CSE/ECE 848
Introduction to Evolutionary Computation

Module 2, Lecture 5, Part 1b
Biological Evolution--Modern

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Crick and Watson

- Discovered in 1953 the existence of DNA and the pairing of bases to form genes
- Actually the work of more than those folks, including Rosalind Franklin who only received some recognition posthumously (and even then grudgingly)

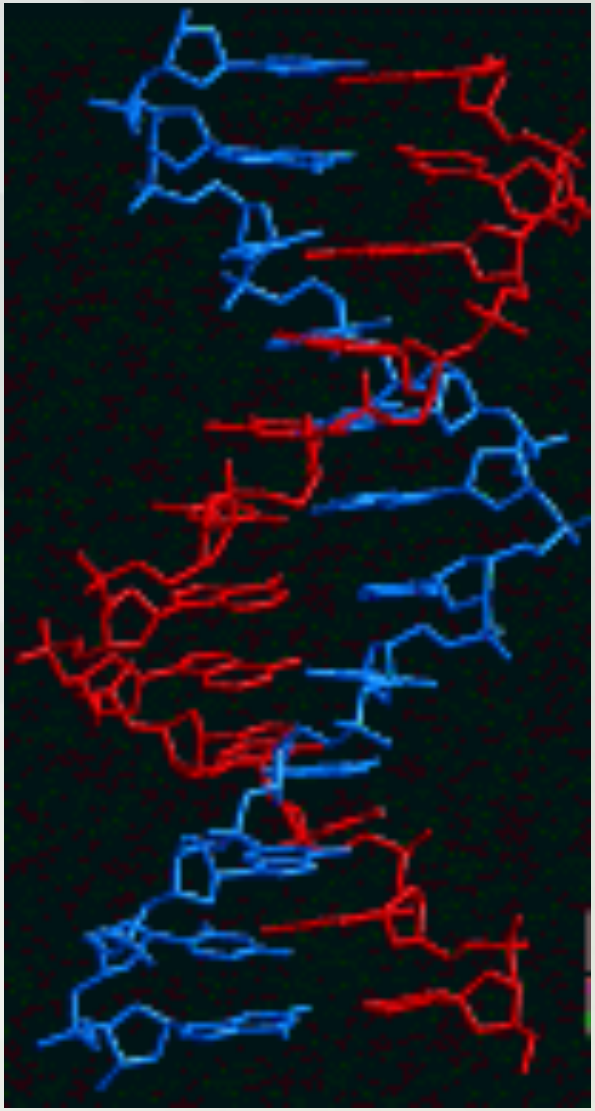
Francis Crick
1916 - 2004

James Watson
1928 -

Rosalind Franklin
1920 - 1958

Some Basic Genetics

- The basis of heredity is the DNA (deoxyribonucleic acid) found in each cell.
- DNA is made up of phosphates, sugars, and bases
- The phosphates form a ladder and the bases bridge the ladder.
- DNA bases are: A (adenosine), T (thymine), C (cytosine) and G (guanine)



More on DNA

- The sequence of bases is the genetically encoded information
- DNA is a long description whose “characters'' are T, G, C, A (about 3 billion bases in humans)
  - Thymine, Guanine, Cytosine, Adenine
- ‘Words’ of the DNA are formed in three-base sequences (triplets or codons)
- RNA is similar to DNA but substitutes uracil for thymine and ribose for deoxyribose (can be double stranded).
- Each triplet of bases (codon) encodes uniquely one amino acid, but multiple different codons sometimes encode the same amino acid (there exist more triplets than amino acids)

Genetics 1

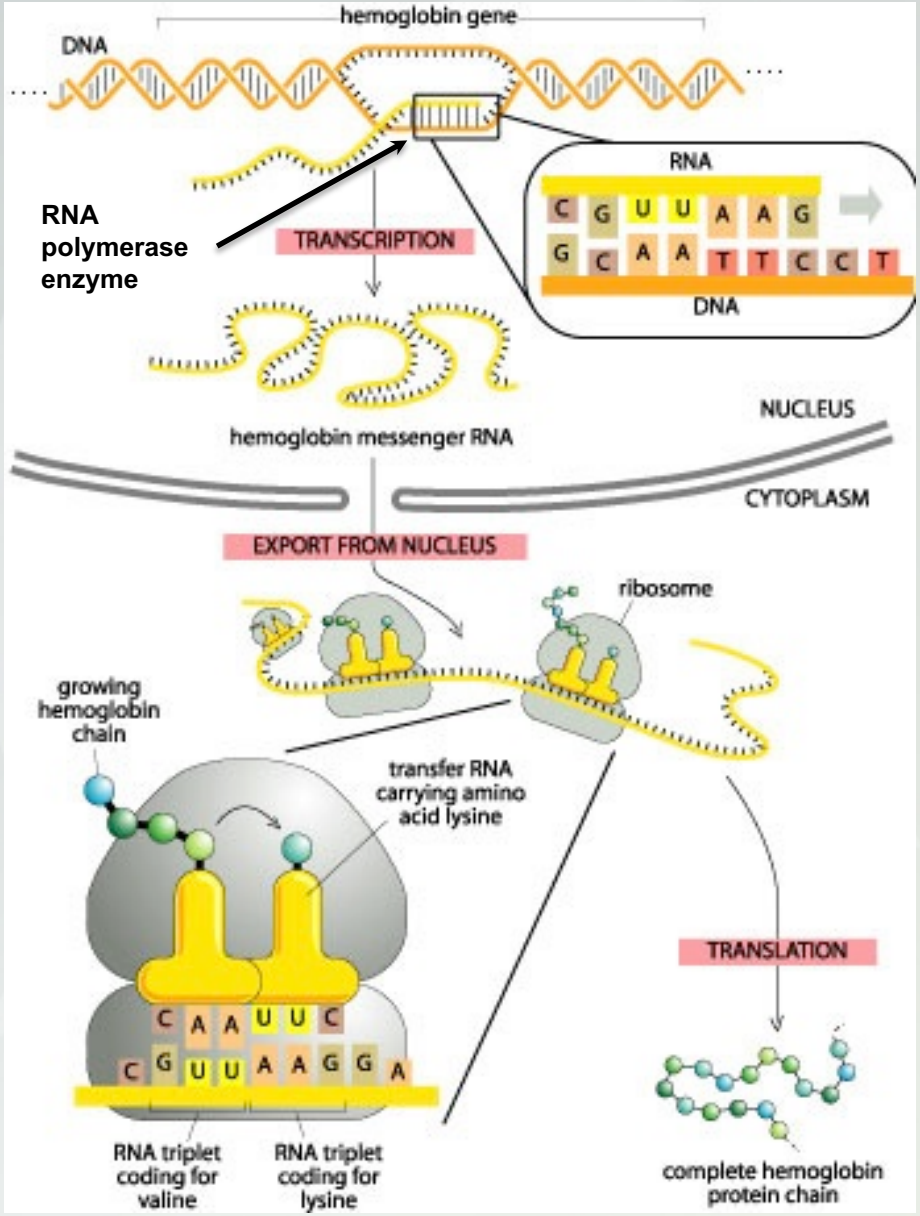
- A sequence of amino acids forms a polypeptide/protein
- A gene is a portion of the DNA that codes for a protein
- A gene can be represented by a number of slightly different sequences called alleles
- (Today, we call those variations of a codon in a gene SNPs (“snips”), for Single-Nucleotide Polymorphisms)
- The totality of an organism's DNA is encoded in its genome, consisting of chromosomes (different numbers for different species)

Genetics II

- Most plants and animals are diploid, where there are two copies of each chromosome
- These homologous chromosomes have (potentially) a different allele for each gene
- *Approximately*, alleles are dominant if they produce much more (and sufficient) protein than their recessive counterparts
- In practice, a trait is *dominant* if the heterozygote expresses the trait indistinguishably from the homozygote for the dominant trait
- If it takes a double dose to express the trait, it is *recessive*
- If the heterozygote expresses the trait differently from either homozygote, then the trait has *partial dominance or intermediate expression*

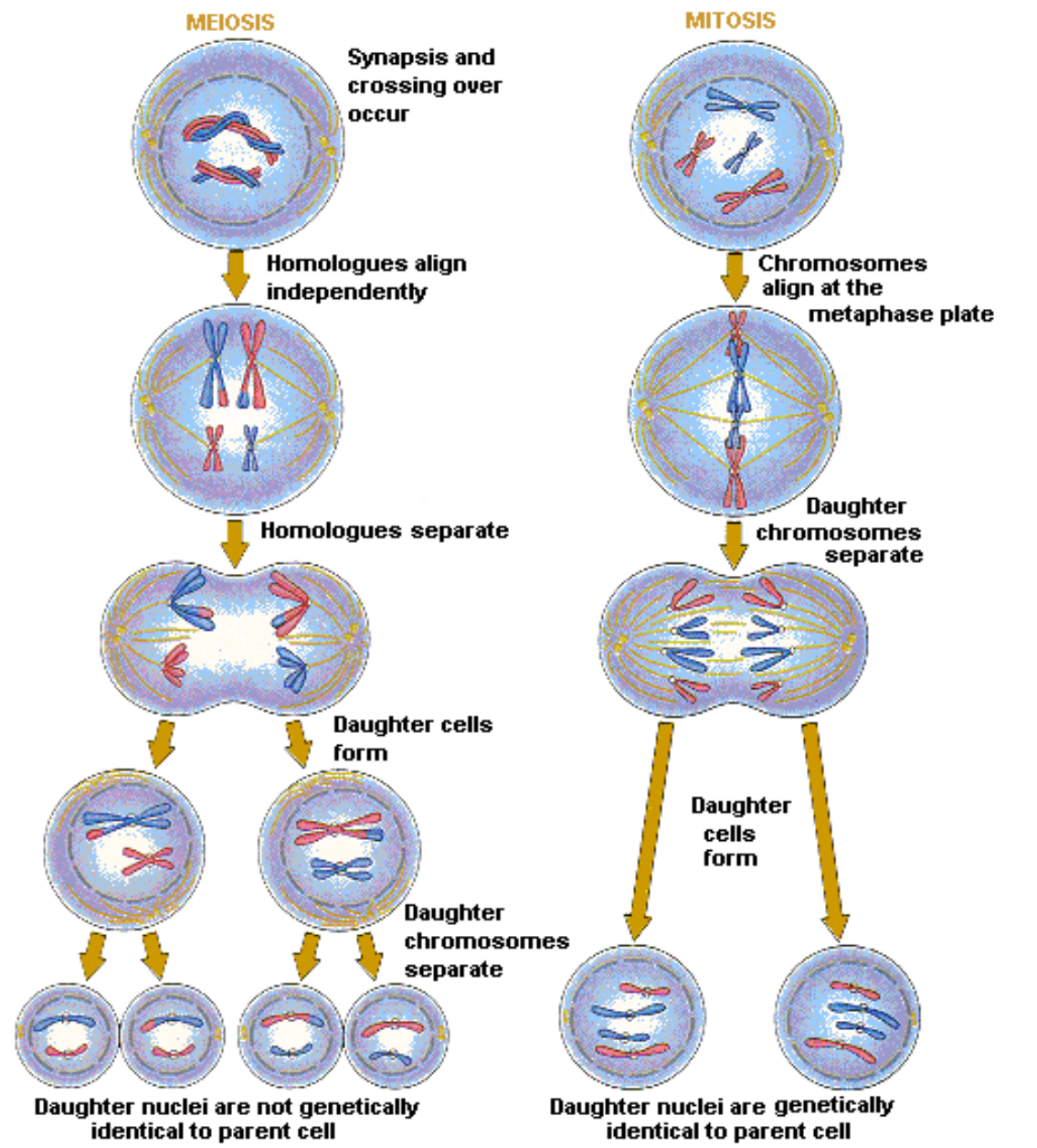
"Central Dogma" of Molecular Biology

- DNA can be transcribed into RNA (*transcription*)
- The RNA is then used as a template to create individual chains of amino acids: *translation*
- This is done in triplets, called codons, with specific start and stop states


hemoglobin gene
DNA
RNA
polymerase
enzyme
TRANSCRIPTION
RNA
C G U U A A G
G C A A T T C C T
DNA
hemoglobin messenger RNA
NUCLEUS
CYTOPLASM
EXPORT FROM NUCLEUS
ribosome
growing
hemoglobin
chain
transfer RNA
carrying amino
acid lysine
C A A U U C
C G U U A A G G A
RNA triplet
coding for
valine
RNA triplet
coding for
lysine
TRANSLATION
complete hemoglobin
protein chain

Cellular Reproduction in Multi-cellular Organisms

- Cells are normally diploid
- 2 sorts of cellular reproduction: Mitosis and Meiosis
- What happens with the chromosome copies?
- Mitosis: Each group of copies of chromosomes separates and the cell divides---NO change in the genome, normally
- Meiosis: Only one set of chromosomes is present in the resulting (haploid) cells (sperm or eggs) – the original diploid cells have divided twice, but the DNA replicated only once, leaving only one copy of each chromosome in the gametes (sperm or eggs)!


MEIOSIS
Synapsis and crossing over occur
Homologues align independently
Homologues separate
Daughter cells form
Daughter chromosomes separate
Daughter nuclei are not genetically identical to parent cell
MITOSIS
Chromosomes align at the metaphase plate
Daughter chromosomes separate
Daughter cells form
Daughter nuclei are genetically identical to parent cell

Cellular Reproduction II

- During meiosis a phenomenon known as *crossover* occurs in which exchange of DNA can occur between homologous chromosomes
  - *Recombination*
- Mating produces (diploid) eggs that start duplicating
- Duplication involves: chromosome copying and cell division (no crossover)
- Mutations can occur during the copying phase during meiosis, and (non-heritably) in other cells (somatic mutations)