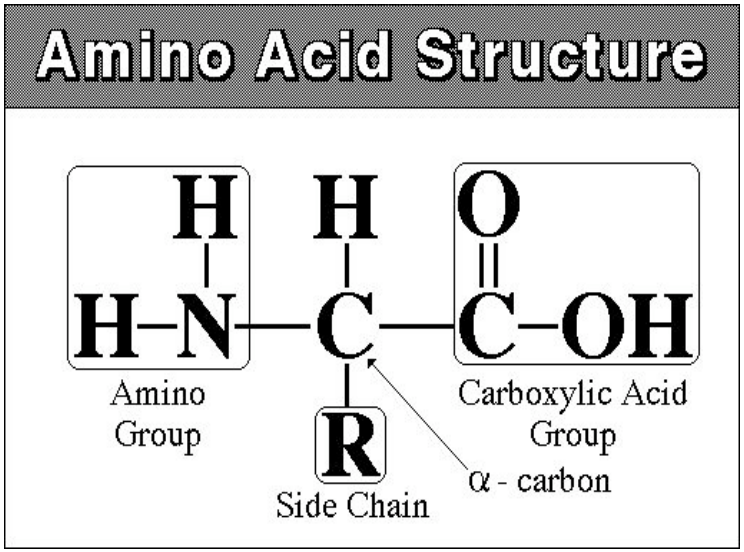
# RNA

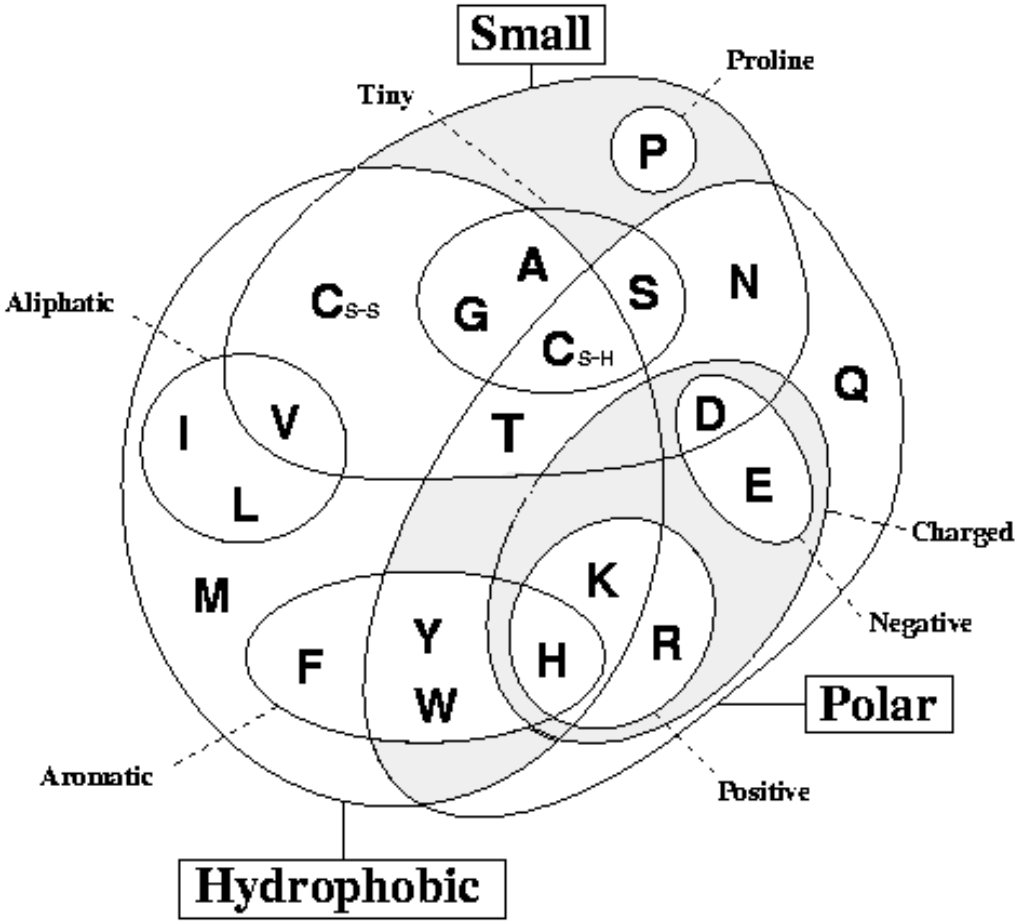



- Contains different sugar and is single-stranded, but essentially same as DNA
- Uracil (U) instead of thymine (T)
- Copies of DNA are made with RNA (called messenger or mRNA) to be translated into protein

http://en.wikipedia.org

# Protein




- Sequences of amino acids (20 different kinds, abbreviated by 3-letter or 1-letter codes)
- Each amino acid has a different side chain which can have different chemical properties

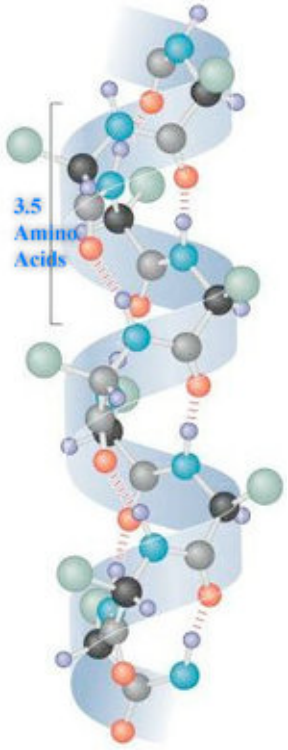
http://en.wikipedia.org

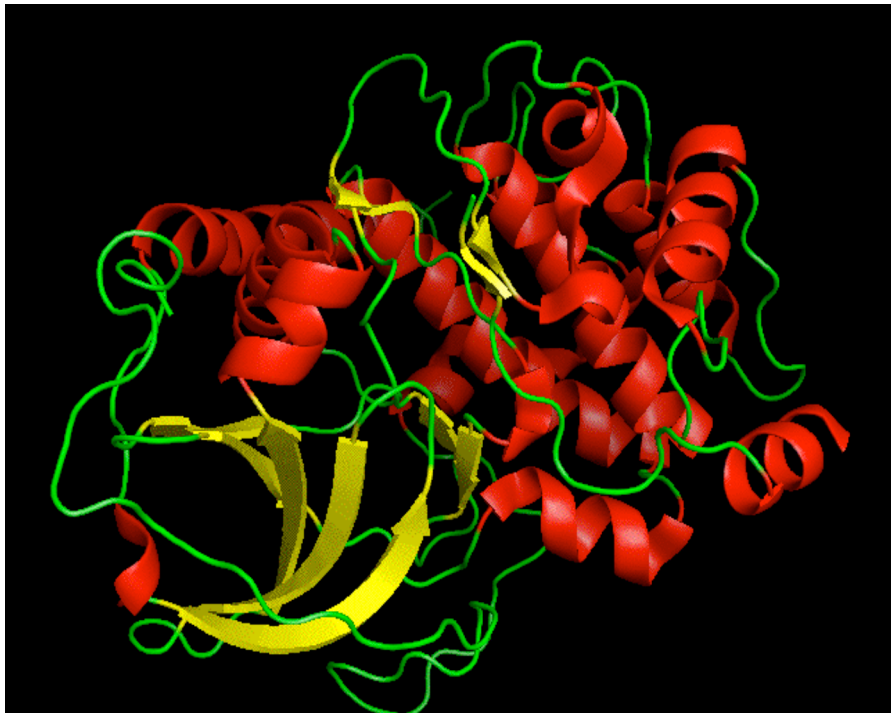
# Levels of protein structure

- Primary (1°): linear sequence
- Secondary (2°): patterned sub-structures (e.g. alpha helices, beta sheets, turns)
- Tertiary (3°): overall shape of one protein molecule, relationship between 2° structures
- Quaternary (4°): shape of multiple protein units that come together into a functional whole

# Protein secondary structure

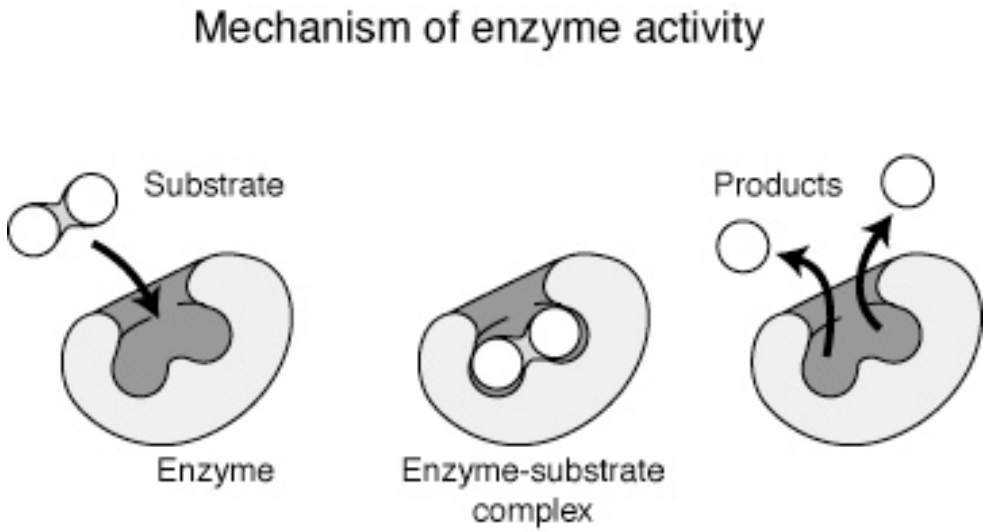
- Alpha helix - formed through hydrogen bonding
  - Common in SS motifs: helix-turn-helix, leucine zipper, zinc finger, etc
  - Diameter of helix = width of DNA major groove
- Beta sheet - adjacent, parallel sequences
  - Can be parallel (same direction) or anti-parallel (opposite direction)



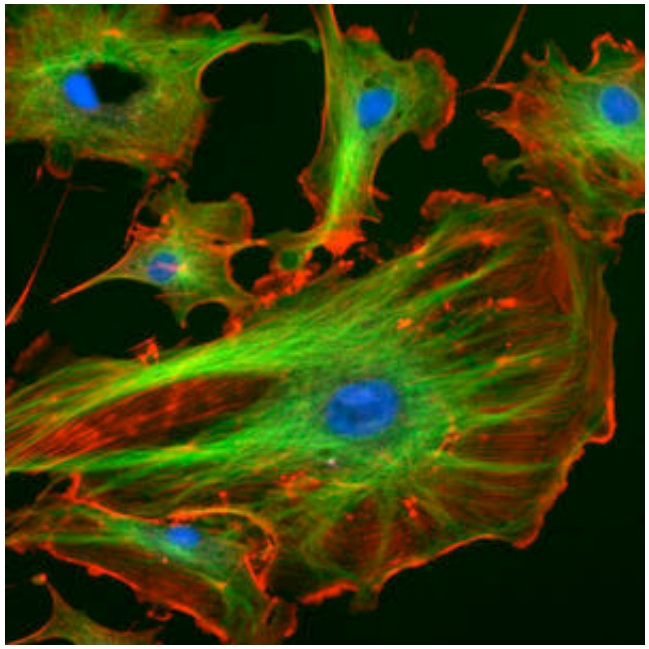



# Protein structure and function

- A protein's function is dictated by its 3-D structure
- Binding sites, catalytic sites, regulation
- **Functions:** transport (ion channels, nuclear pore complex), infrastructure (actin, tubulin), chemical reactions (enzymes), signaling (receptors), regulation (transcription factors, kinases), power tools (polymerases)…




http://www.accessexcellence.org/RC/VL/GG/enzyme.html



# The genetic code

DNA base triplets = codons

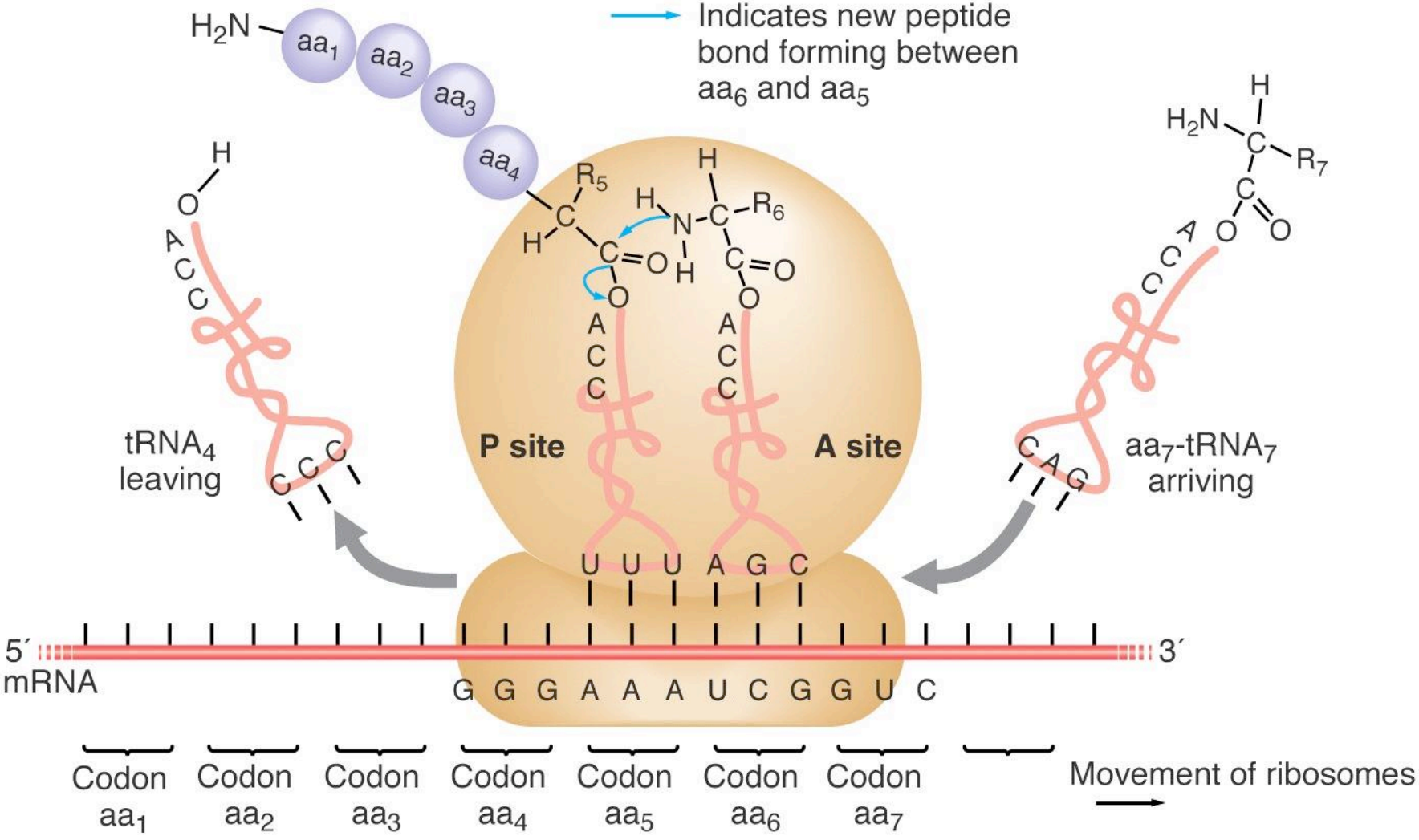
Each codon codes for an amino acid, a start, or a stop

Note code redundancy

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

http://www.mun.ca/biology/scarr/MGA2-03-28.jpg

# Translation




http://www.mun.ca/biology/scarr/4241F2_ribosome.jpg

# Molecular evolution

- Changes in DNA can lead to changes in protein, which can affect cell function

- Redundancy in genetic code means some DNA changes have more effect than others
  - Synonymous = amino acid stays the same
  - Non-synonymous = amino acid changes

- Changes occur through mutation (radiation, chemical), mistake (during replication), and lack of repair (after mutation or mistake)

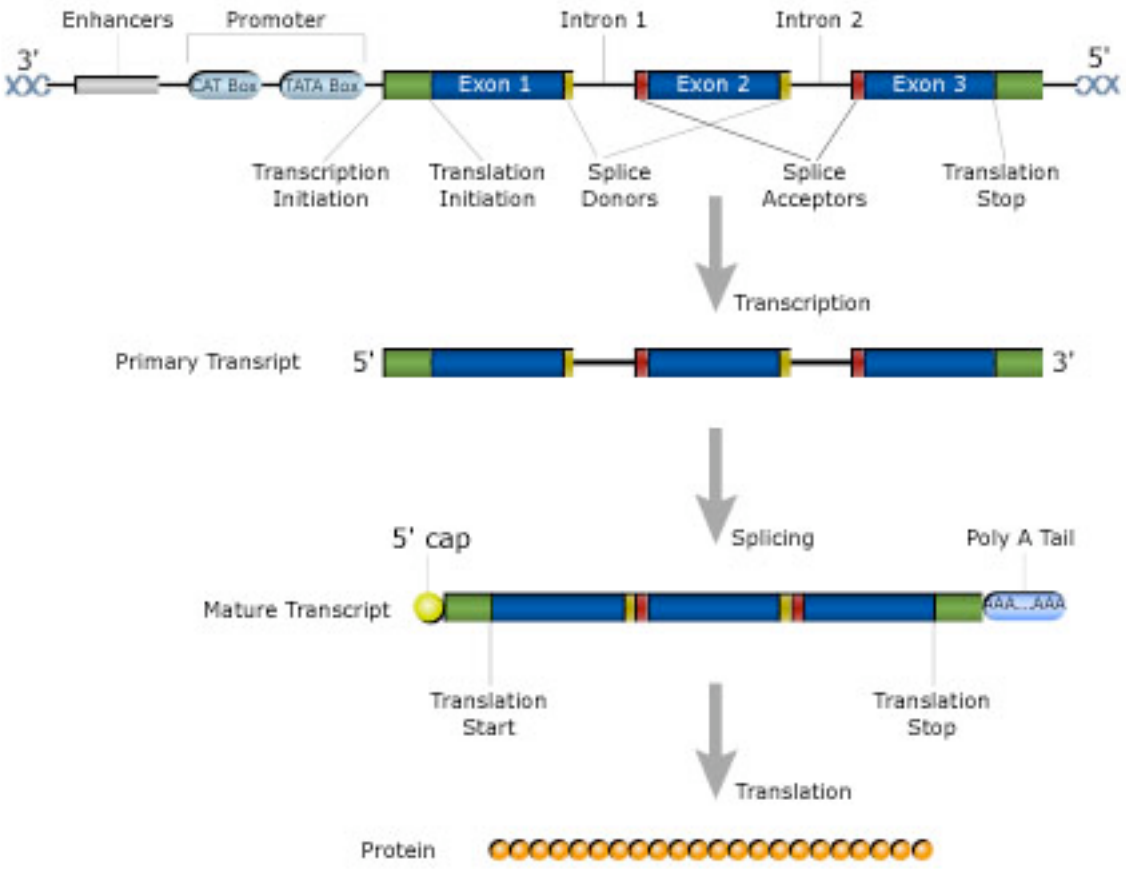
# Molecular evolution

- Changes in cell function ultimately determine whether the DNA change is kept or is lost
  - Changes that result in lower fitness --> DNA is not passed on (through cell replication)
  - Changes that don't harm or help don't affect chances of being passed on
  - Changes that help are more likely to be passed on
- Note: Only changes that occur in the germline, or reproductive cells, have any chance of being passed on to subsequent generations of organism

# Molecular evolution

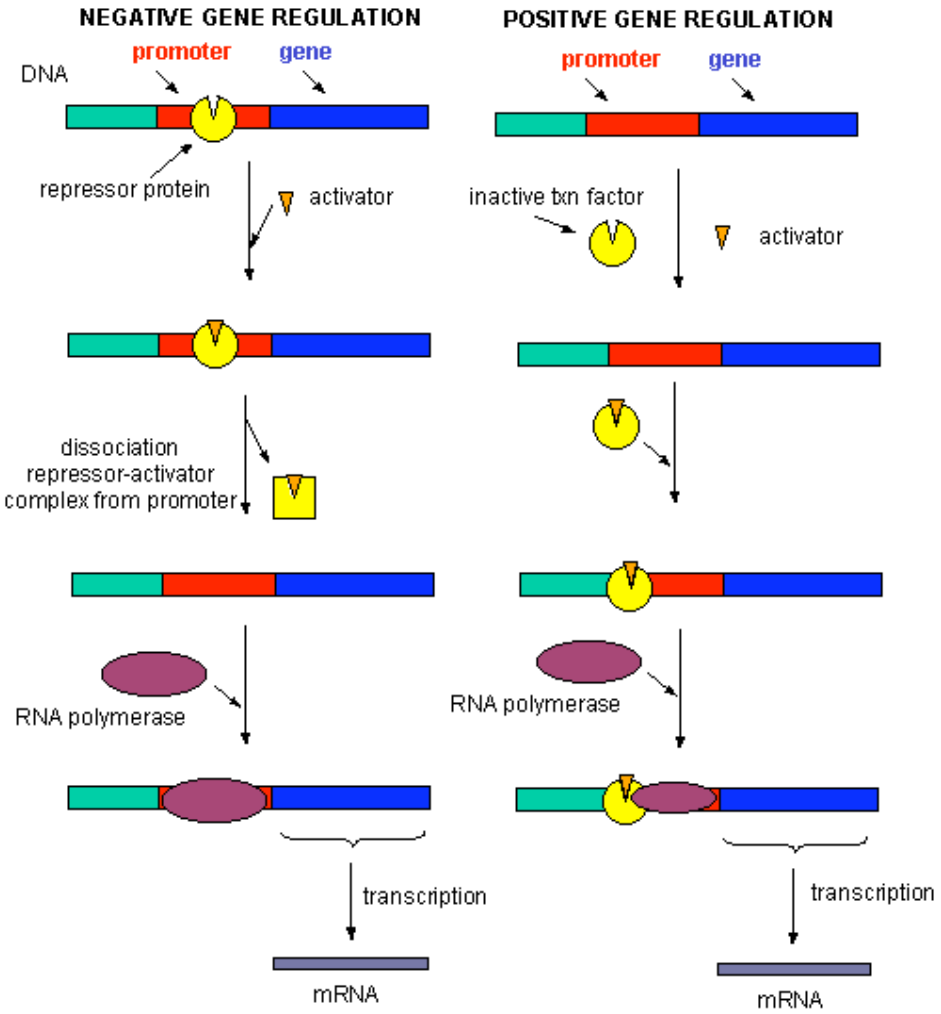
- DNA that is necessary for survival is less likely to change (because almost all changes are bad)
- This leads to conserved regions of DNA, and this is why we associate sequence conservation with functional importance
- Regions not directly coding for protein can also be important (e.g. regulatory regions) and will tend to be conserved

# Gene structure




- Exons = coding regions
- Introns = non-coding regions
- Transcription into mRNA starts at TSS
- Factors needed to start transcription bind in promoter region

# Gene regulation (in eukaryotes)

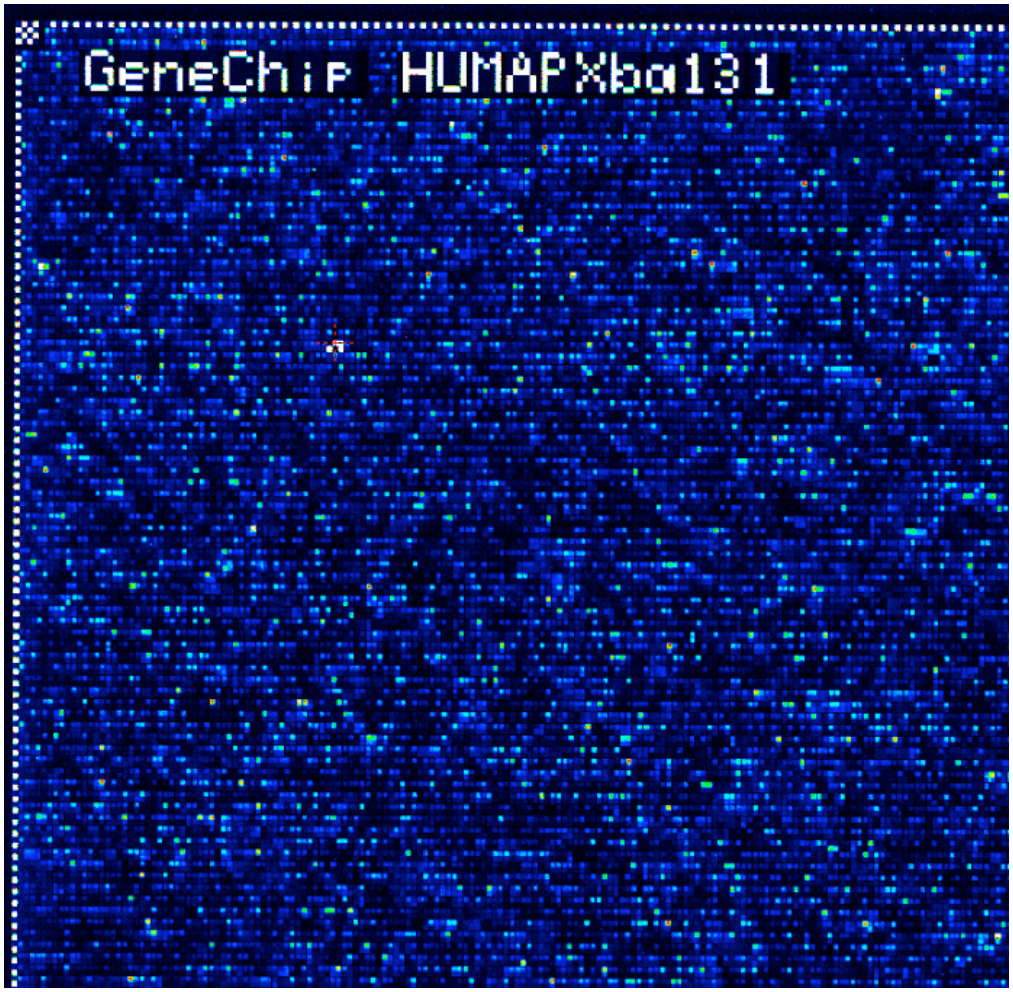



- Gene transcription = gene expression
- A number of transcription factors need to be present or absent in order for gene to be expressed
- These factors are proteins that are regulated either at the protein or gene level
- Negative feedback, positive feedback, and more complex regulatory circuits are used

http://employees.csbsju.edu/hjakubowski/classes/ch331/bind/negposreg.gif

# Gene expression

- The amount of a gene's mRNA present in the cell is a measure of the gene's expression level
- A gene's expression level is determined by its regulation
- Genes involved in the same processes will be regulated similarly, and thus will have similar patterns of expression
- Genes needed in certain conditions will be up-regulated, genes not needed will be down-regulated
- This is the basis for microarray experiments




http://www.rzpd.de/images/HumanMapping10K.jpg