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Some Basics of Molecular Biology

Hubert Rehrauer

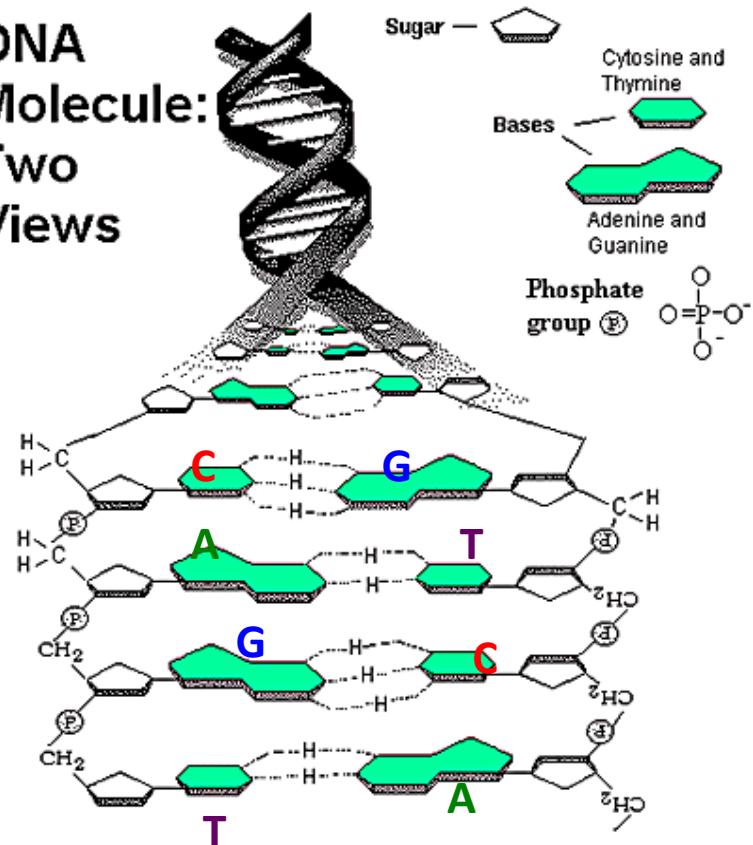


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What is DNA?

- A long backbone of sugars with nucleotides attached
 - Adenine (A)
 - Guanine (G)
 - Cytosine (C)
 - Thymine (T)
- It can form a self-complementary double helix
- In living organisms, the DNA is the carrier of the hereditary information, it is the source code of life

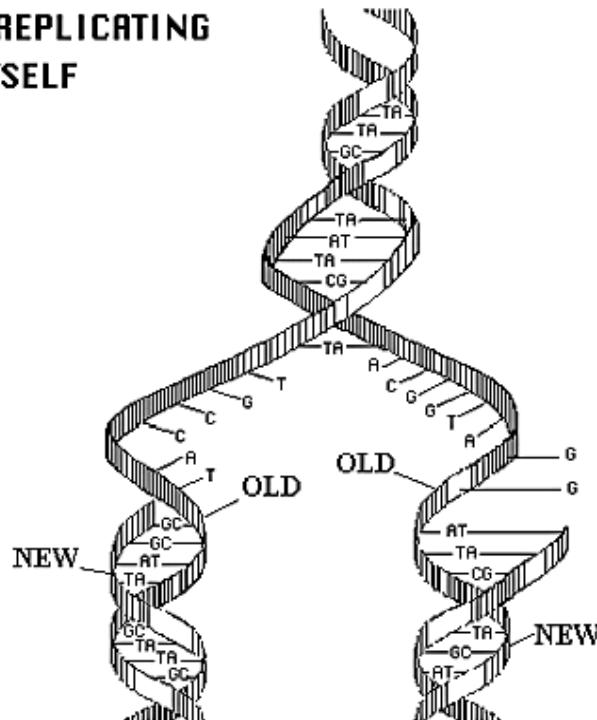
DNA Molecule: Two Views



DNA replication

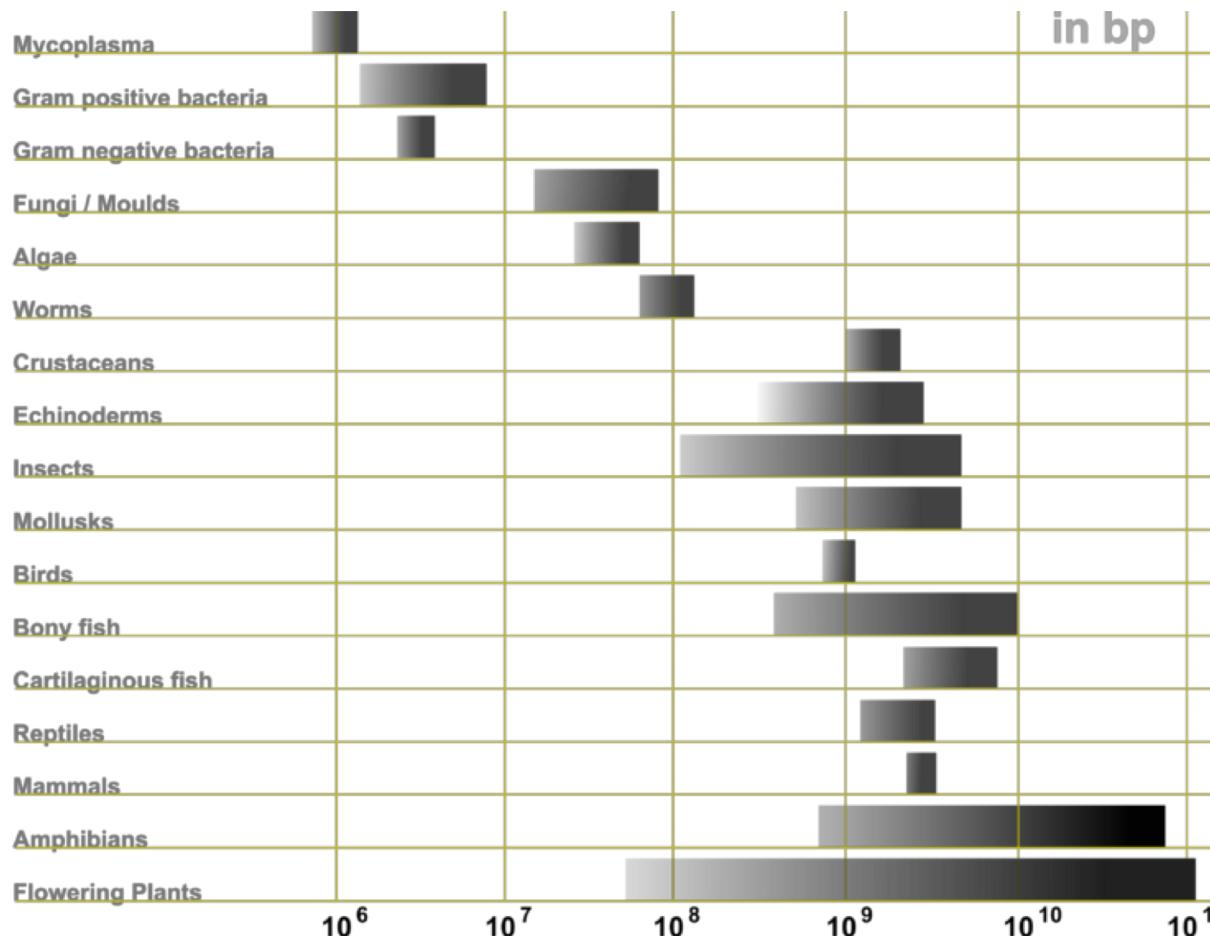
- The helix becomes unzipped and each strand acts as a template for a new complementary strand of DNA

DNA REPLICATING ITSELF





Genome Sizes

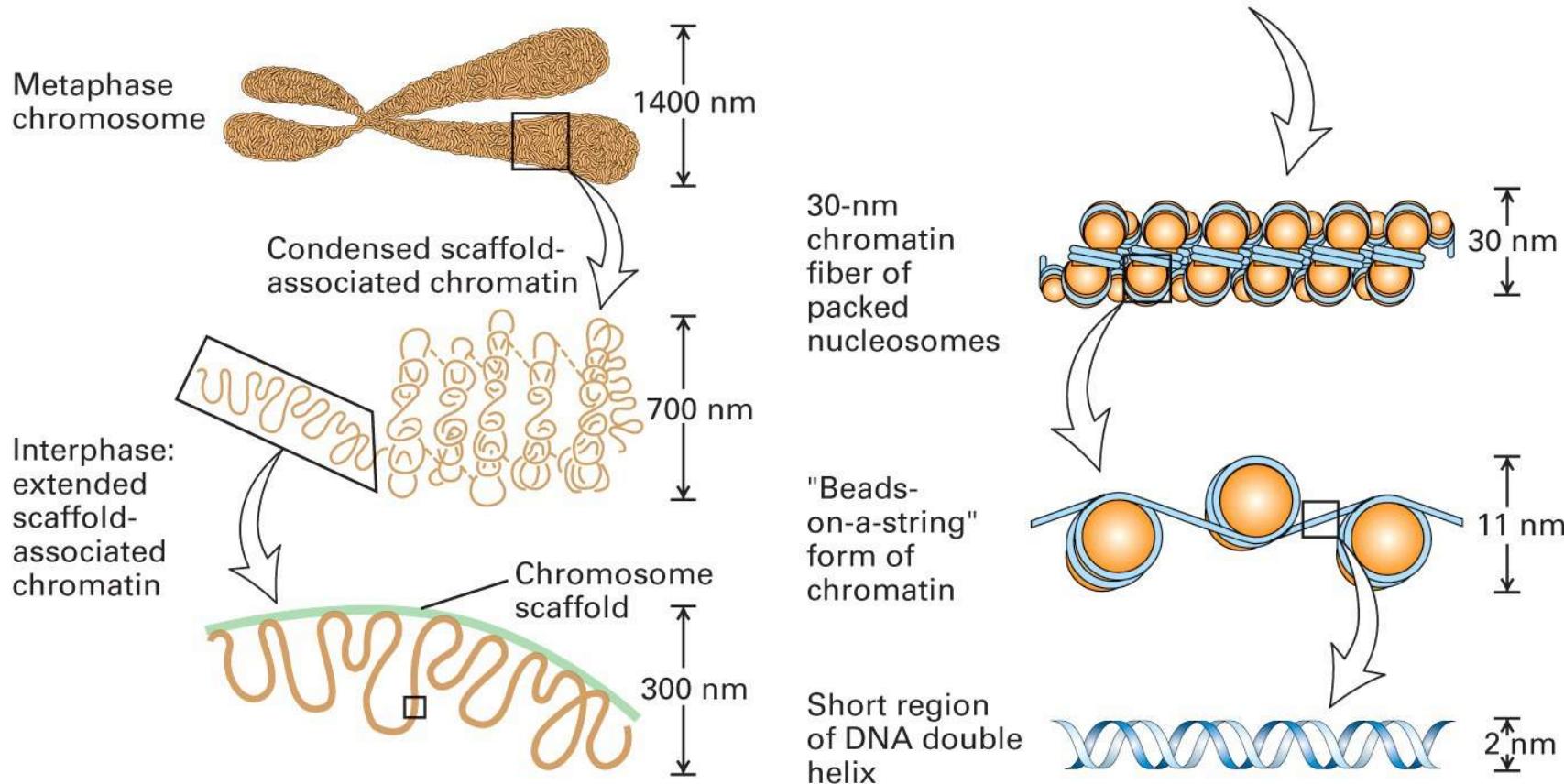


The size of the human genome is 3.2 billion base pairs. The length of this DNA string is approx. 2m.

http://en.wikipedia.org/wiki/Genome_size

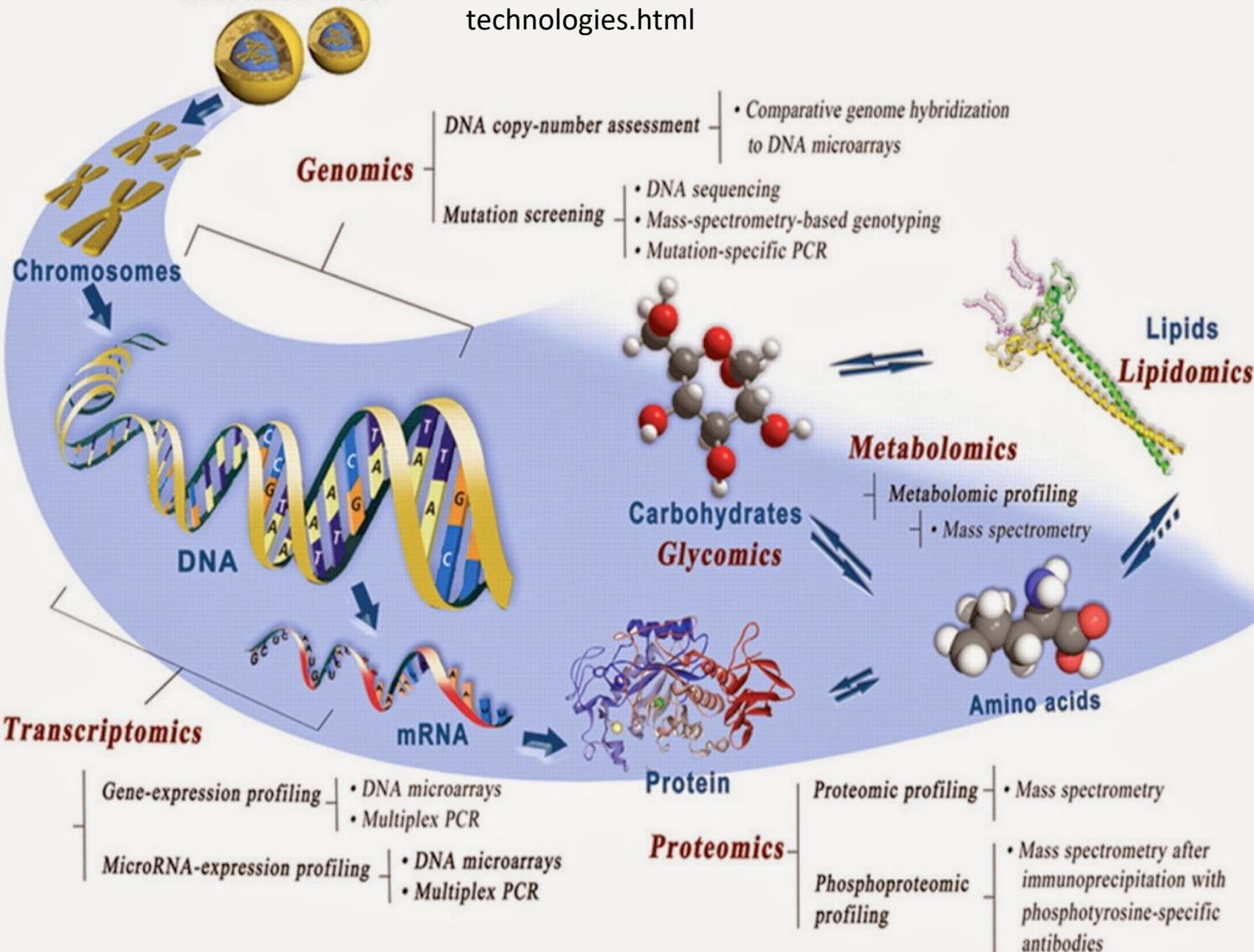
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DNA Superstructure



Tissue/Cell Lines

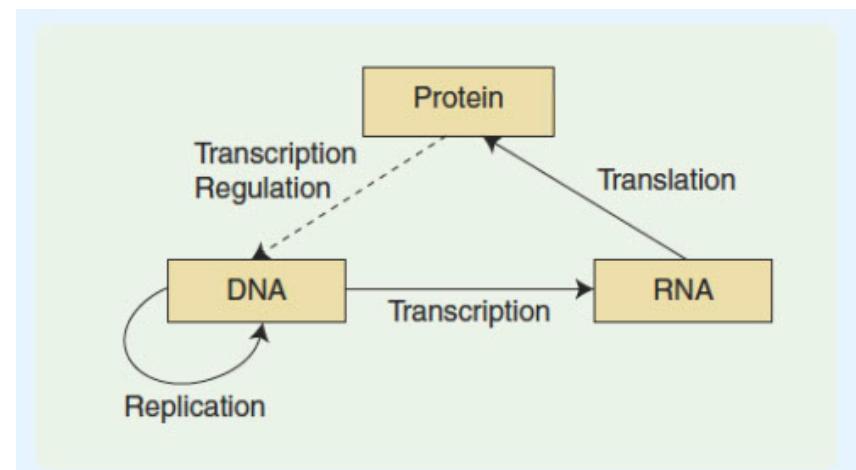
<http://intro2res2014.blogspot.com/2014/10/omics-technologies.html>



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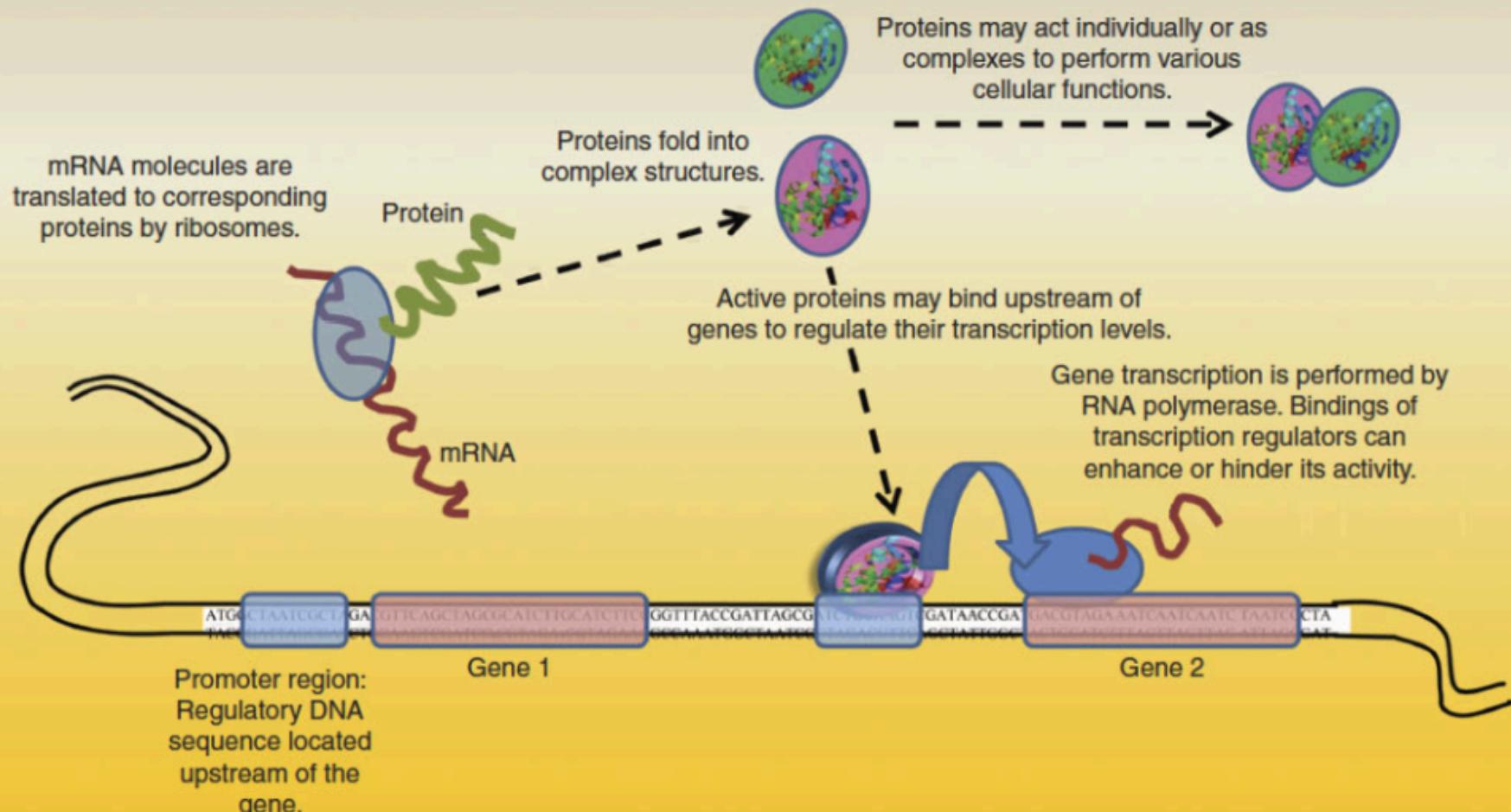
Genes

- A gene is a region of DNA that controls a hereditary characteristic
- Usually a gene is transcribed into a messenger RNA which is then translated into a protein.
- In humans genes constitute only ~3% of the human genome



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The Central Dogma





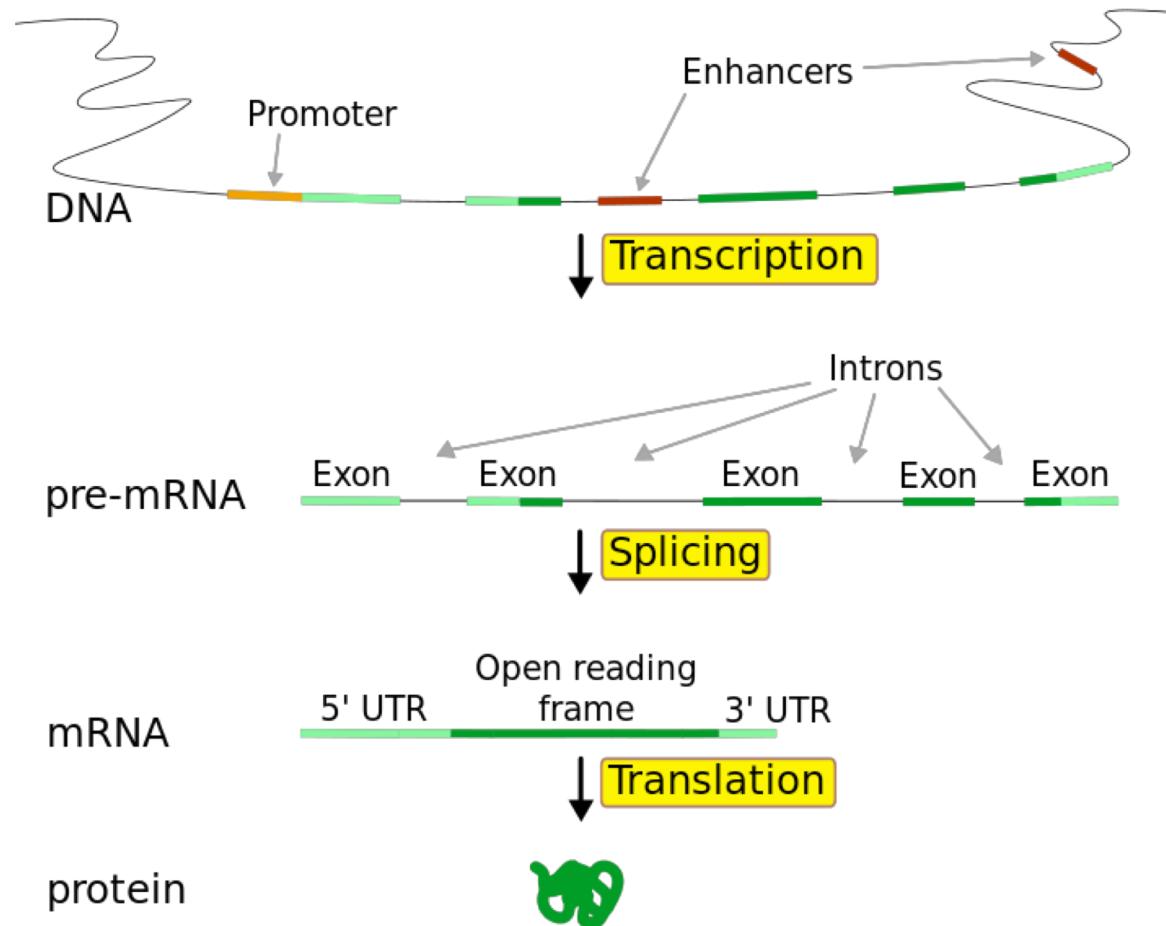
Transcription

The transcription process generates a messenger RNA molecule from a gene region.

RNA is like DNA but

- the sugar-phosphate is different: ribose instead of deoxyribose
- In all places where the DNA has a T the RNA has a U (uracil)

In higher organisms the protein coding sequences (exons) are interspersed by non-coding sequences (introns) which are spliced out.

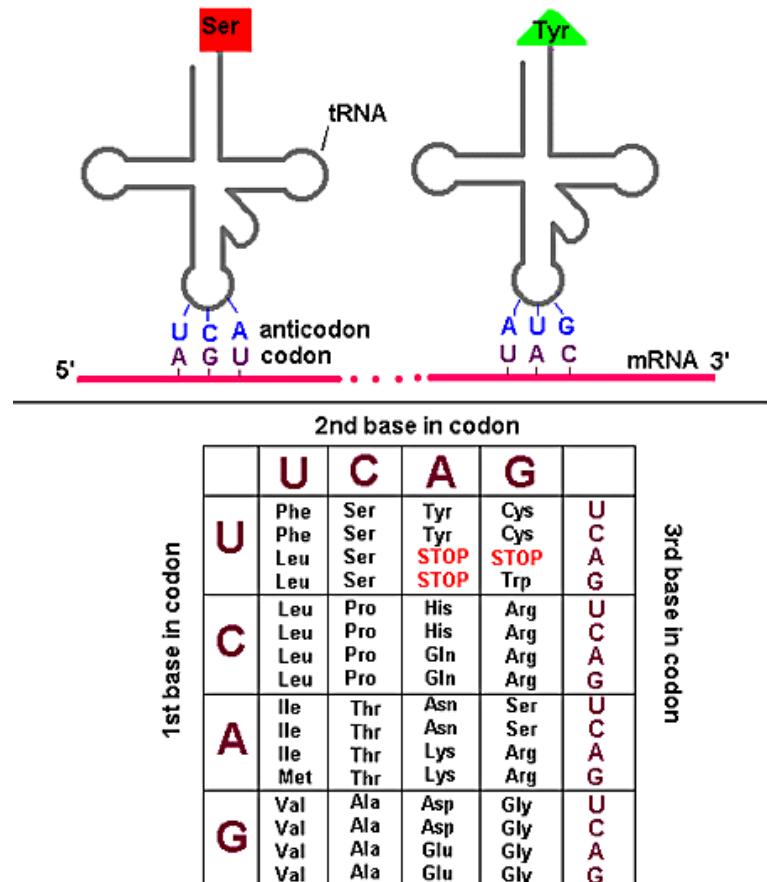


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Translation: The Genetic Code

The translation process generates a protein based on the information in the messenger RNA

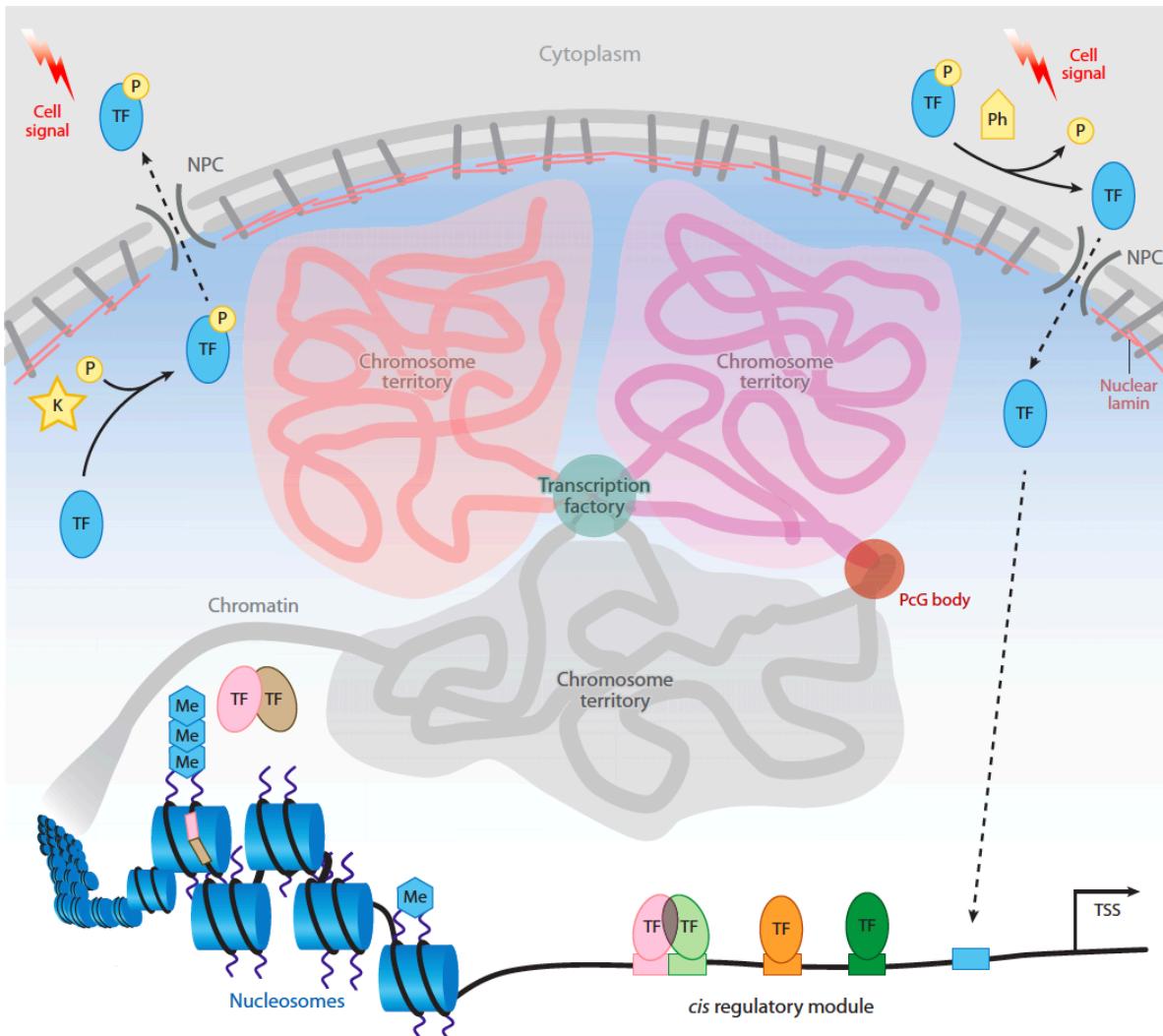
- A protein is a linear polymer of amino acids linked together by peptide bonds.
- Proteins are the main functional chemicals in the cell, carrying out many functions, for example catalysis of the reactions involved in metabolism.
- Proteins have a complex spatial structure



The Genetic Code

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Transcriptional Regulation



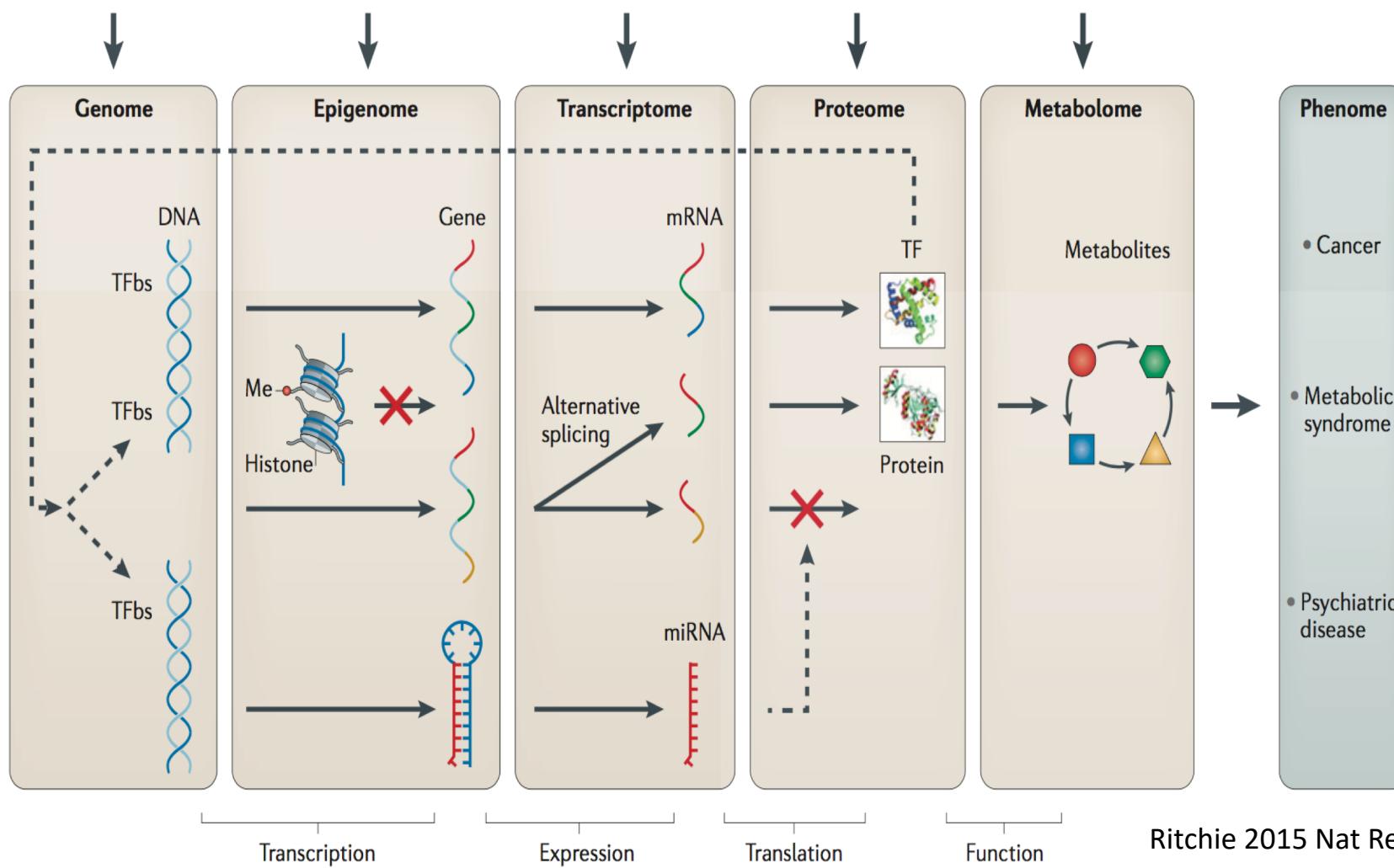
- SNP
 - CNV
 - LOH
 - Genomic rearrangement
 - Rare variant

- DNA methylation
 - Histone modification
 - Chromatin accessibility
 - TF binding
 - miRNA

- Gene expression
 - Alternative splicing
 - Long non-coding RNA
 - Small RNA

- Protein expression
 - Post-translational modification
 - Cytokine array

- Metabolite profiling in serum, plasma urine, CSF, etc

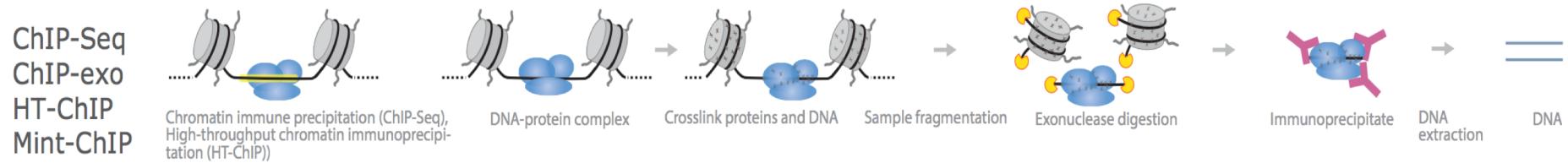


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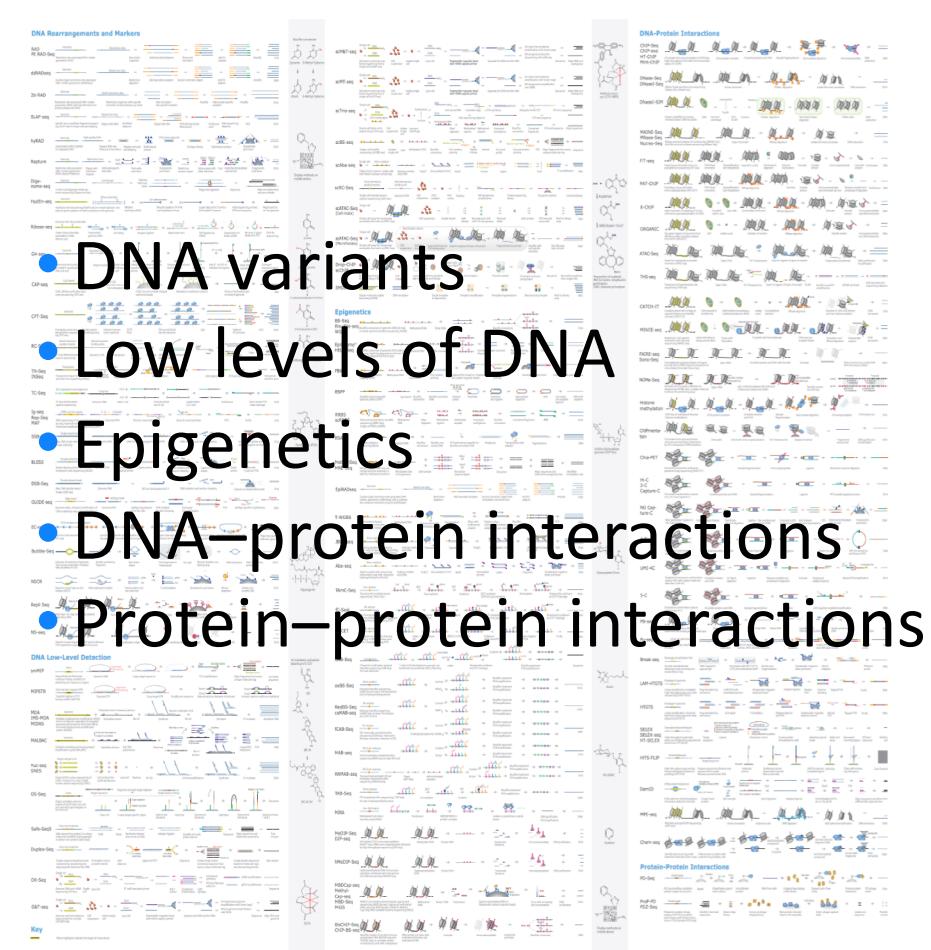
NGS Protocols

- Example: Preparation of DNA for a ChIP-seq experiment

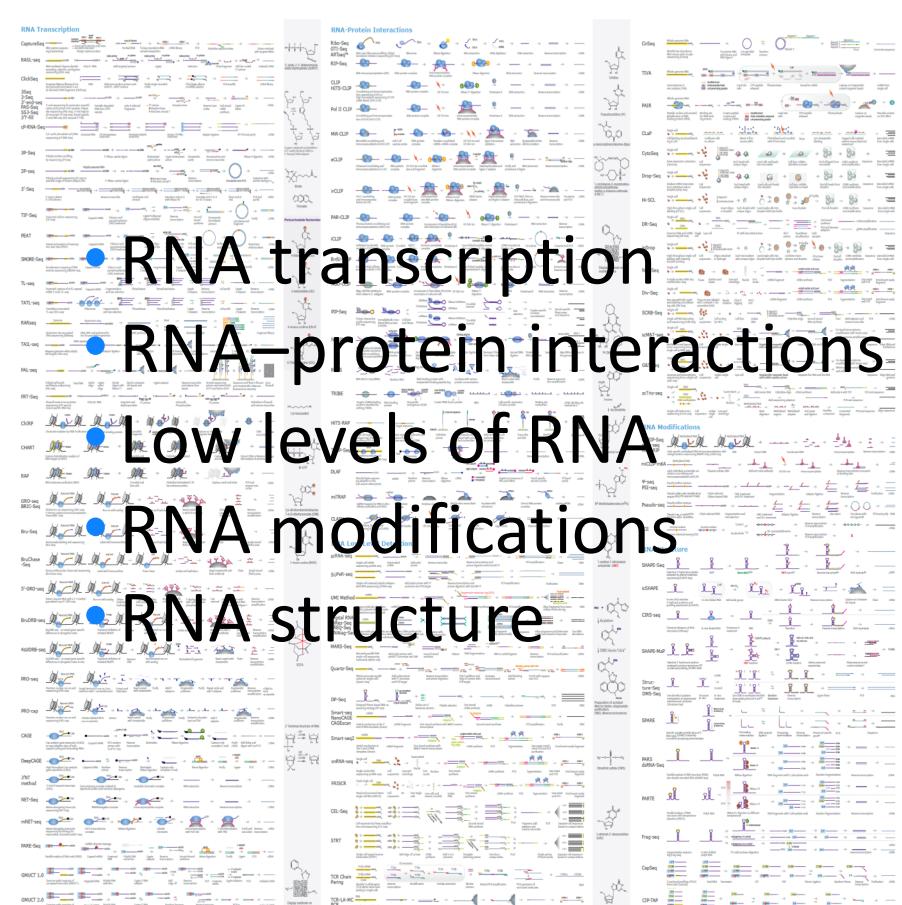
DNA-Protein Interactions



- The preparation determines how sequenced reads have to be interpreted



DNA variants
Low levels of DNA
Epigenetics
DNA–protein interactions
Protein–protein interactions



- RNA transcription
- RNA–protein interactions
- Low levels of RNA
- RNA modifications
- RNA structure