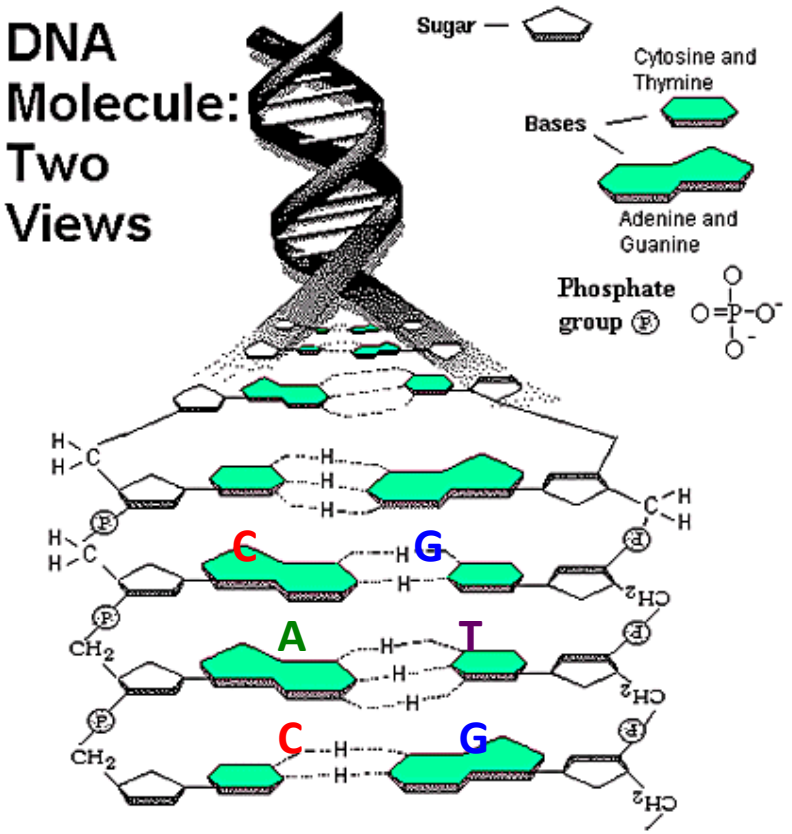
Some Basics of Molecular Biology

Hubert Rehrauer

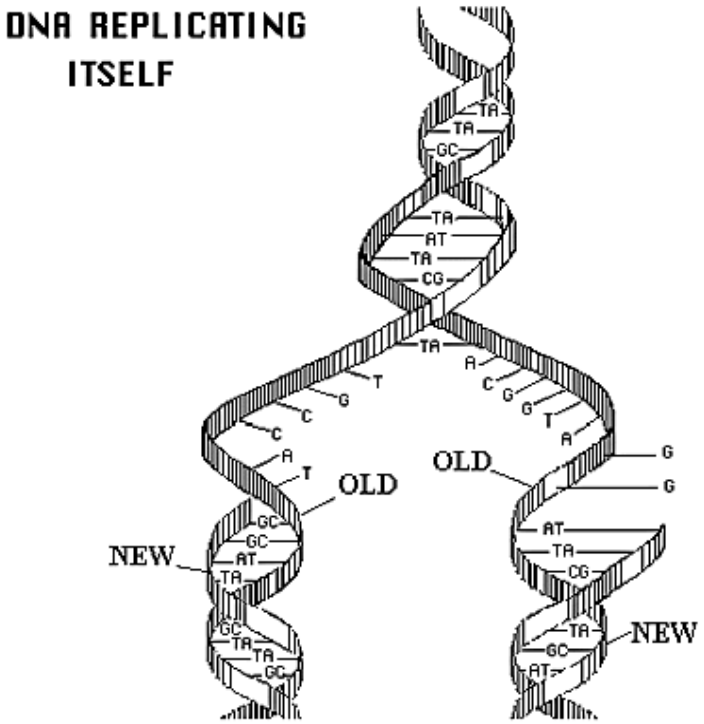
What is DNA?

- 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

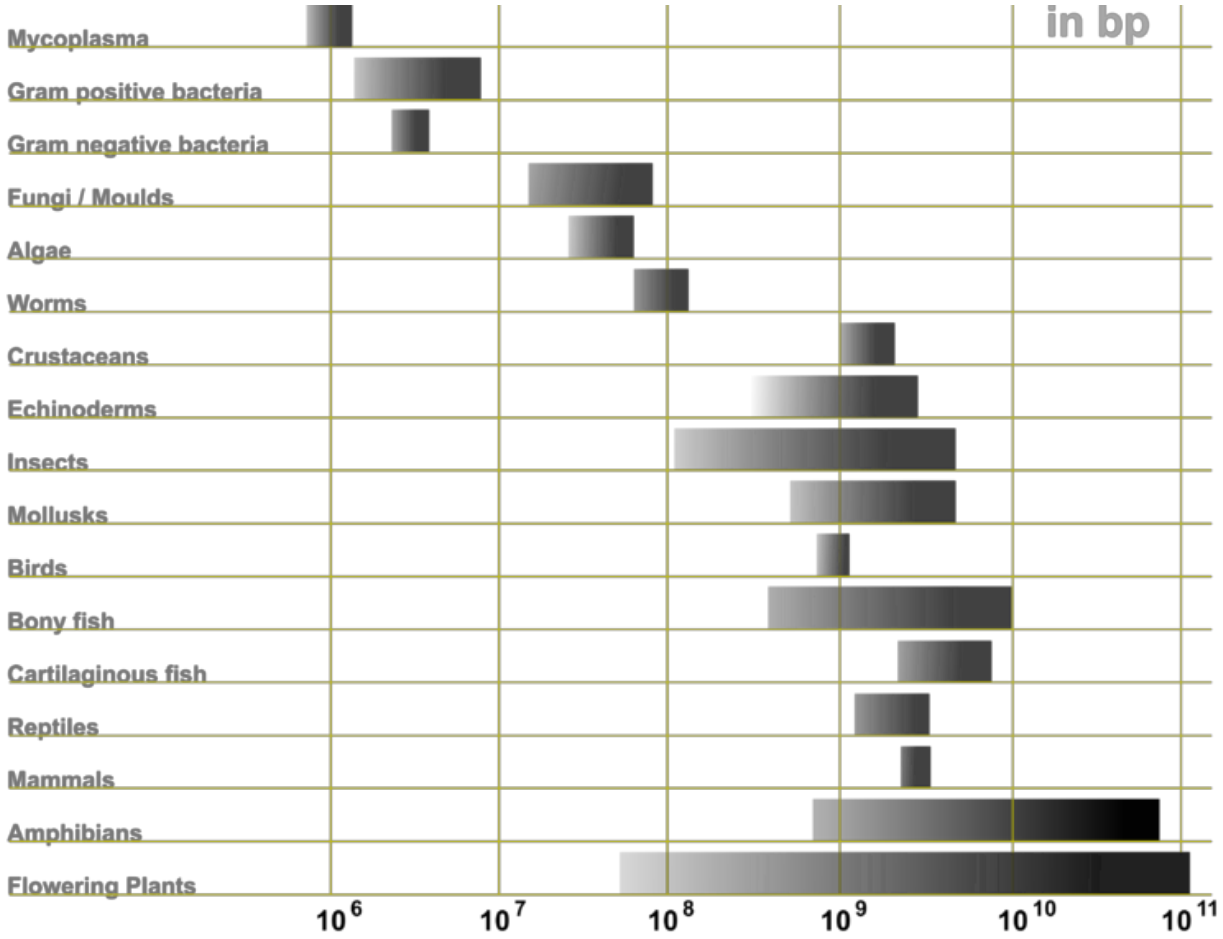


DNA replication

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



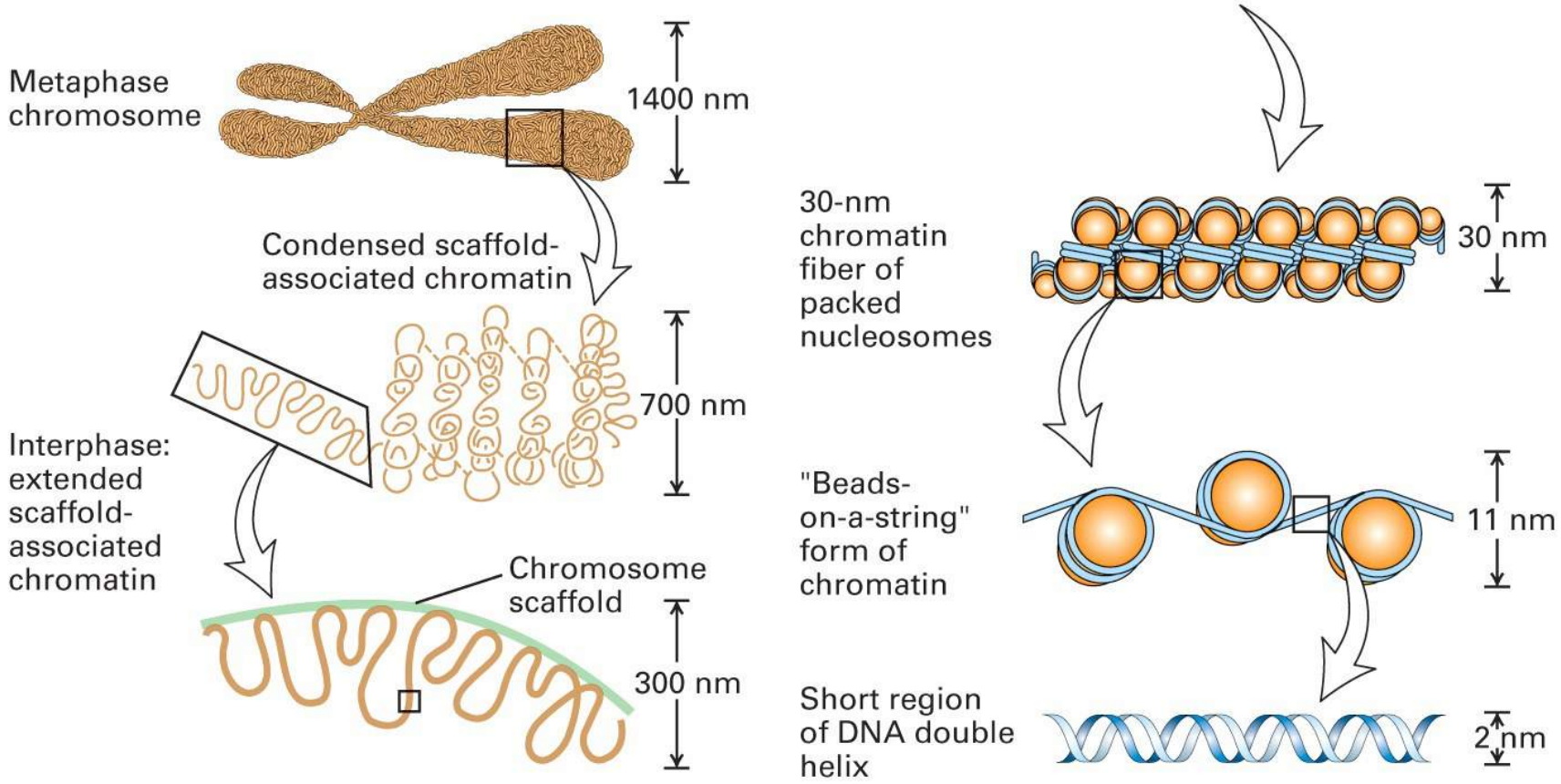
Genome Sizes



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

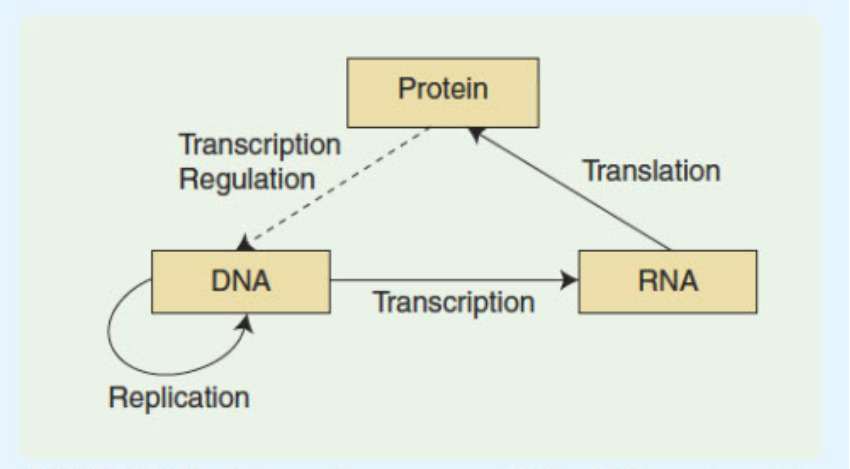
DNA Superstructure



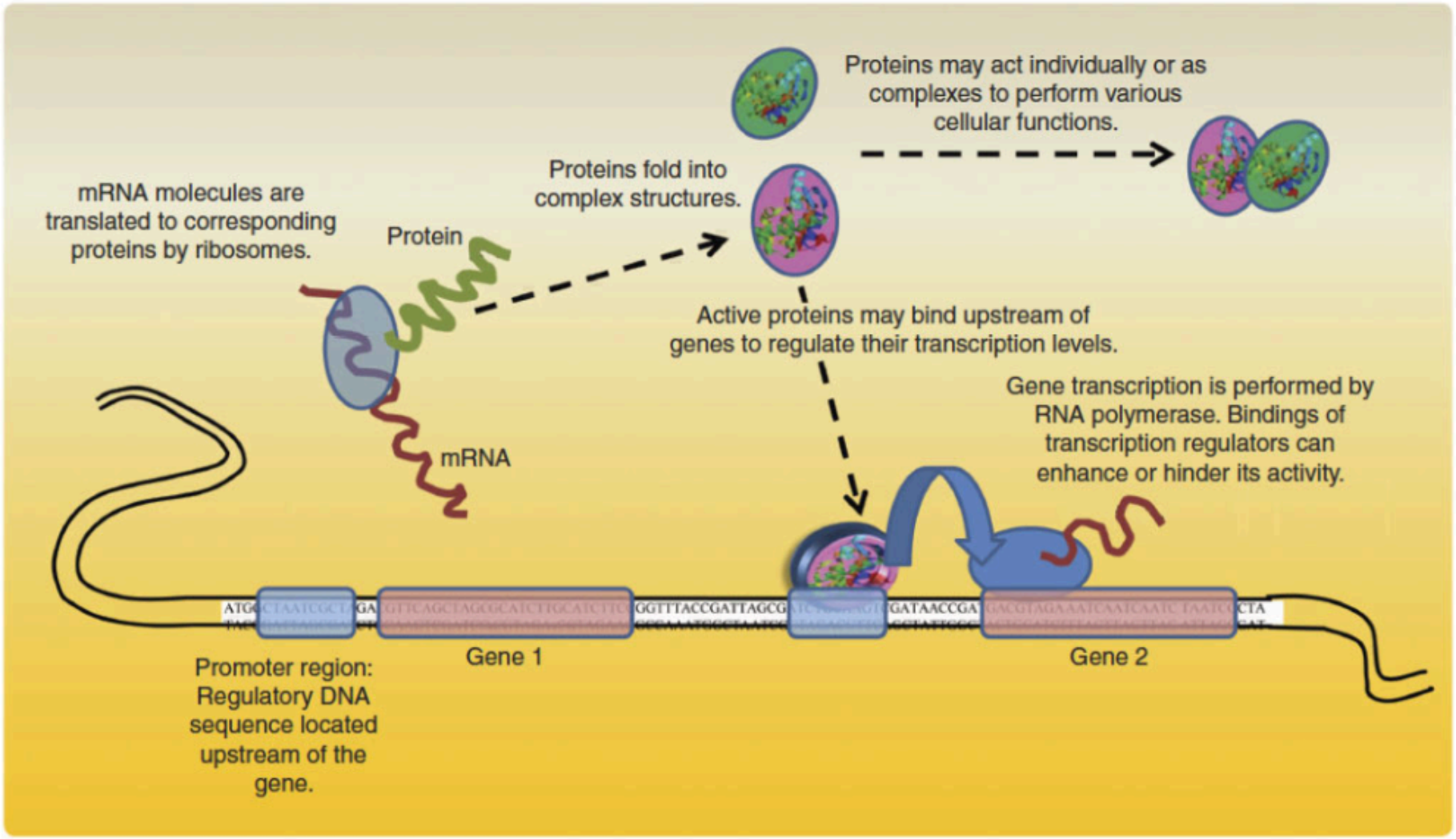
Lodish et al. *Molecular Biology of the Cell* (5th ed.). W.H. Freeman & Co., 2003.

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



The Central Dogma



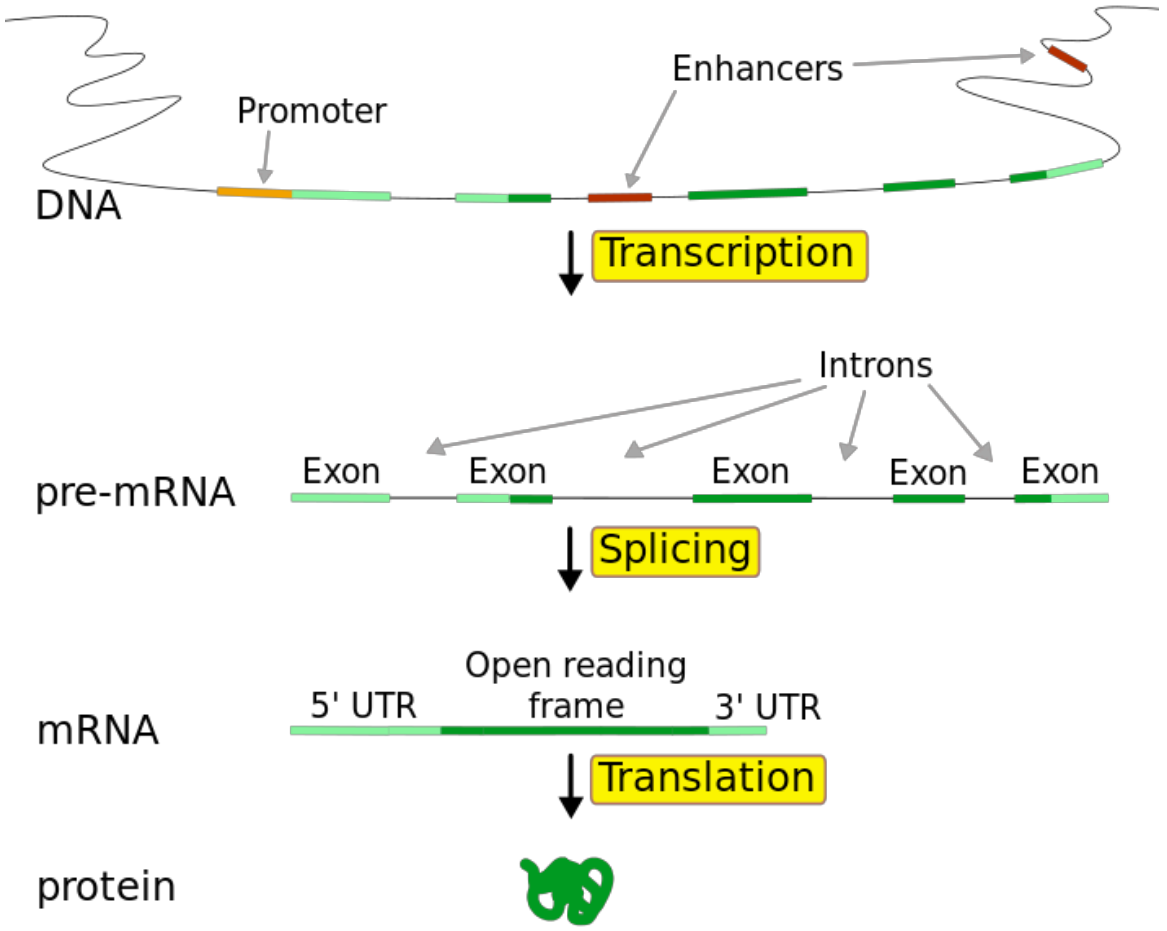
Elvitigala et al. 2010

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 the RNA has a U (uracil)

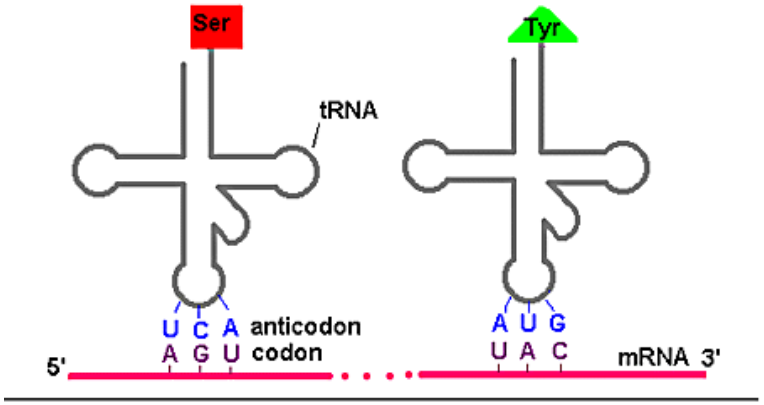
In higher organisms the protein coding sequences (exons) are interspersed by non-coding sequences (introns) which are spiced out.



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

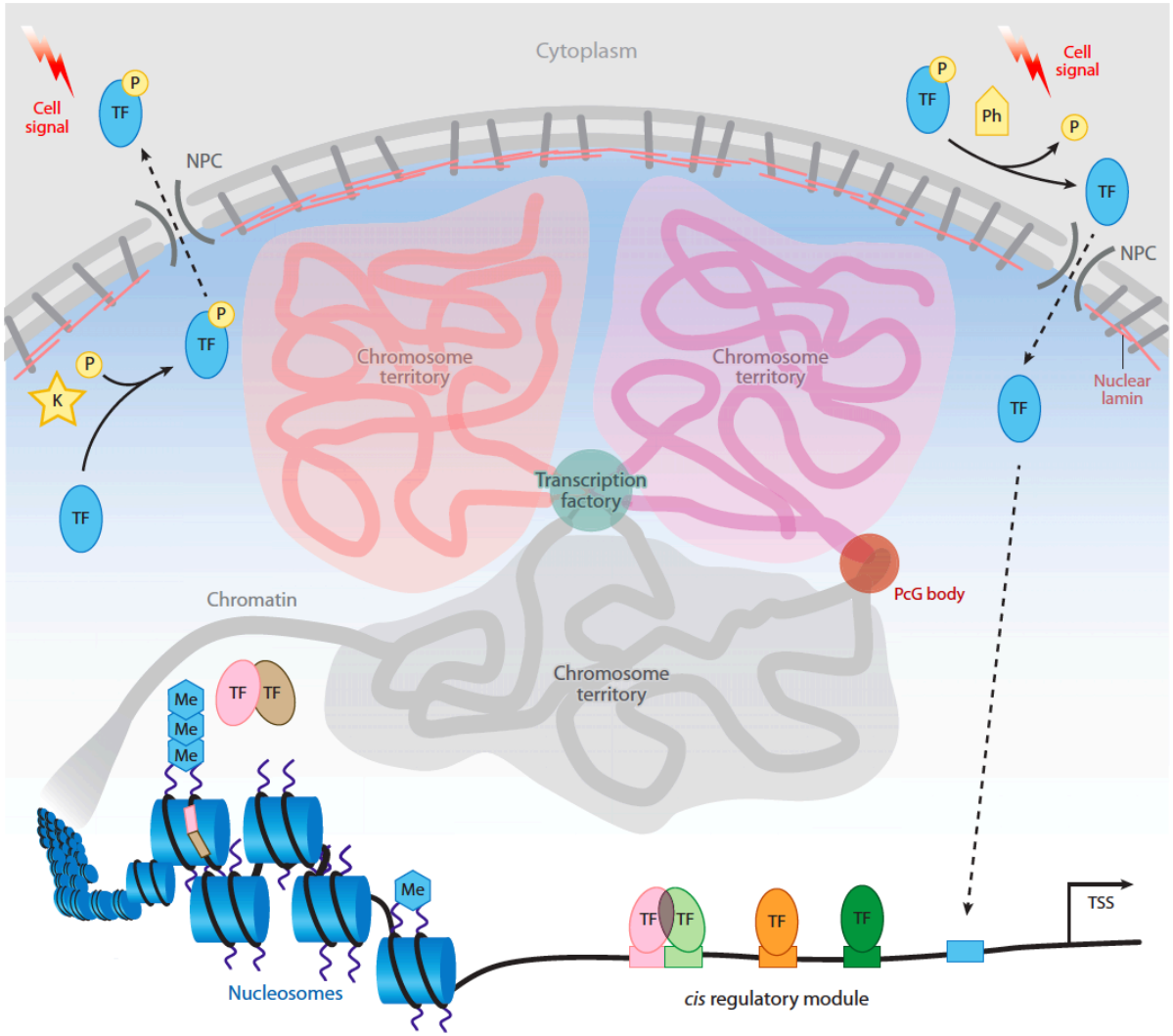


2nd base in codon

1st base in codon	U	C	A	G	3rd base in codon
U	Phe	Ser	Tyr	Cys	U
	Phe	Ser	Tyr	Cys	C
	Leu	Ser	STOP	STOP	A
	Leu	Ser	STOP	Trp	G
C	Leu	Pro	His	Arg	U
	Leu	Pro	His	Arg	C
	Leu	Pro	Gln	Arg	A
	Leu	Pro	Gln	Arg	G
A	Ile	Thr	Asn	Ser	U
	Ile	Thr	Asn	Ser	C
	Ile	Thr	Lys	Arg	A
	Met	Thr	Lys	Arg	G
G	Val	Ala	Asp	Gly	U
	Val	Ala	Asp	Gly	C
	Val	Ala	Glu	Gly	A
	Val	Ala	Glu	Gly	G

The Genetic Code

Transcriptional Regulation



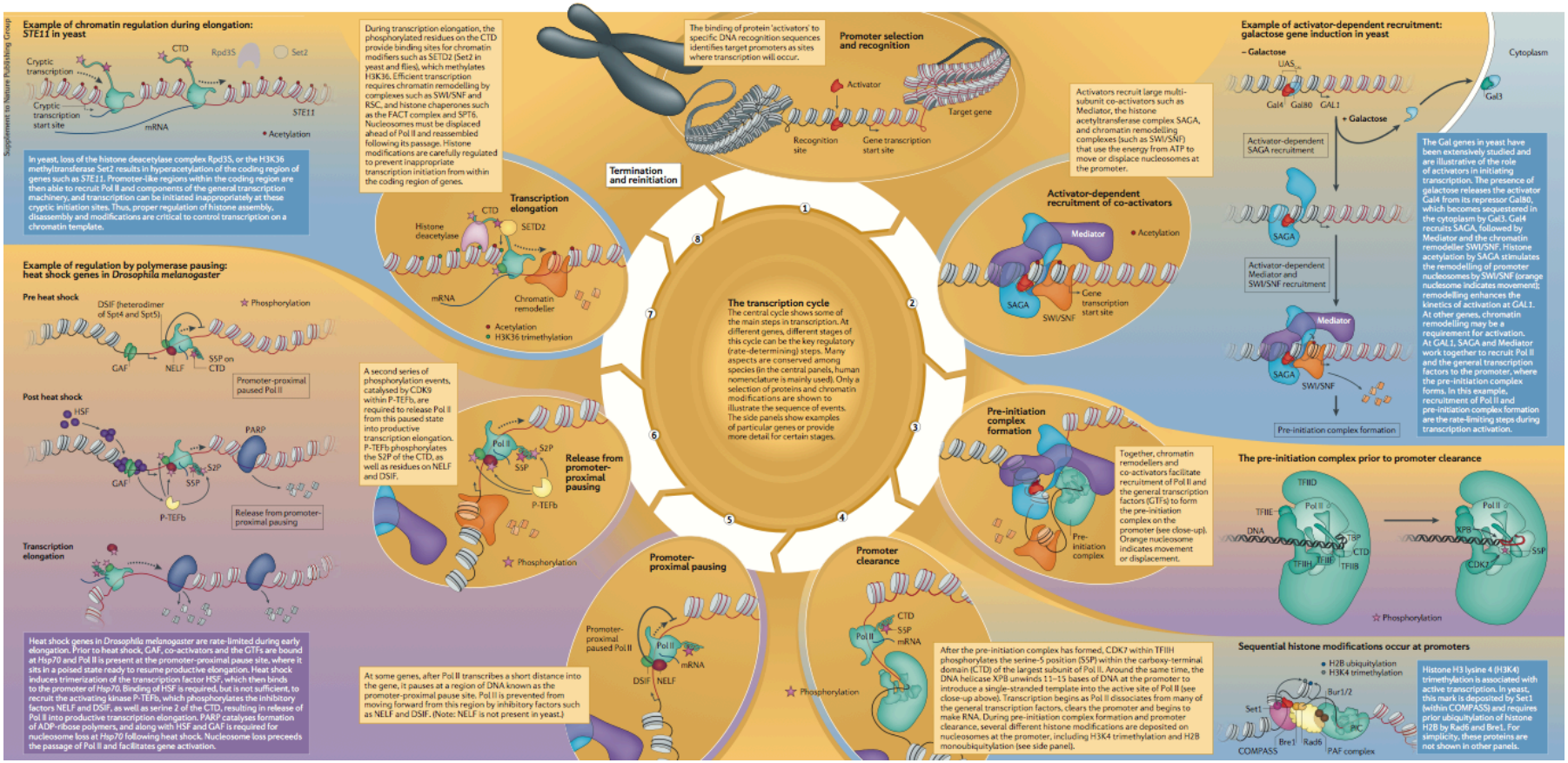
http://www.annualreviews.org/doi/pdf/10.1146/annurev-genet-110711-155437

nature REVIEWS GENETICS

Chromatin remodelling and the transcription cycle

Vikki M. Weake and Jerry L. Workman

Transcription by RNA polymerase II (Pol II) occurs in the context of chromatin within a eukaryotic cell. Chromatin is generally inhibitory to transcription, so a variety of mechanisms are required to activate transcription from a nucleosomal template. One of the first steps is that large co-activator complexes interact with small activator proteins to identify gene promoters that are ready to be transcribed. Nucleosome remodelling complexes that use energy from ATP to move or displace nucleosomes from DNA facilitate the recruitment and assembly of these complexes on the promoter and enable rapid gene activation. Even during transcription elongation, nucleosomes must be removed for efficient passage of the polymerase. Furthermore, these same nucleosomes must be reassembled rapidly and modified appropriately following passage of the polymerase to prevent inappropriate initiation of transcription from promoter-like elements within the coding region.



Transcriptional Regulation

- DNA in a living cell is in a highly compacted and structured state
- Transcription factors and RNA polymerase need ACCESS to do their work
- Transcription is dependent on the structural state – SEQUENCE alone does not tell the whole story
- The accessibility of the DNA is controlled by
  - DNA modifications (methylation)
  - Histone modifications
  - DNA binding of Transcription Factors