

Chapter 5: DNA & Chromosomes

*How do we make those functional proteins?

- DNA: stores information
- RNA: retrieves information
- Protein: translate information to function
 - The information is needed to be passed from one to cell to the next during replication (mitosis)
 - And from one generation to the next during reproduction (meiosis)

*Deoxyribonucleic acid, DNA

- Recognized in the 1940's as the likely carrier of genetic information
- Structure determined by Watson and Crick with the help of Rosalind Franklin and Chargaff
- Composed of nucleotides (building blocks of DNA): Adenine, Guanine, Cytosine, and Thymine
 - All covalently linked by phosphodiester linkage to form polynucleotide chains (DNA strands)
- 10 base pairs per helical turn
- Major groove – wider; minor groove – smaller
- DNA molecule composed of two DNA strands held together by hydrogen bonds between paired bases
 - Adenine – Thymine (A-T)
 - Guanine – Cytosine (G-C)
 - Base pair: each purine-pyrimidine pair
- DNA strands run antiparallel
 - 5' phosphate
 - 3' hydroxyl
- DNA is a double helix
 - Bases inside of helix
 - Sugar-phosphate backbone on the outside of helix

*Complementary base pairing

- Energetically favorable in interior to hold backbones an equal distance apart along the DNA

*Hydrogen bonds between strands

- Two bonds between Adenine and Thymine
- Three bonds between Guanine and Cytosine
- ****Only fits if strands run antiparallel****

*Chromosomes: how the data is stored!

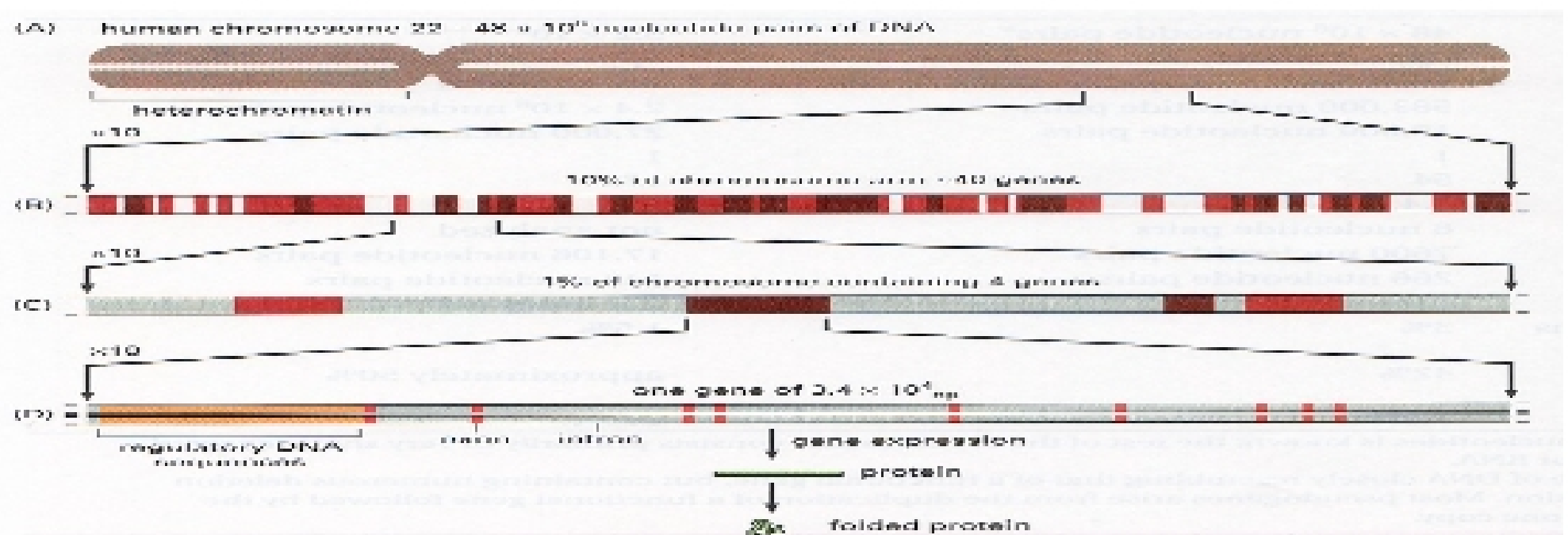
- Human cell contains 2m of DNA but cell nucleus is 5-8 μm in diameter
- Eukaryotic cells: long double stranded DNA packaged into chromosomes
- Bacteria: single, circular DNA molecule

*Chromosomes

- Contains our genes
- Functional units of heredity
- Region of DNA that controls a discrete hereditary characteristic of an organism, usually responsible for specifying a single protein or RNA molecule
- Contains large regions of noncoding DNA – often referred to as “junk DNA”, which is now known to be involved in the regulation of our genes

*Organization of genes on a human chromosome

- If you stretched out all of a human's DNA, it would be 1.8 meters long. Therefore, to fit it into a nucleus our DNA is tightly wound into a structure that we call chromosomes.
- 10% of one chromosome arm contains 40 genes. 1% has 4 genes.
- Regulatory DNA sequences turn the gene on and off.
 - They contain the code to say when this gene should be transcribed and how much.
- Actual gene is made up of introns and exons.
 - Introns = removed during RNA processing
 - Exons = contain the sequence for the gene

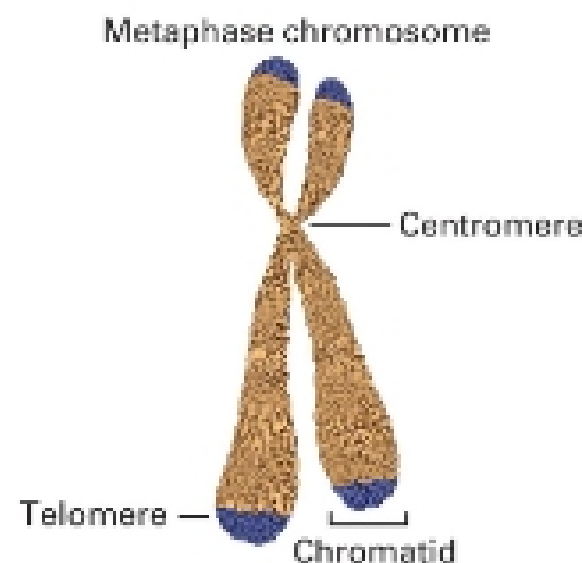


*Eukaryotic (human) DNA

- 23 pairs of chromosomes
 - 22 autosomes and one pair of sex chromosomes
- Each cell has 46 single chromosomes
- Each chromosome is a single, long DNA molecule
- Chromatin – complex of DNA and proteins (packaging, repair, etc.)
- 22 pairs of homologous chromosomes, 1 pair of non-homologous chromosomes (sex chromosomes – XY or XX)
- Homologs: same genes, different alleles

*Chromosomal Replication

- Four phases of eukaryotic cell cycle: G1 -> G2 -> S phase -> M
- G1 & G2 = gap phases, where the cell grows and makes proteins
- Interphase: G1, G2, & S
 - Long, thin, loose threads of DNA, not easily visible
- G1 = the cell makes all the RNA and proteins it needs
- S phase (interphase) = chromosomes are copied, *DNA replication* at replication origin.
 - Cell has twice as much DNA as it did in G1
- G2 = cell makes all the proteins it will need to divide
- Mitosis (M) phase = growth stops and the cell divides
 - DNA is dense and compact, DNA is easily visible
 - Each early M phase chromosome has two sister chromatids
 - Chromosomes are joined together at the centromere
 - Telomeres form caps at the end of each chromatid



*Essential chromosome elements

- Replication Origin: where duplication of DNA begins (multiple locations)
- Centromere: allows one copy of each chromosome to be distributed to each daughter cell
- Telomere: found at the end of each chromosome; enable ends to be replicated and caps end of chromosome to prevent it from being identified as broken DNA in need of repair

*Interphase chromosomes

- DNA in interphase chromosomes is less compact than mitotic chromosomes (allowing access for replication)
- Occupy different territories within the nucleus

*Interphase nucleolus

- Heterochromatin: gene-poor, located around the periphery
- Nucleolus: contains the genes for ribosomal RNA; these genes are located on multiple chromosomes but are clustered together in the nucleolus