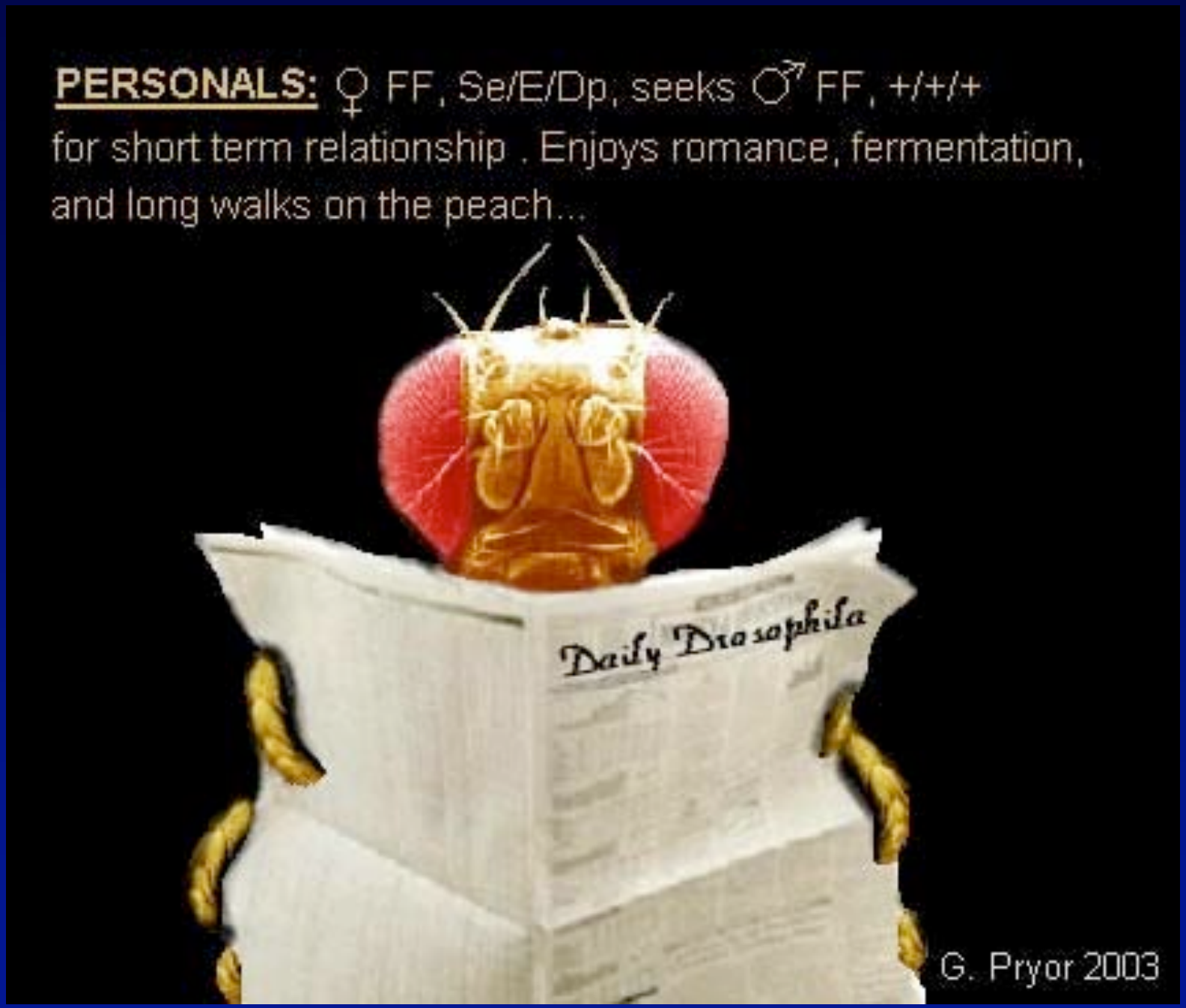

PERSONALS: ♀ FF, Se/E/Dp, seeks ♂ FF, +/+/+
for short term relationship . Enjoys romance, fermentation,
and long walks on the peach...
Daily Drosophila
G. Pryor 2003

Sex Must Be An Advantage

- Sexual reproduction persists in many, many populations
- Must be great enough to offset disadvantages of anisogamy, ~~mating~~, genetic recombination, and **meiosis**.

What was the disadvantage?

Meiosis

Each parent loses half his/her genetic information.

But also some advantages to meiosis.

We'll come back to this….

Why Sex?

- The Red Queen Theory
  - "It takes all the running you can do, to keep in the same place." Red Queen - *'Alice in Wonderland'*
- Parasite-host interactions
  - Sexual reproduction persists because it enables species to rapidly evolve new genetic defenses against parasites
    - Guppy and snail species exhibit sexual reproduction when higher level of parasitism
      - (Dybdahl and Lively 1995; Howard and Lively 1994).

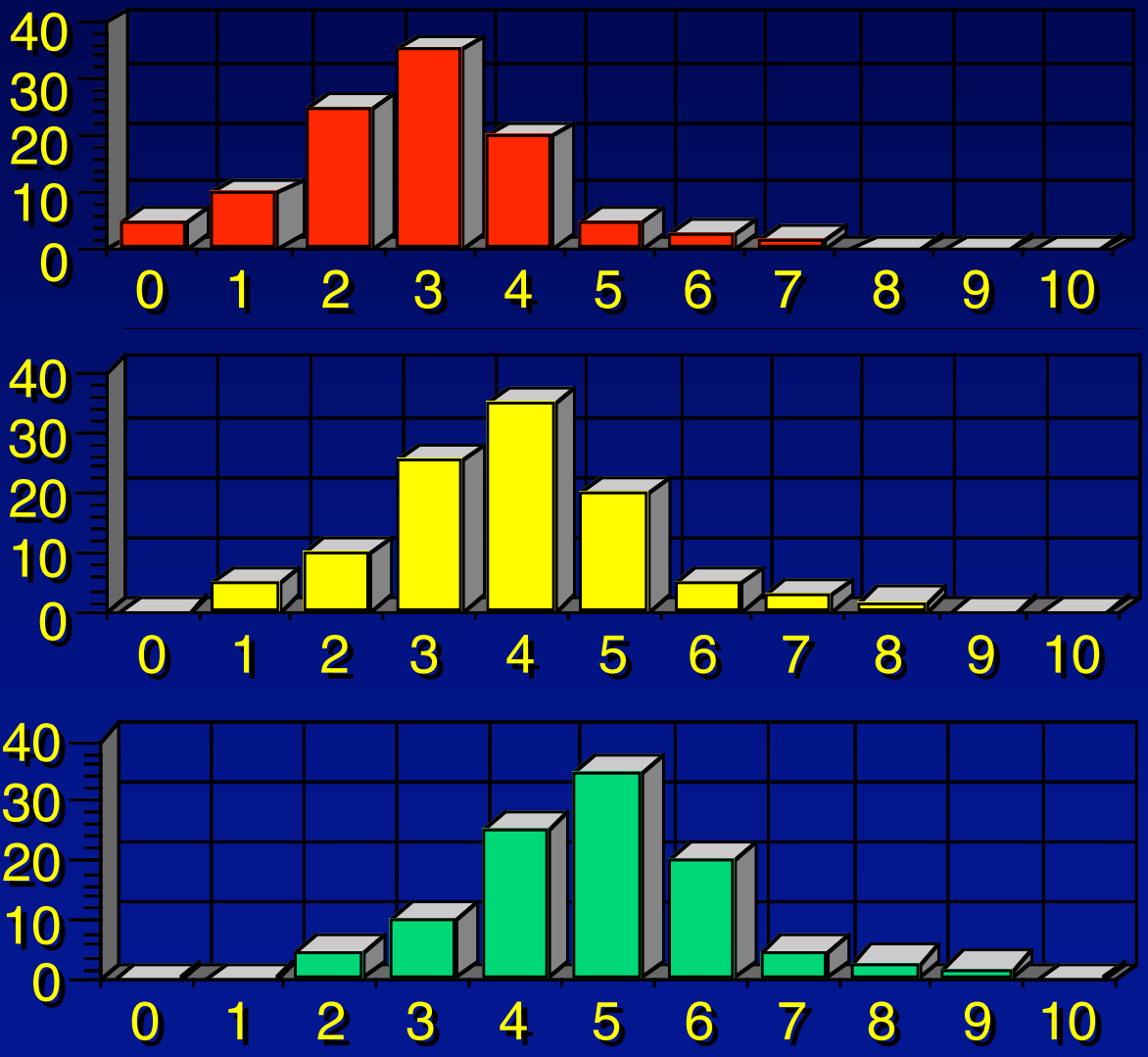
Additional Hypotheses

- Many
  - Fixation of rare beneficial mutations
  - Heterogeneous habitats
  - Deleterious mutations removed
    - Muller's ratchet

Muller's Ratchet

- Herman Muller (1964)
  - Nobel Prize for mutagenic effects of radiation
- Back mutation from deleterious to wild-type alleles is extremely rare
  - In asexual population mutations accumulate over time
  - Can't be removed
  - Genomes without mutation become rare, then extinct
  - mitochondria and chloroplasts do not recombine and would undergo Muller's ratchet except for their small size. Same true of Y-chromosome.

Muller's Ratchet



- Frequency of asexual individuals with different numbers of mutations at three time periods.

Evolution of Sexes

- Anisogamy evolved from isogamy
  - evolution of large versus small gamete
- If:
  - Large size enhances survival of offspring
    - Movement difficult
  - Selection for 'transport' of second gamete

Sex vs. Gender

Sex: either of the two major forms of individuals that occur in many species and that are distinguished respectively as female or male

- based on type of gonad/gamete produced

Gender: the behavioral, cultural, or psychological traits typically associated with one sex

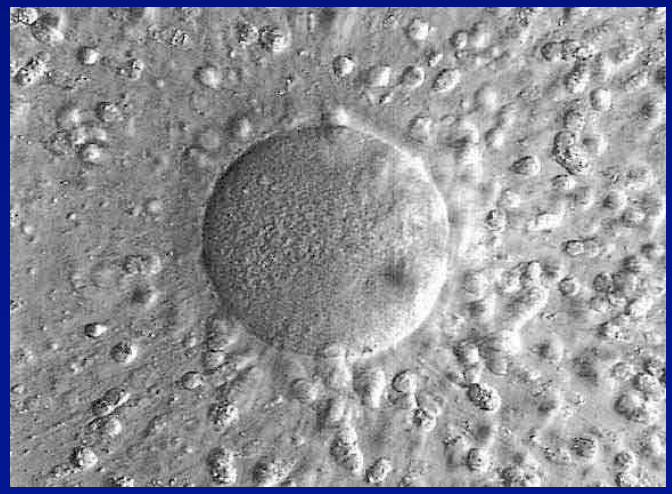
Merriam-Webster online

Evolution of Gender

- Anisogamy gives rise to different mating types
  - (+ / -) (female/male)
- Recognition of opposite type has advantages
  - chemical (pheromones)
  - visual signals
    - secondary sex characters
      - Coloration
      - Horns
      - Behavioral display

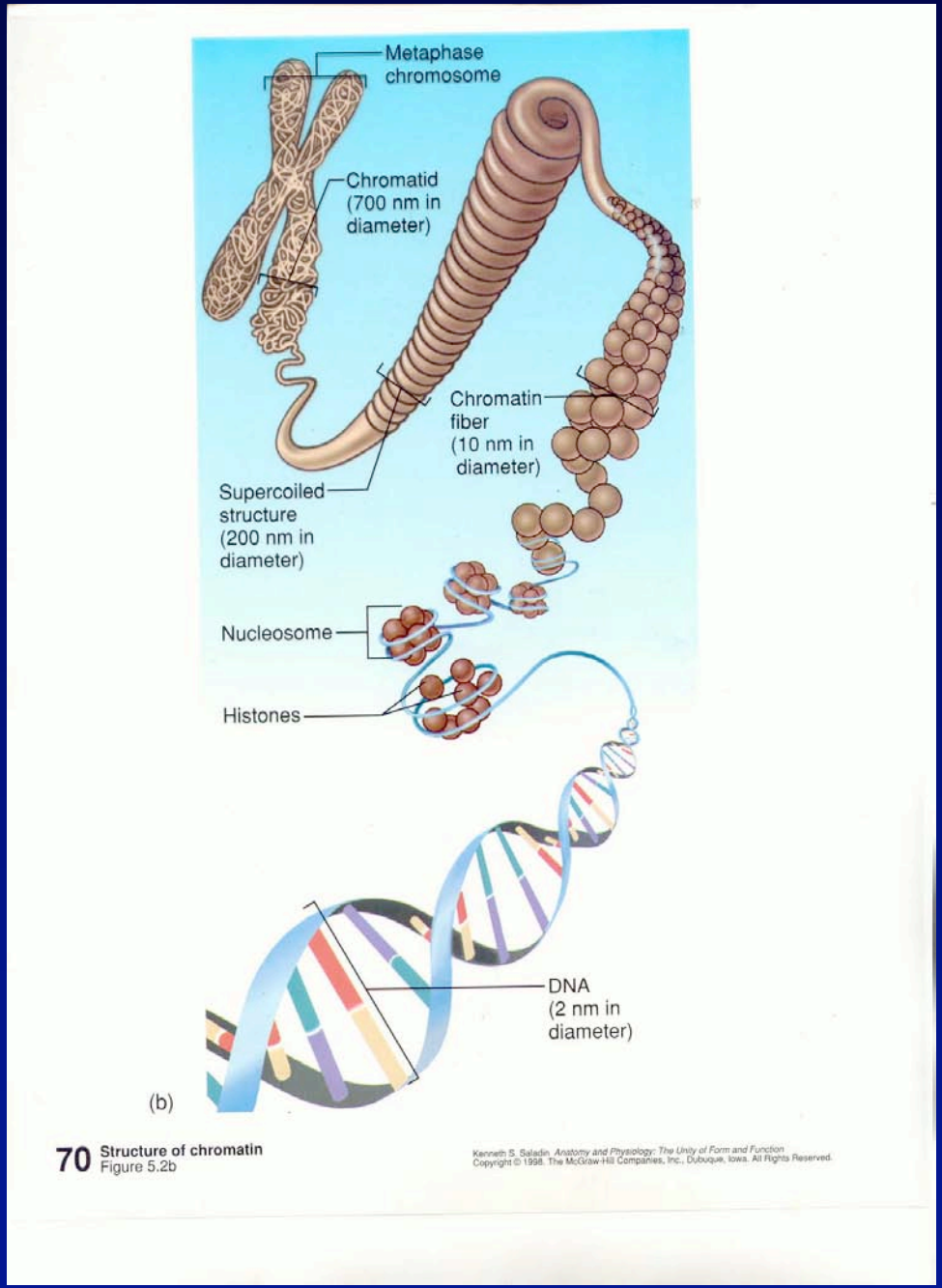
Cell Biology and Genetics

- DNA structure, exons, introns
- Regulation of gene expression
- Replication, transcription, translation
- Meiosis and Mitosis



DNA structure

Nucleosomes: 147 bp coiled almost twice around set of 8 histones (proteins)

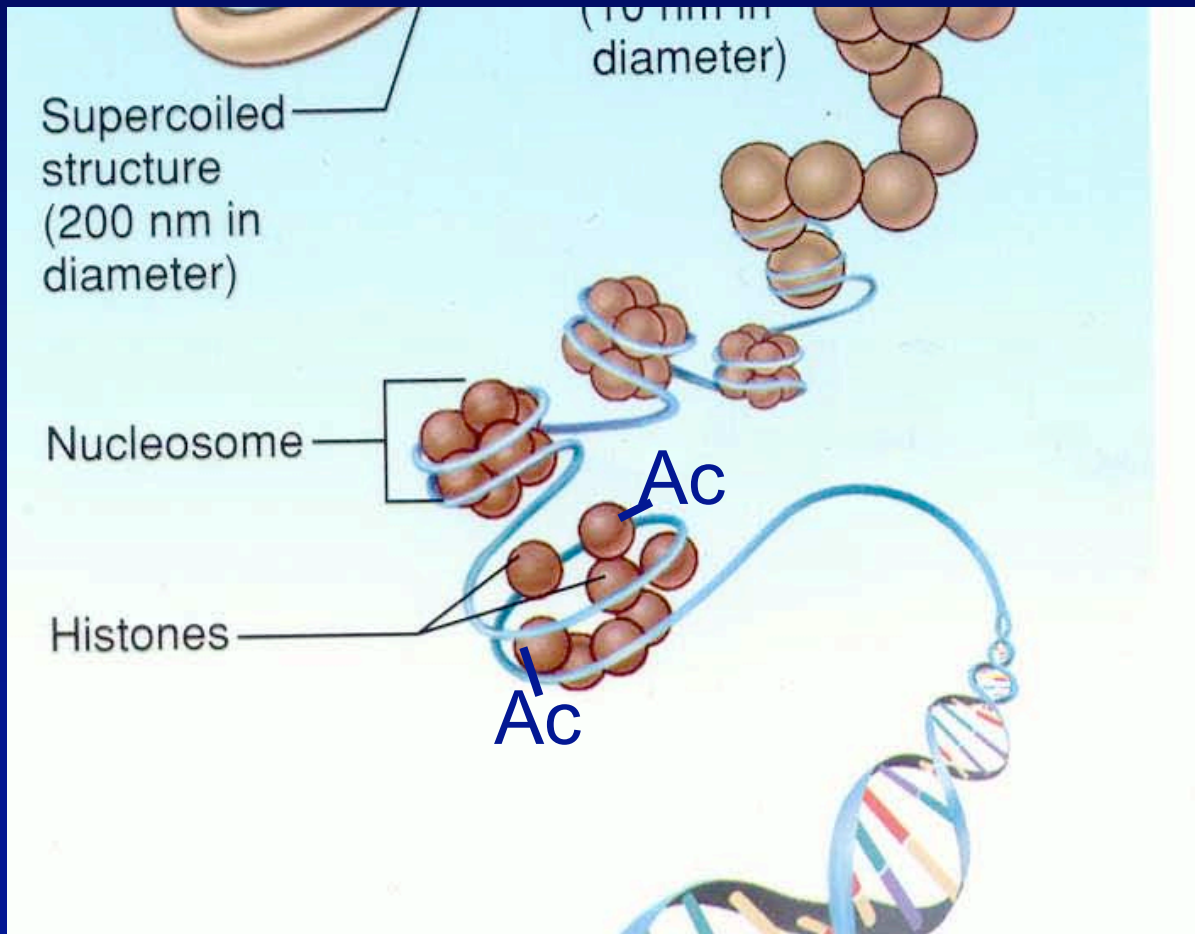


Regulation of Gene Expression

1. Acetyl groups attached to histones.

Acetyl -$COCH_3$,

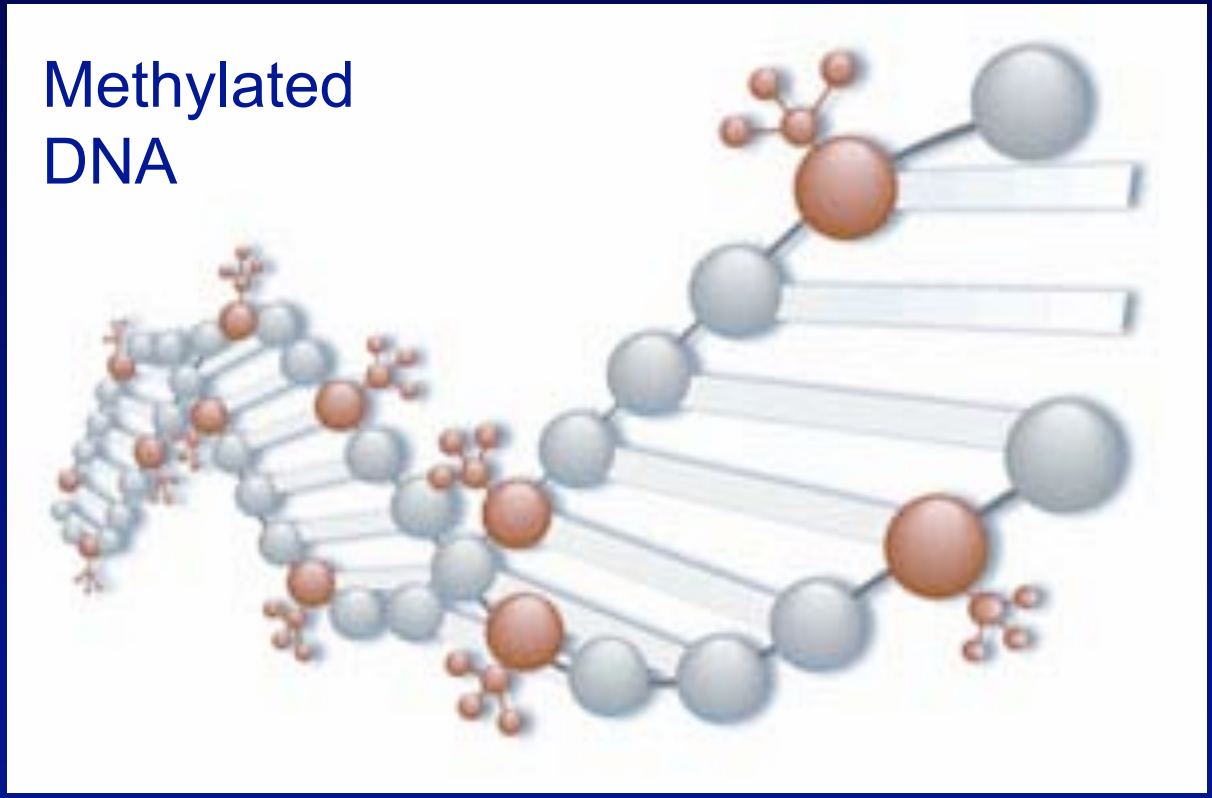
Acetylation tends to activate a gene



Regulation of Gene Expression

2. Methyl groups attached to DNA.

methyl -CH_3

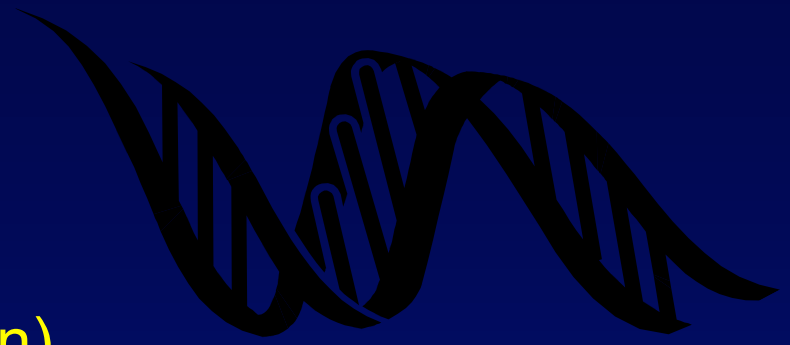


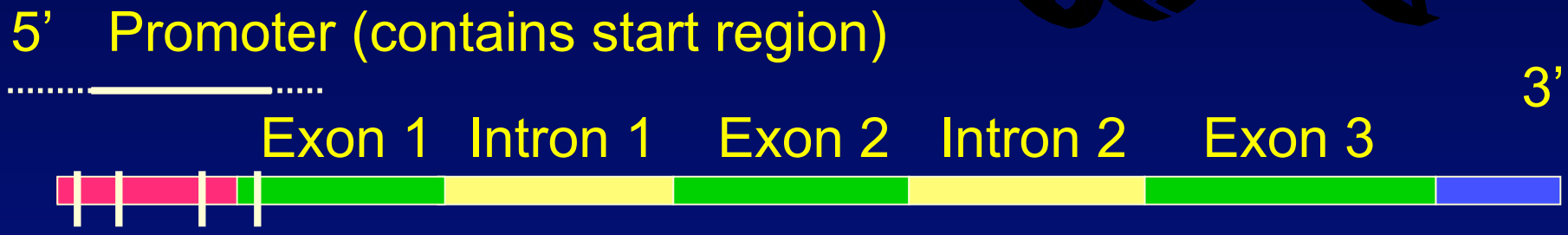
CpG islands within/near the promoter

Typically silencing

Transient/permanent (X-inactivation)

Anatomy of a gene

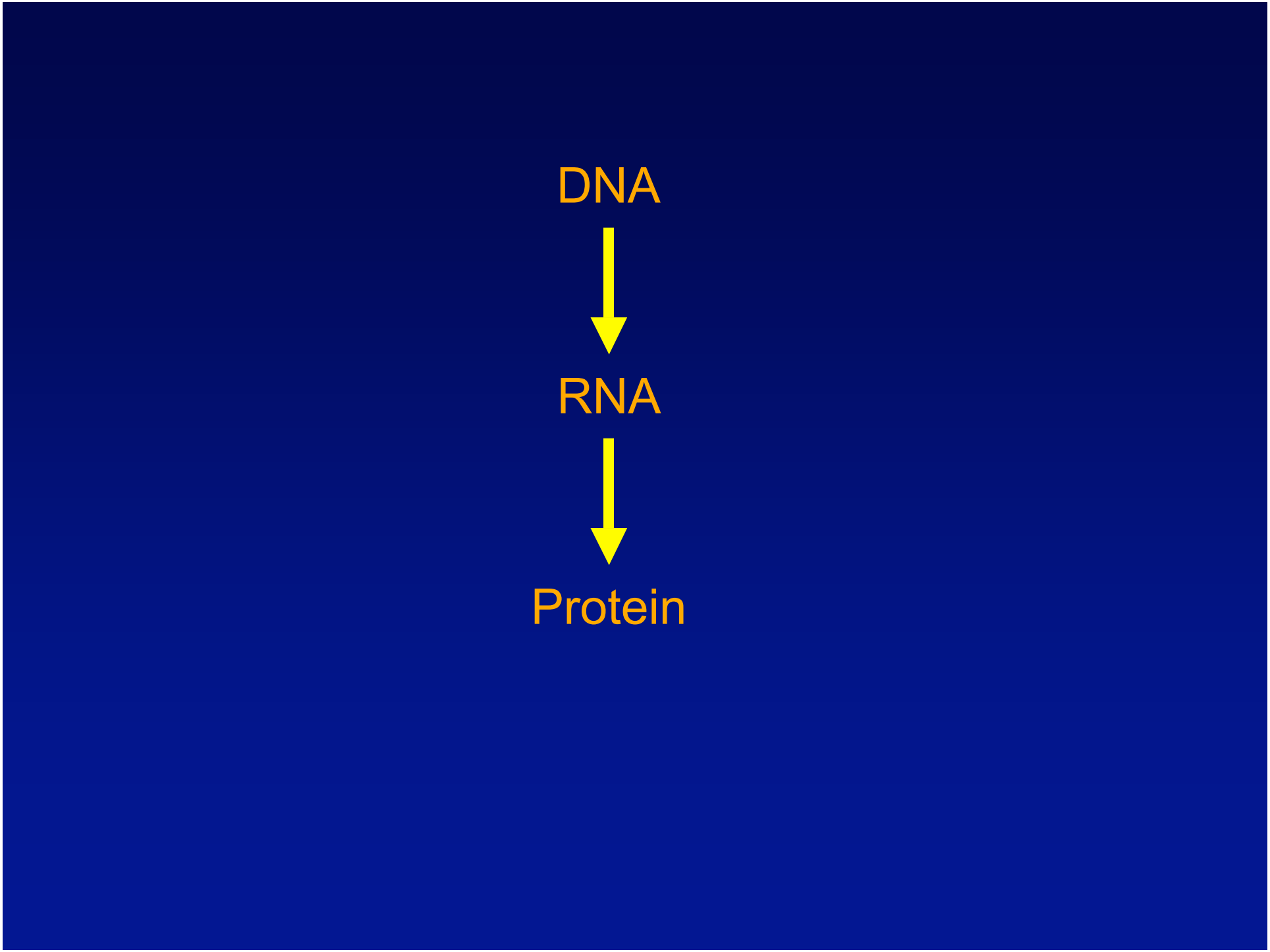


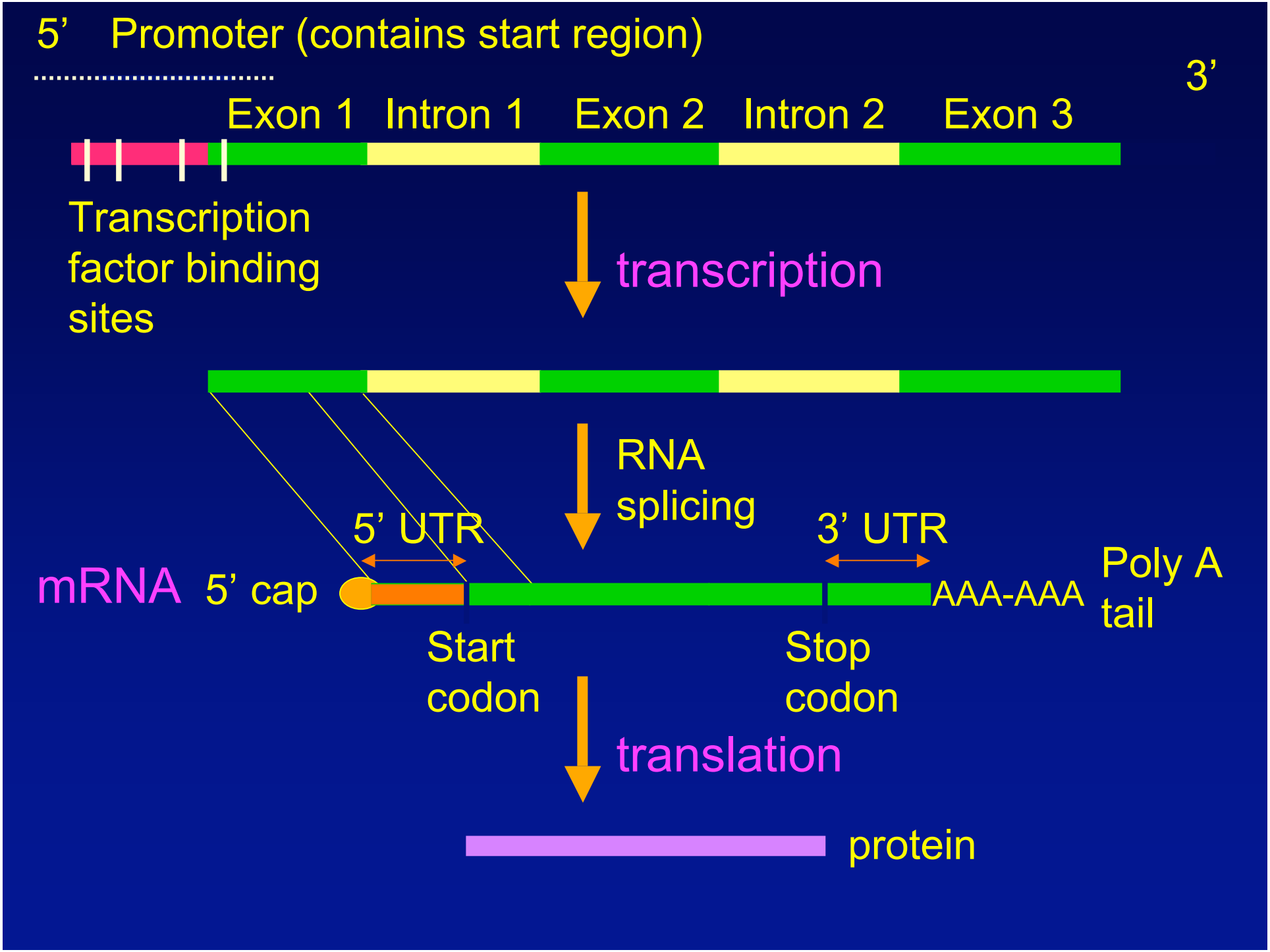


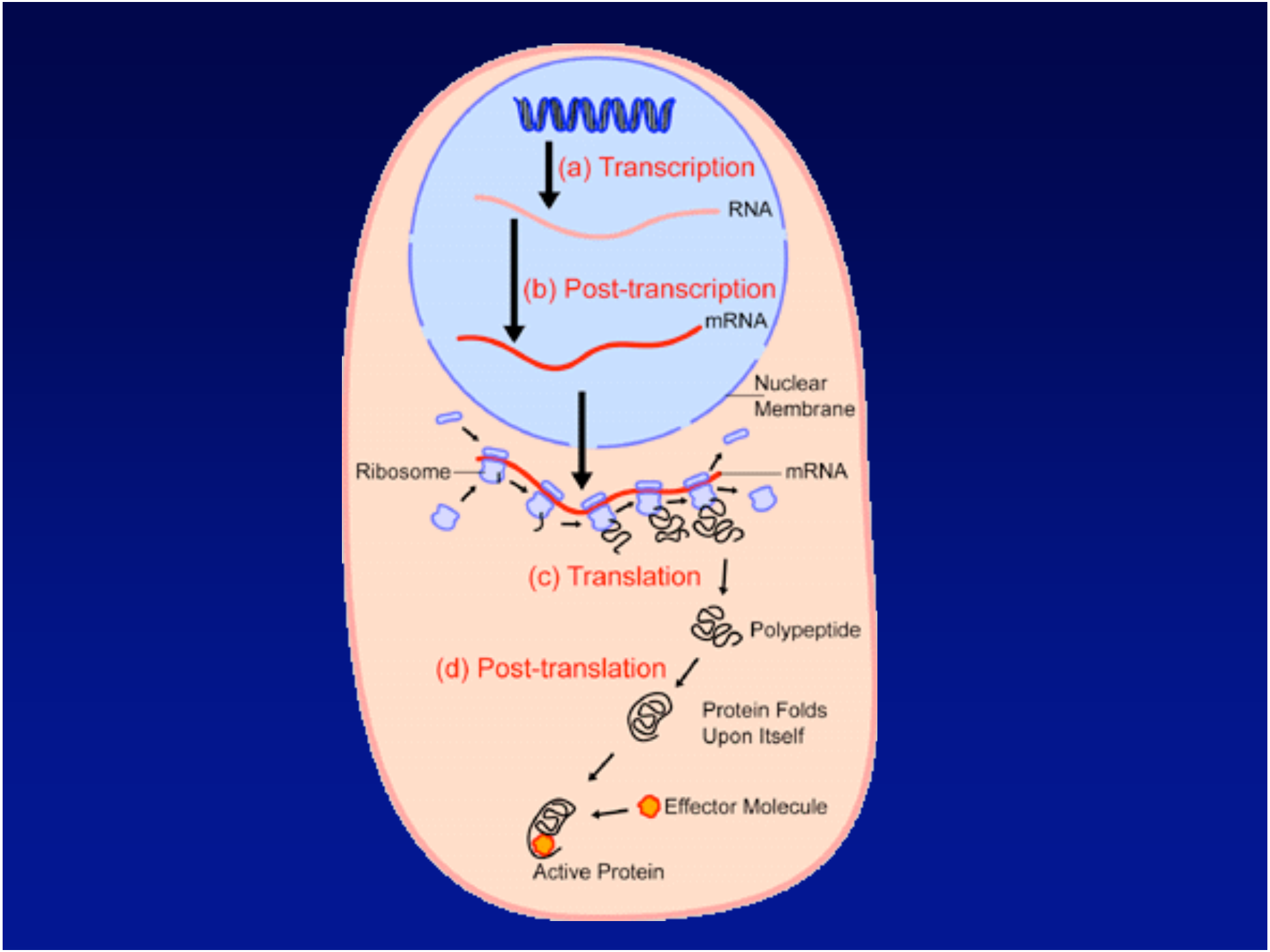
Transcription factor binding sites

Introns “interrupt”

What is meant by central dogma?


DNA
RNA
Protein


5’ Promoter (contains start region)
3’
Exon 1
Intron 1
Exon 2
Intron 2
Exon 3
Transcription factor binding sites
transcription
RNA splicing
5’ UTR
3’ UTR
mRNA
5’ cap
AAA-AAA
Poly A tail
Start codon
Stop codon
translation
protein

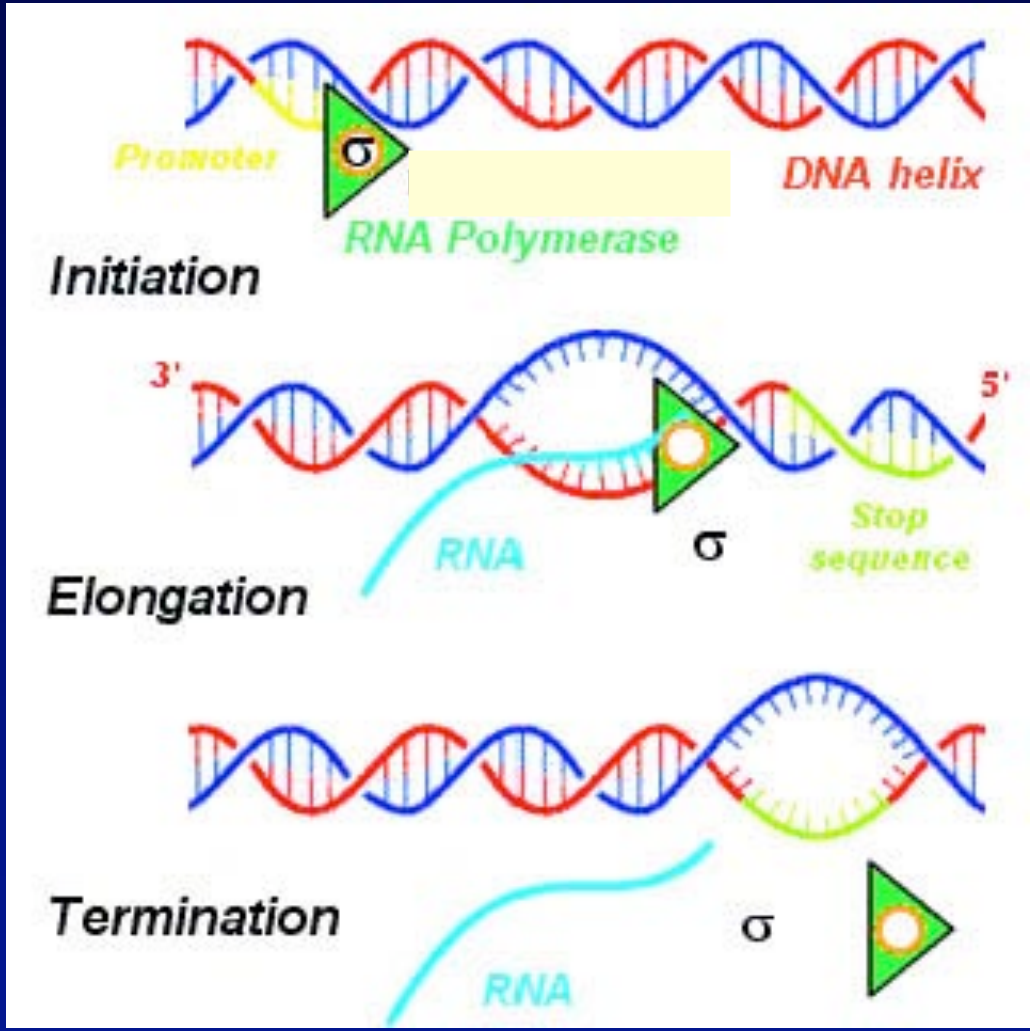

(a) Transcription
RNA
(b) Post-transcription
mRNA
Nuclear Membrane
Ribosome
mRNA
(c) Translation
Polypeptide
(d) Post-translation
Protein Folds Upon Itself
Effector Molecule
Active Protein

transcription

RNA polymerase binds to DNA promoter on template strand (prokaryotes)

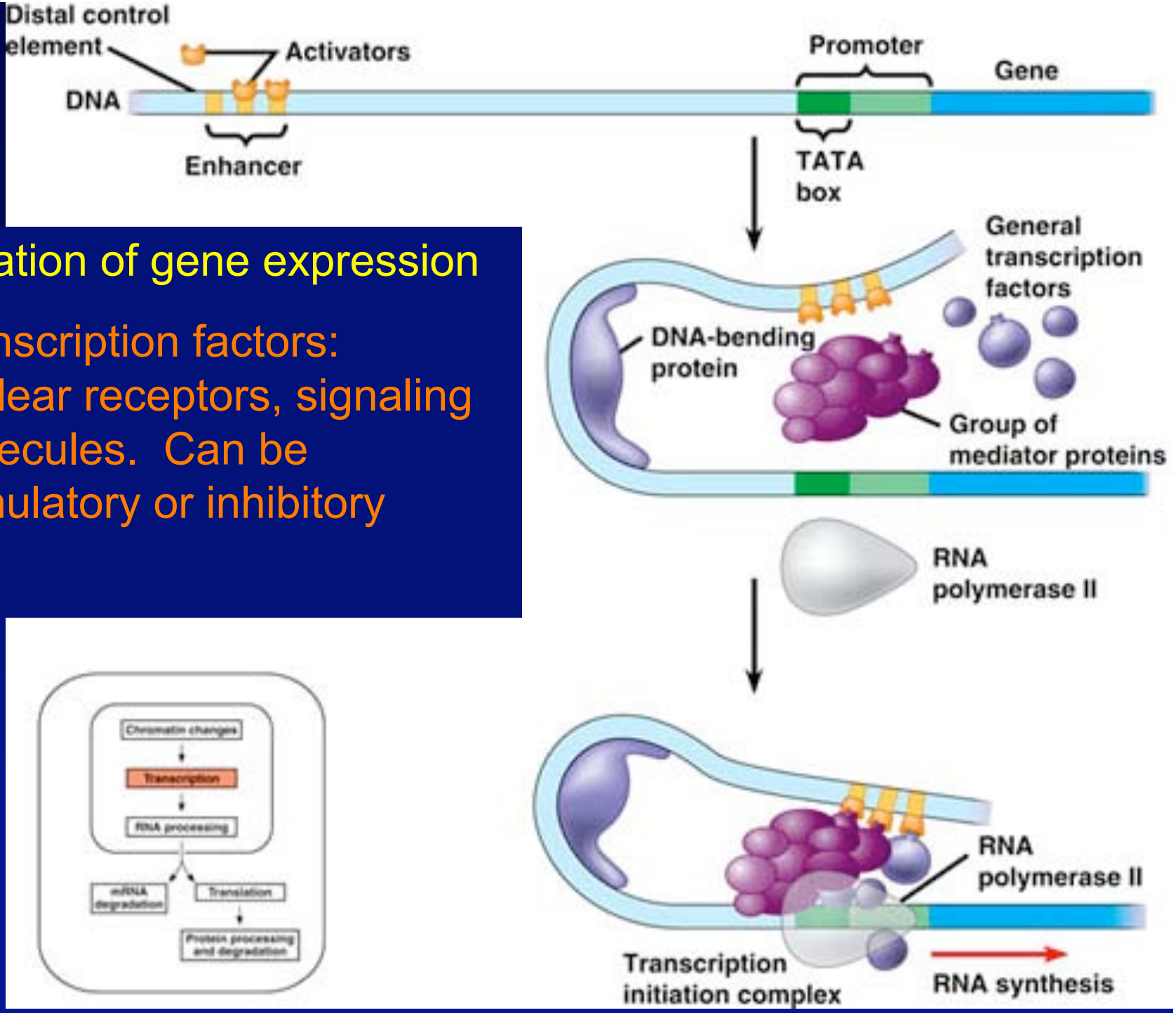
Or

Transcription factors bind to the promoter and then RNA polymerase binds the transcription factor complex (Eukaryotes)



Regulation of gene expression

3. transcription factors: nuclear receptors, signaling molecules. Can be stimulatory or inhibitory

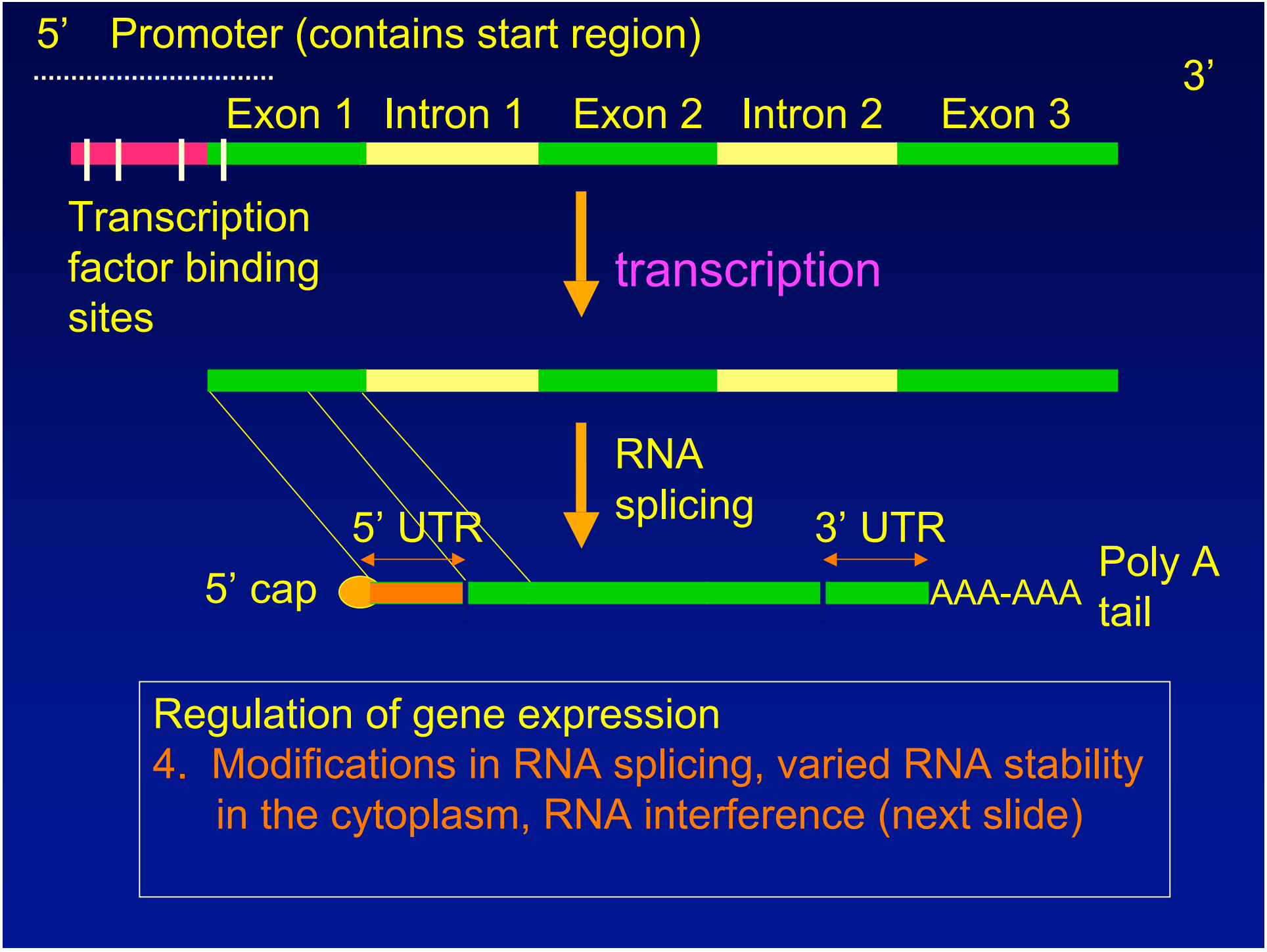


Transcription

Animations

http://www.dnai.org/a/index.html

Steroid nuclear receptors
http://stke.sciencemag.org/content/vol2004/issue256/images/data/pe51/DC1/STKE_Nuclear_Receptor_Animation.mov
(RNAPII is RNA polymerase II)

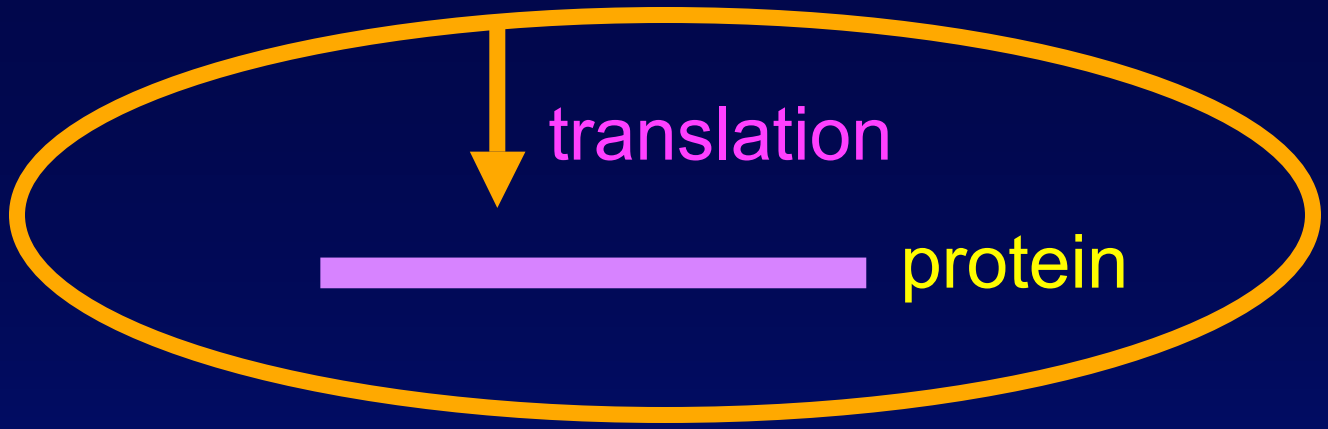


Regulation of gene expression

4. Modifications in RNA splicing, varied RNA stability in the cytoplasm, RNA interference (next slide)

RNAi – RNA interference

http://www.nature.com//focus/rnai/animations/animation/animation.htm



Regulation of gene expression

5. Post-translational regulation

- *Protein splicing*
- *Interactions between proteins and activators/repressors*
- *Protein targeting for degradation (proteasome)*

Translation animation

http://www.dnai.org/a/index.html

Proteasome animation

http://www.mlnm.com/clinicians/oncology/velcade/mechanism.asp

Regulation of gene expression

6. Signaling cascades: membrane receptors, signaling agents (cAMP), enzymes (MAP kinase, tyrosine kinases, RNA polymerase)

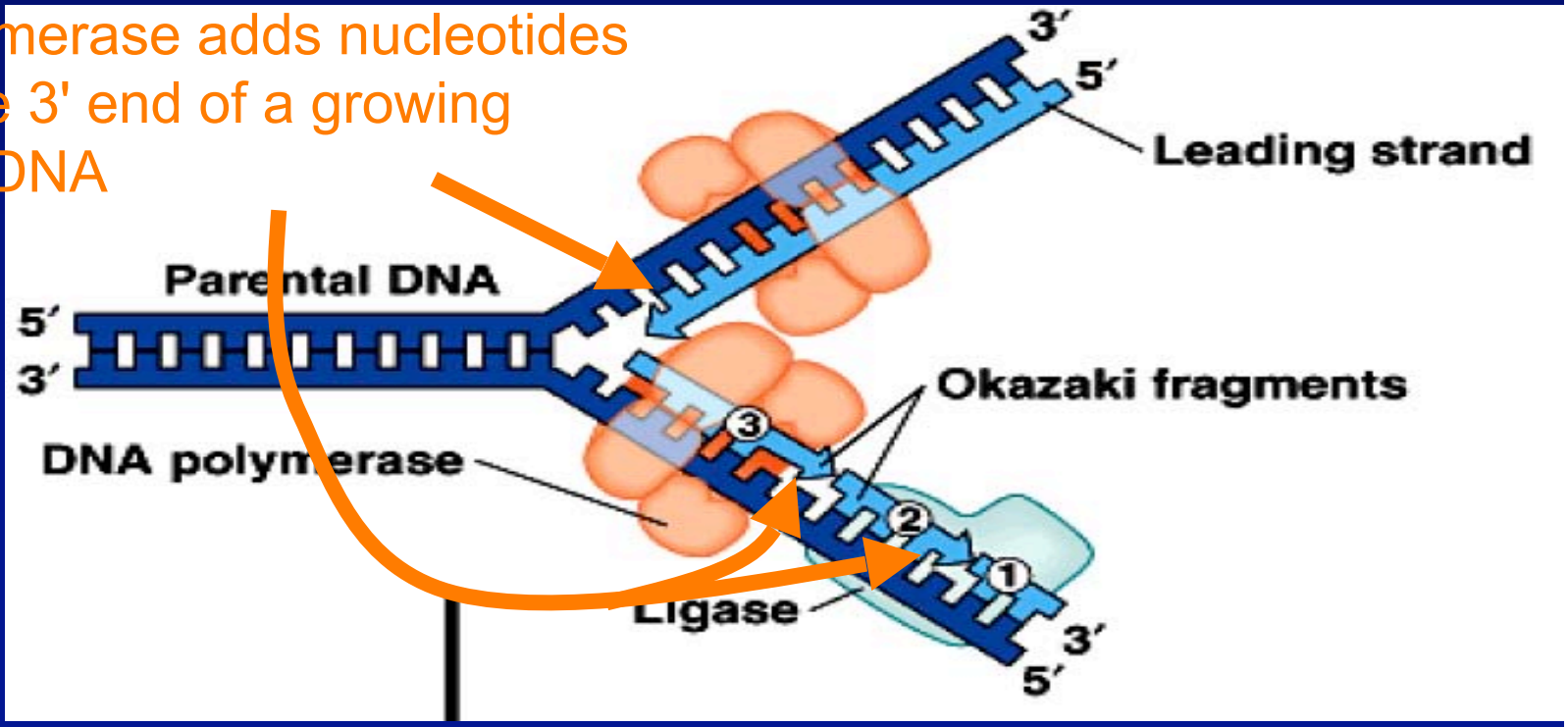
Animation

http://www-ermm.cbcu.cam.ac.uk/02004441h.htm

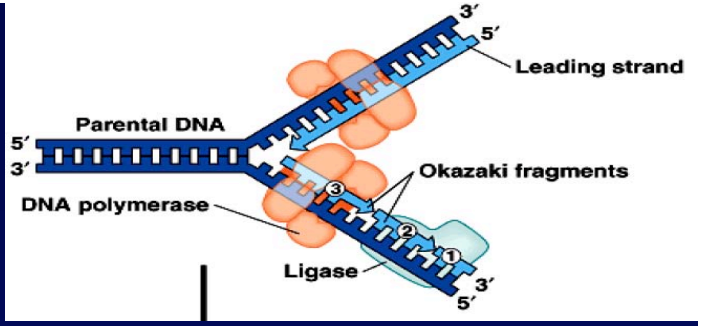
DNA Replication

- "Leading strand" – synthesis of new DNA occurs in the 5'→3‘ direction towards the replication fork
- "Lagging strand" - synthesis proceeds away from the fork – still 5'→3'

DNA polymerase adds nucleotides only to the 3' end of a growing strand of DNA



Steps of DNA replication



1. *Helicase* unwinds double-stranded DNA
2. *Single-stranded binding proteins* stabilize the single-stranded molecules (prevent the two strands from re-coiling)
3. *Primase* attaches the RNA primer
4. *DNA polymerase* extends the new strand (leading) or Okazaki fragment (lagging) from the 3' end of the RNA primer
5. A second *DNA polymerase* replaces the RNA primer with DNA
6. *Ligase* joins the Okazaki fragments of the lagging strand

Replication animation

http://www.dnai.org/a/index.html

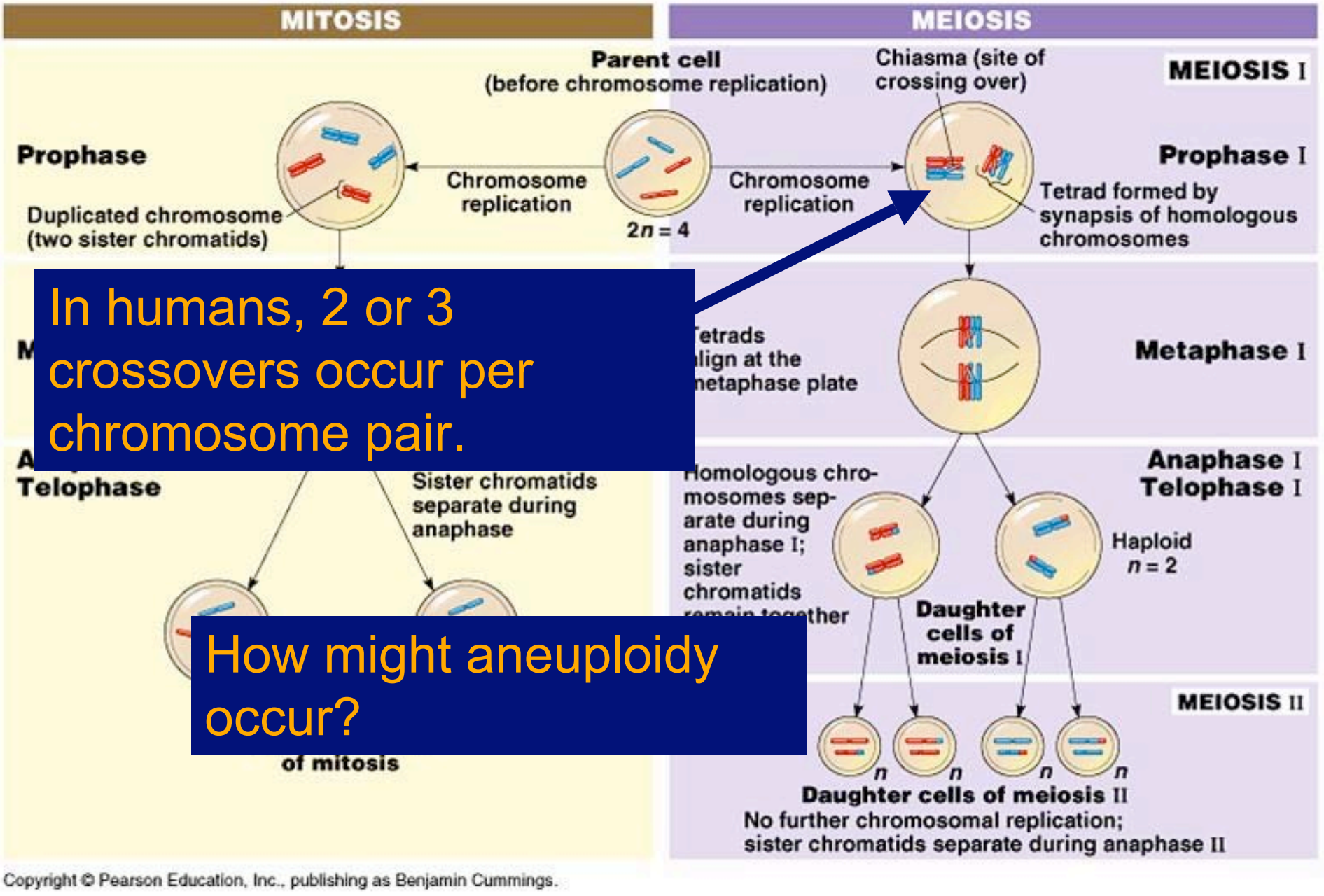
DNA Repair

1. DNA polymerase proof-reads as it replicates
2. Excision (removal) of short pieces of DNA containing mismatched base(s) – catalyzed by nucleases (DNA cutting enzymes)

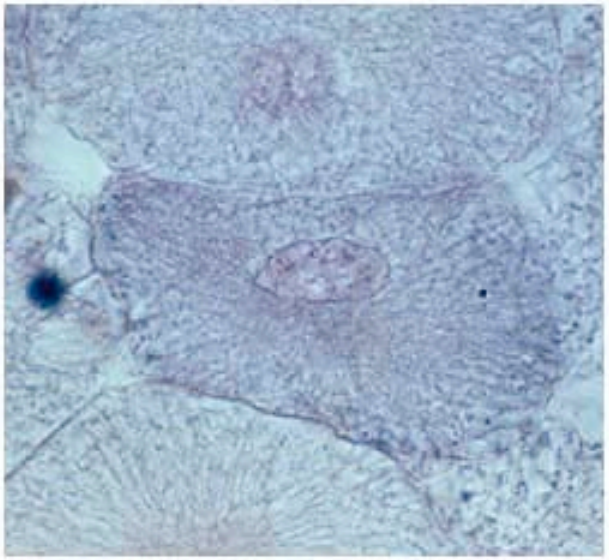
What other enzymes are needed for nucleotide excision repair?

DNA polymerase – adds bases

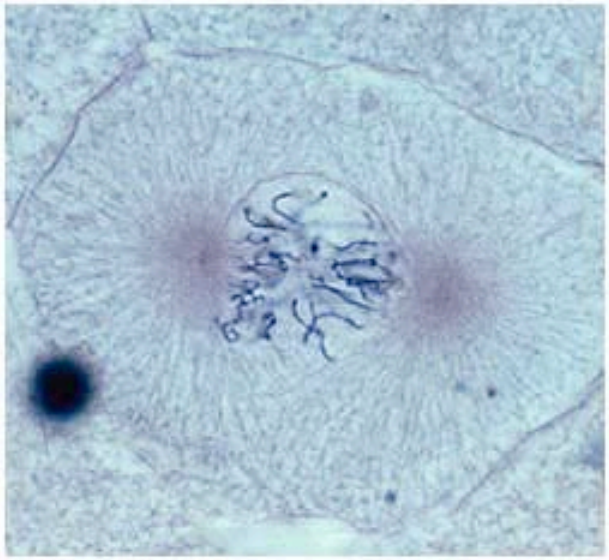
Ligase – glues ends of DNA together



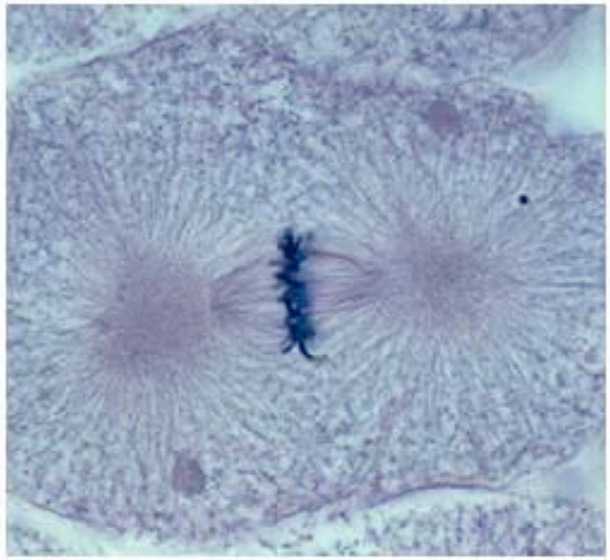
Comparison of meiosis and mitosis



Interphase

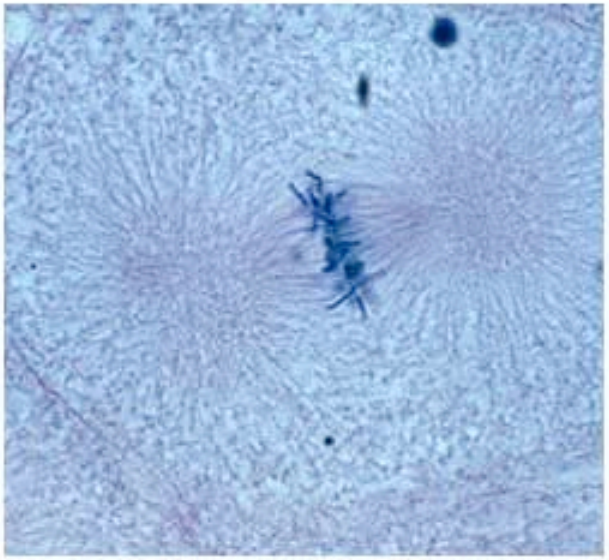


Prophase

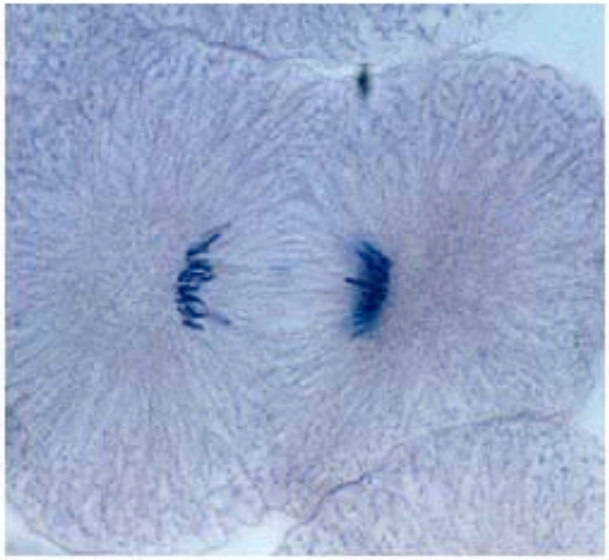


Metaphase

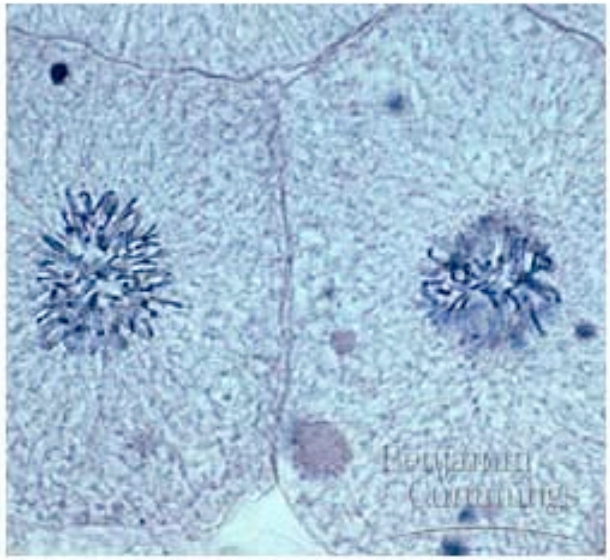
mitosis



Anaphase



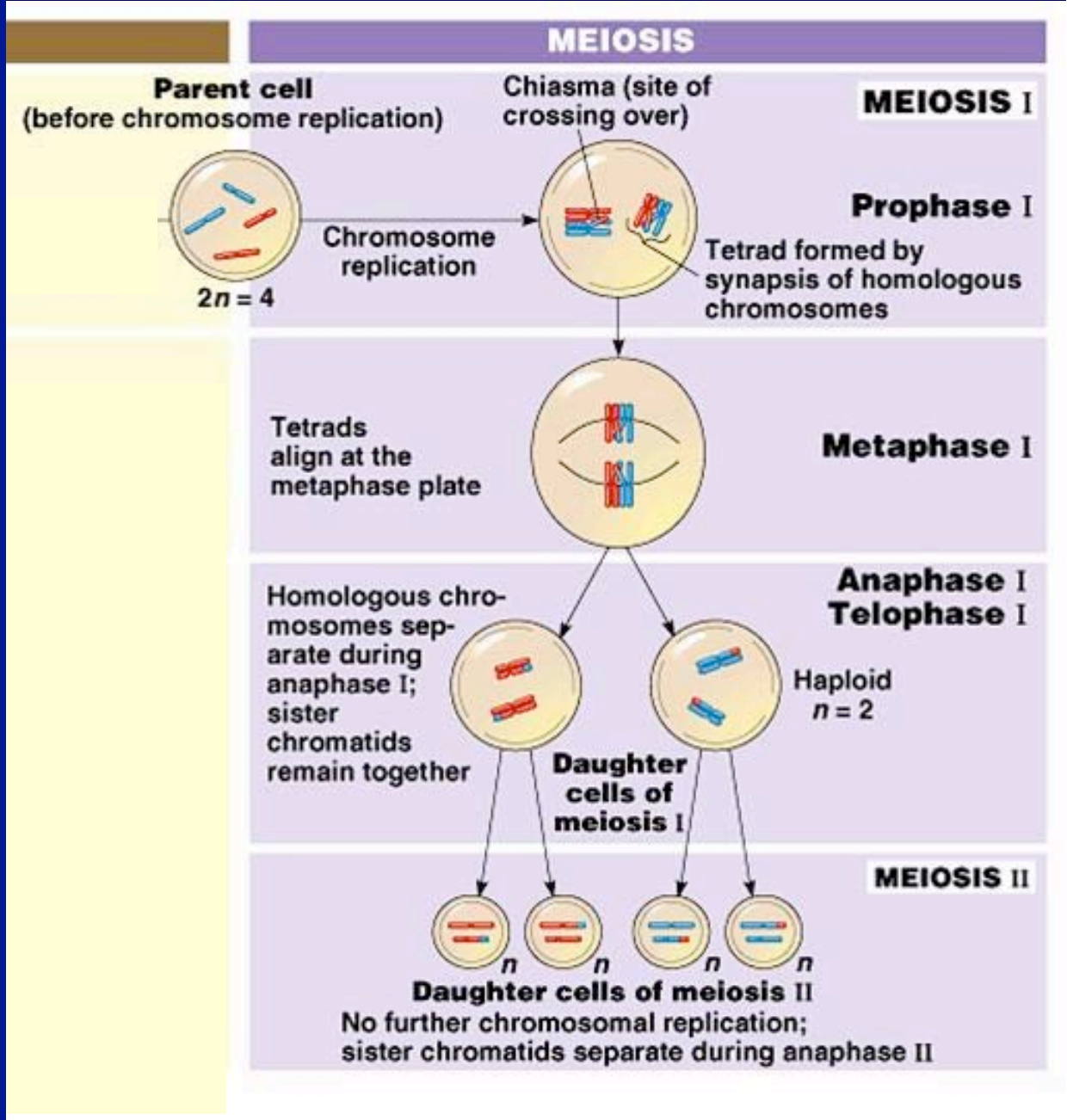
Early Telophase



Late Telophase

Immediate Benefit Hypothesis

- (Bernstein and Bernstein, 1991)
- Breaks/lesions in DNA molecule can be repaired during chromosome replication
- Because DNA polymerase proofreads as it replicates DNA



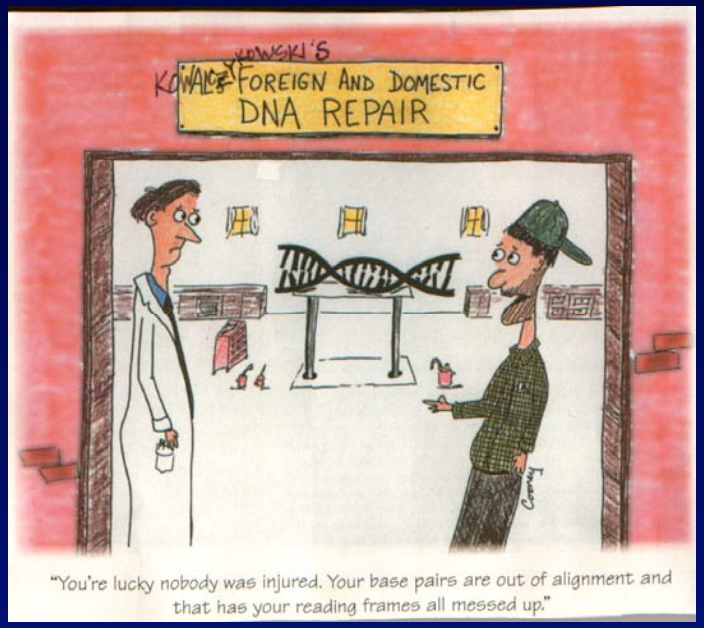
Immediate Benefit Hypothesis

- Immediate benefit hypothesis
  - (Bernstein and Bernstein, 1991)
  - Molecular recombination facilitates DNA repair
    - Breaks/lesions in DNA molecule can be repaired by copying homologous chromosome (chromosome replication), because DNA polymerase proofreads as it replicates DNA
  - Formation of new gene combinations are a by-product of DNA repair
    - not reason for evolution of recombination/sex

One possible evolutionary path to sexual reproduction

1. DNA repair → 2. Mitotic recombination → 3. meiosis → 4. Sexual reproduction

Problem?



"You're lucky nobody was injured. Your base pairs are out of alignment and that has your reading frames all messed up."

- DNA repair does not require meiosis or syngamy
- Permanent diploid species exist - thus can repair DNA without the above
- Origin of recombination could have been a response driven by need for DNA repair
  - but what about meiosis & syngamy?