General Biology 1
BIO1101
Syllabus & Textbook: http://goo.gl/rvgdrH

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Email: mgotesman@citytech.cuny.edu

Letter Grade	Numerical Ranges
A	93-100
A-	90-92.9
B+	87-89.9
B	83-86.9
B-	80-82.9
C+	77-79.9
C	70-76.9
D	60-69.9
F	59.9 and below

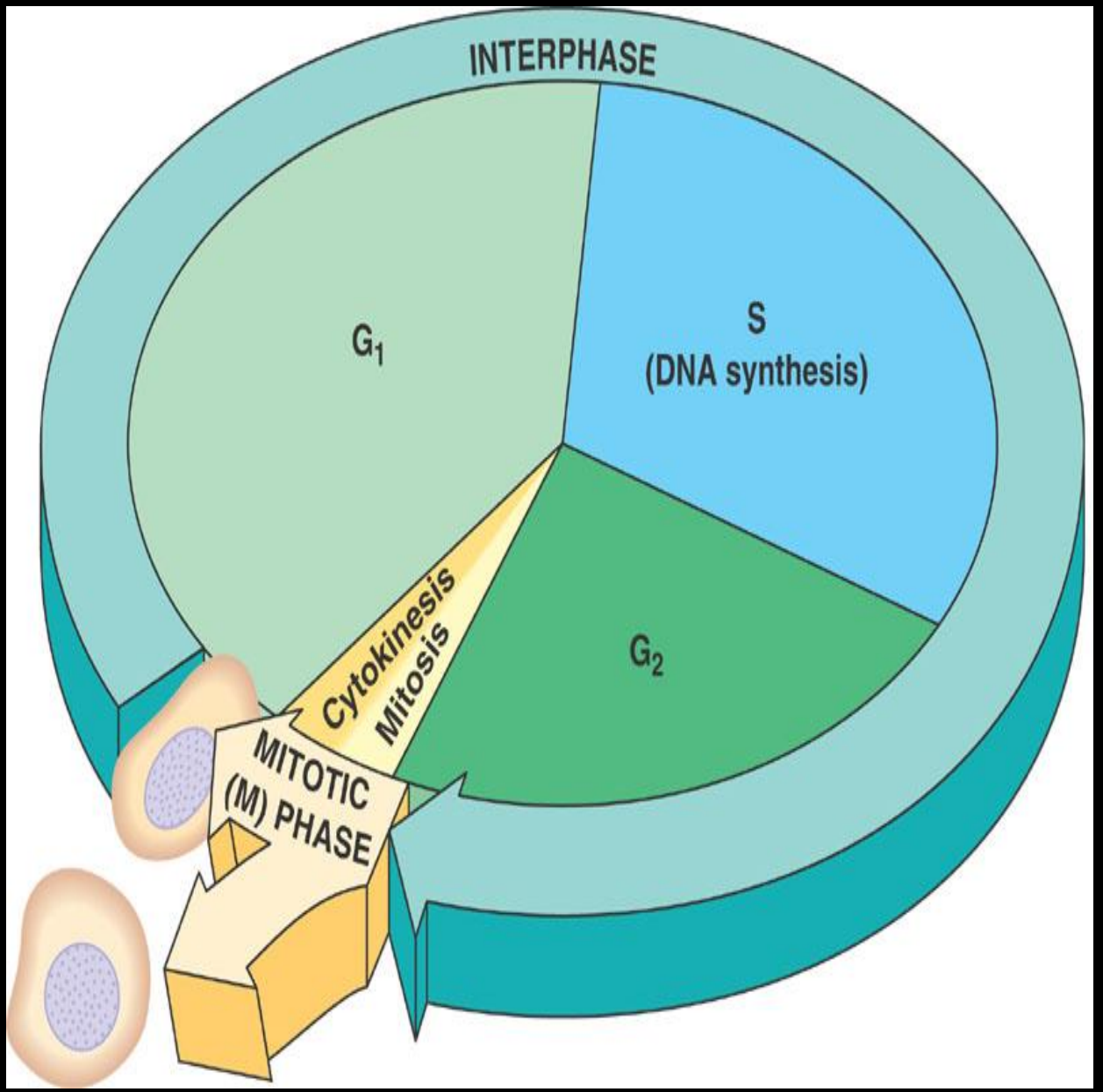
OER

Lecture:https://openlab.citytech.cuny.edu/bio-oer/page/2/
Lab: https://openlab.citytech.cuny.edu/bio-oer/

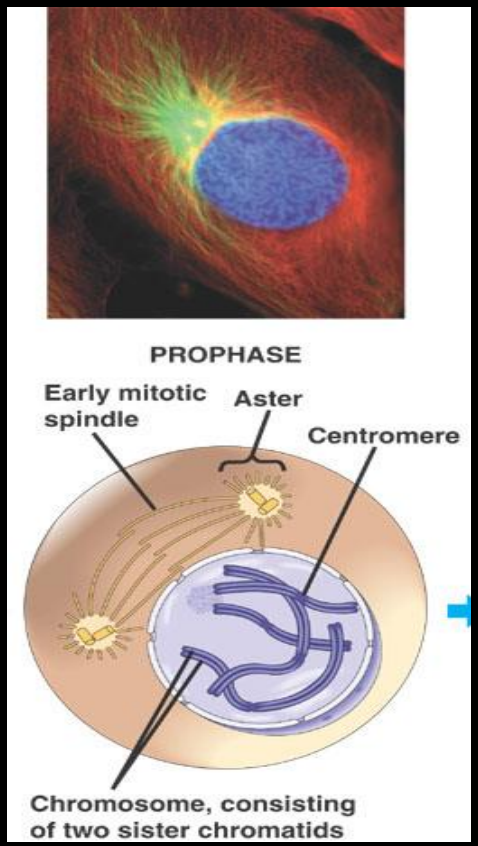
Grade Breakdown:

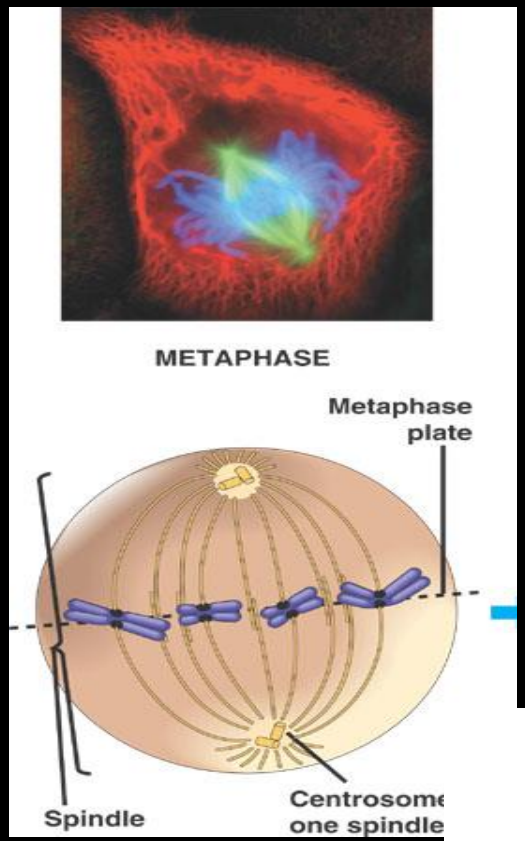
Exams (4): 20% Each
Quizzes: 20% Average

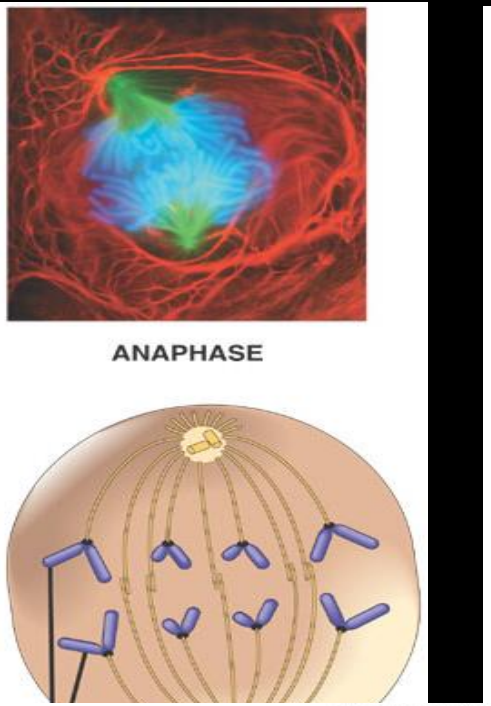
The Cell Cycle

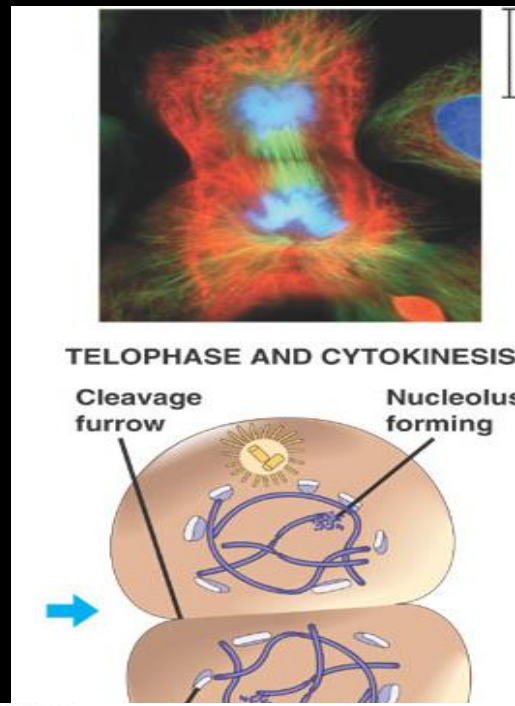


Mitosis

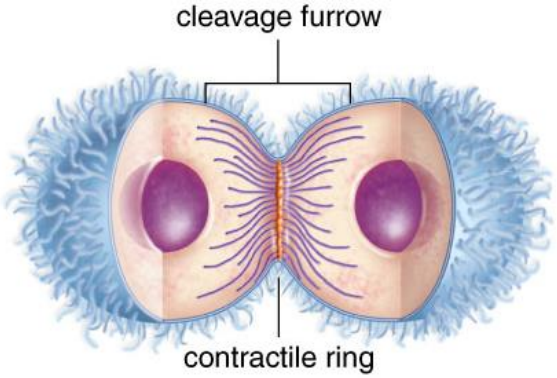


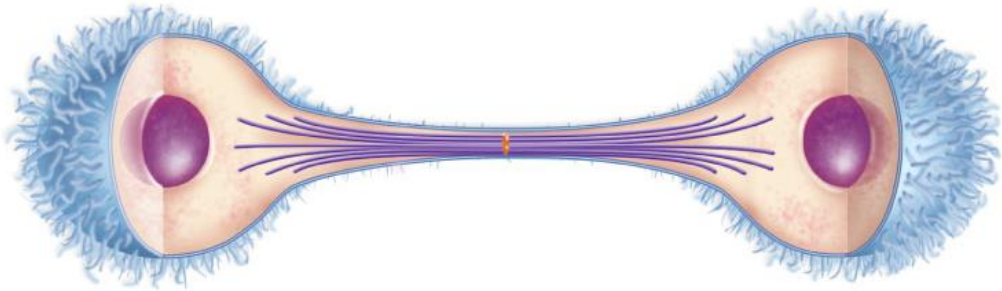






Cytokinesis →





Chromosomes

- What are Chromosomes and why do we care if they move apart?
- Chromosomes are the physical basis of inheritance (brown hair or anything else)
- **Locus** – the physical location of a gene (trait) on a chromosome (plural = loci)

Mitotic chromosome:

Each chromosome has 2 arms

- p – short arm (p for petit)
- q – long arm (q for queue)

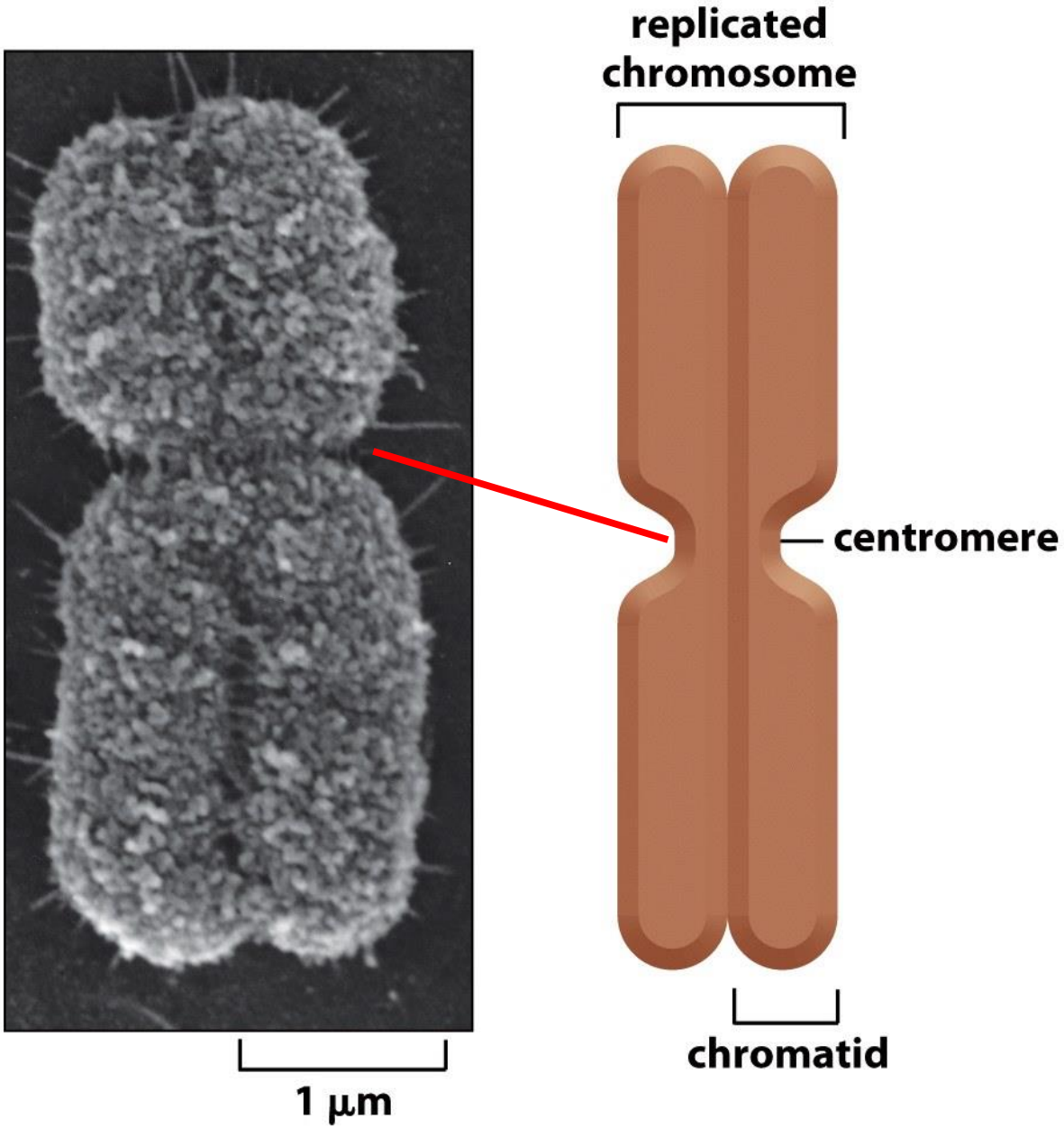
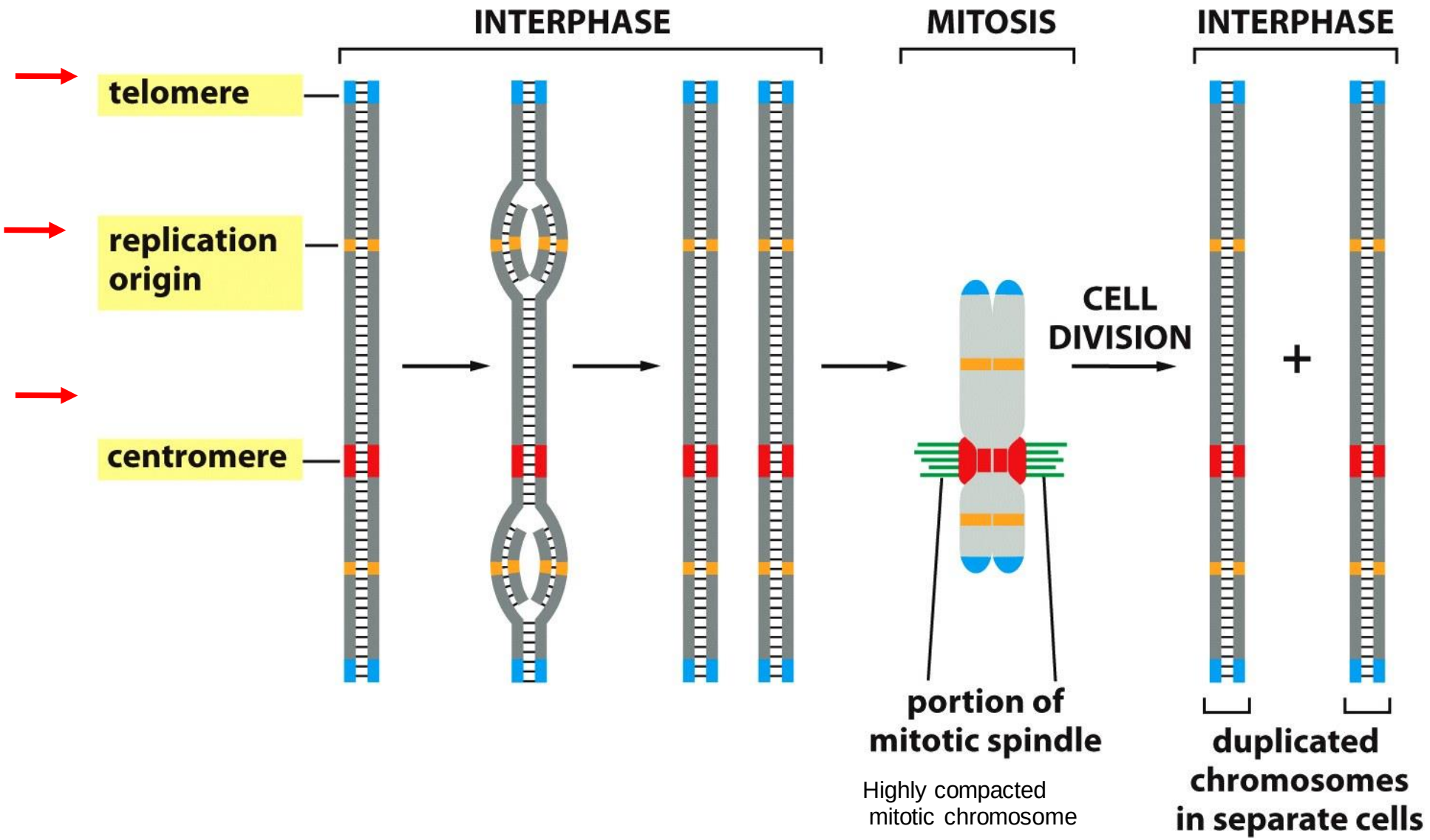


Figure 5-17 *Essential Cell Biology* (© Garland Science 2010)

Three specialized sequences that play role in DNA replication



(1 Telomere for each end)

Figure 5-16 *Essential Cell Biology* (© Garland Science 2010)

Karyotype – arrangement (by length) of a person's chromosomes, longest to shortest, (sex chromosomes last).

Humans : 23 pairs of chromosomes:

22 pairs of **autosomes** (non-sex)

1 pair of sex chromosomes (X and Y)

- XX = female, male = XY
- Thus, X chromosome is *essential*,
- Y is not
  - X is large,
  - Y is very small (diminutive)

So Total = 23 pairs, (n=23)

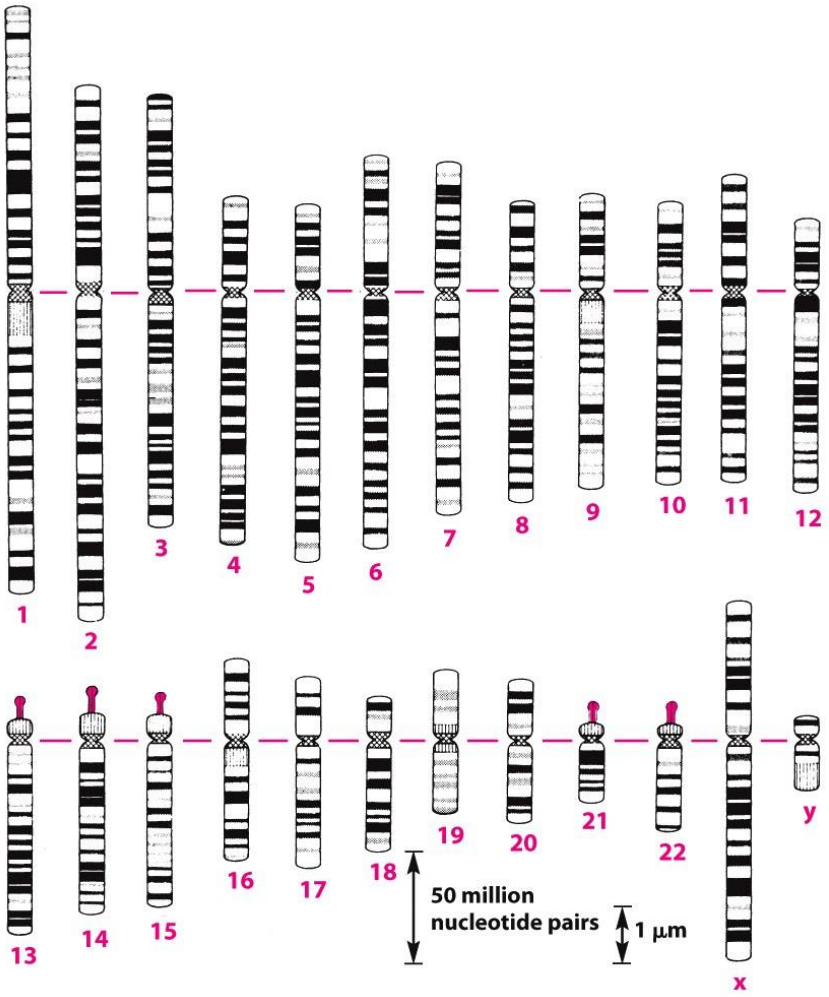
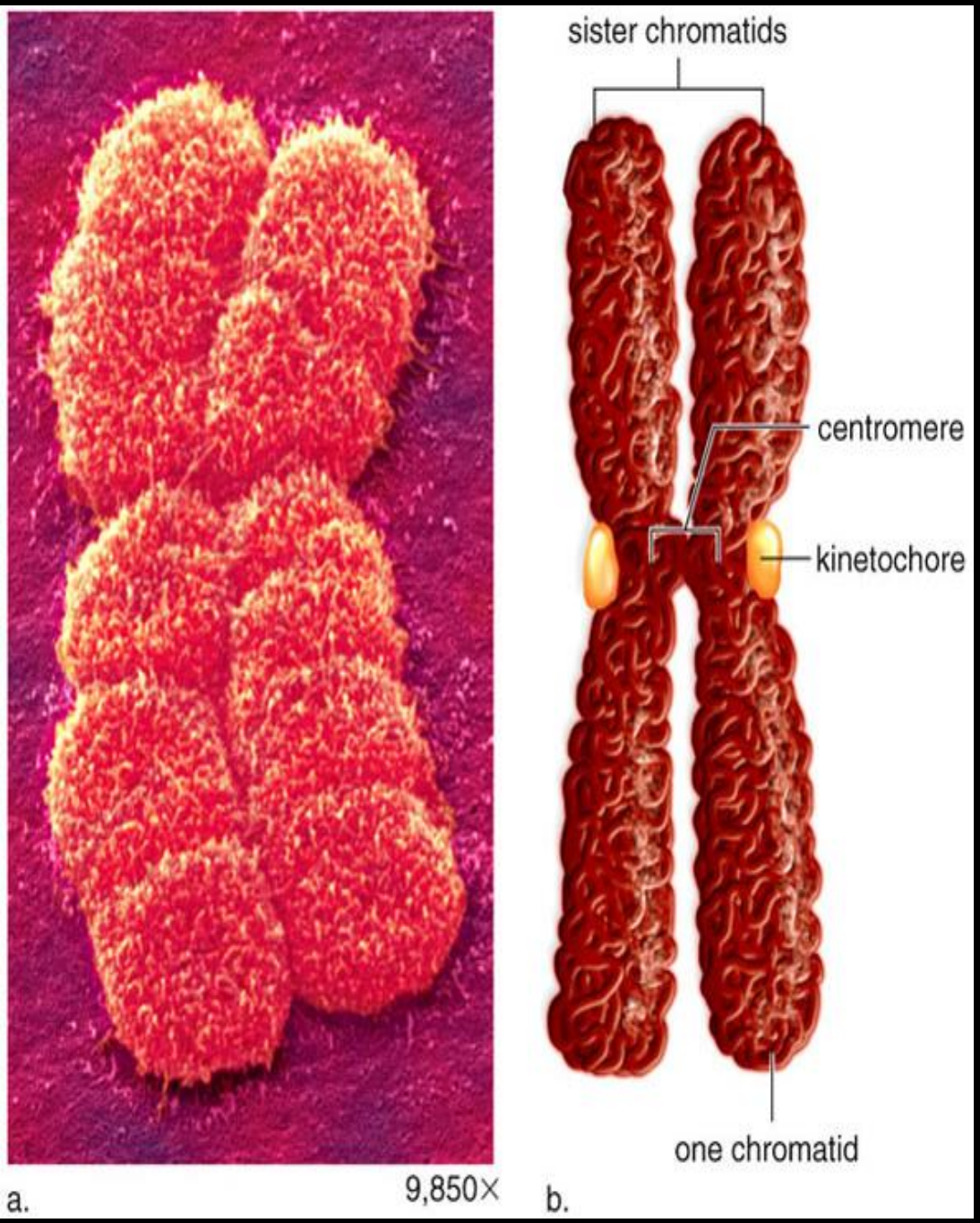
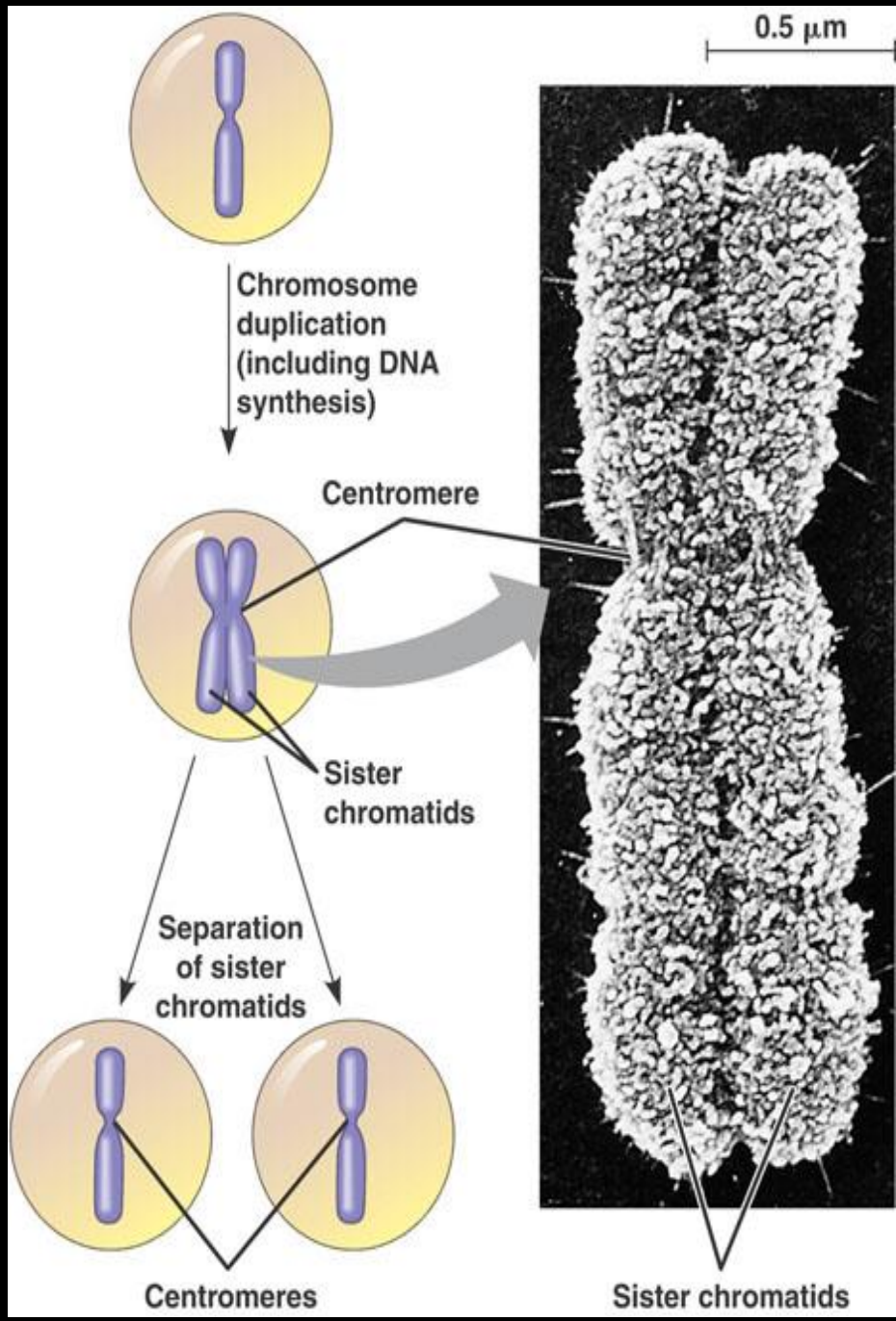


Figure 5-11 *Essential Cell Biology* (© Garland Science 2010)

Duplicated Chromosome





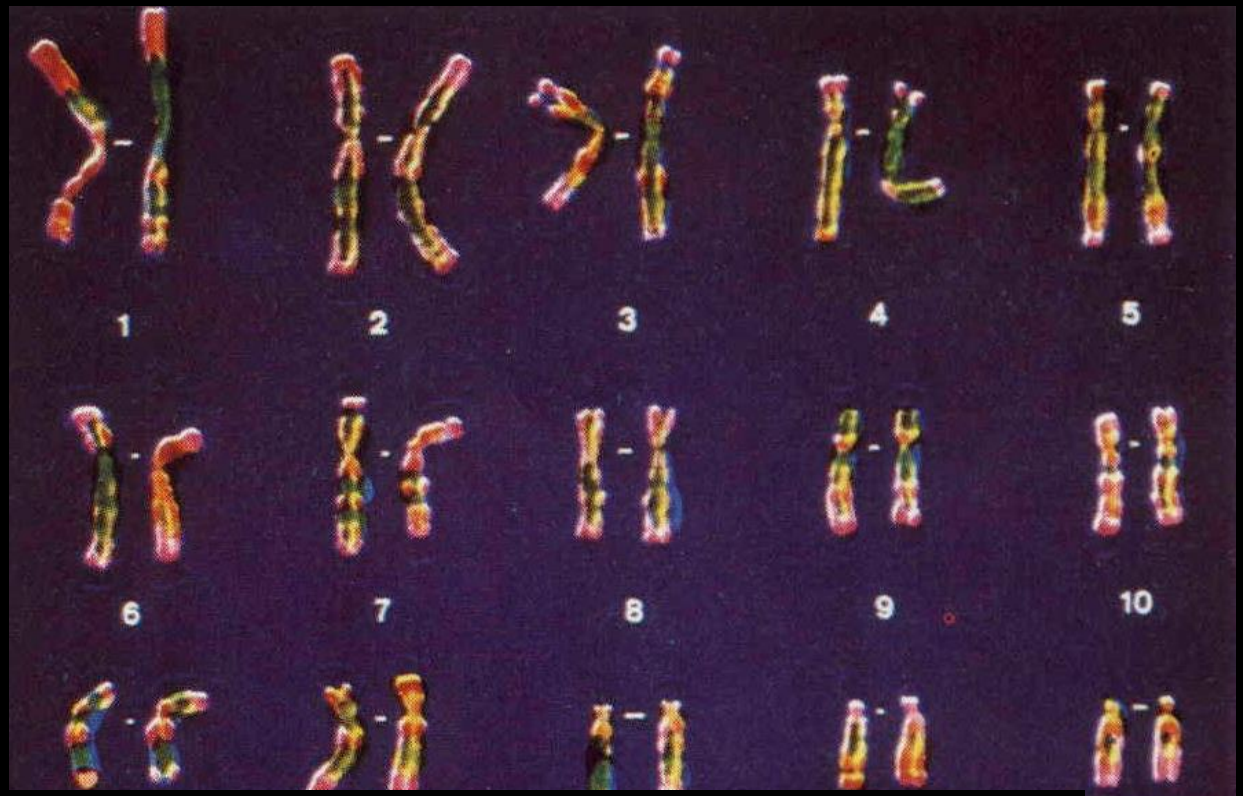
A karyogram

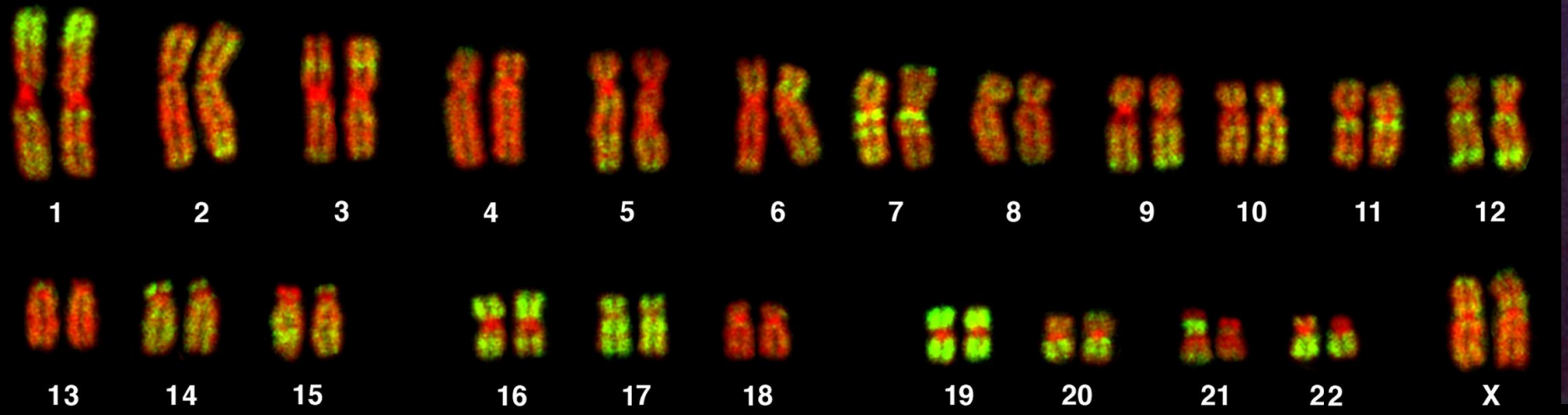
Chromosome:

- Chroma: color
- Soma: body

23 – Chromosomes
~23,000 Genes

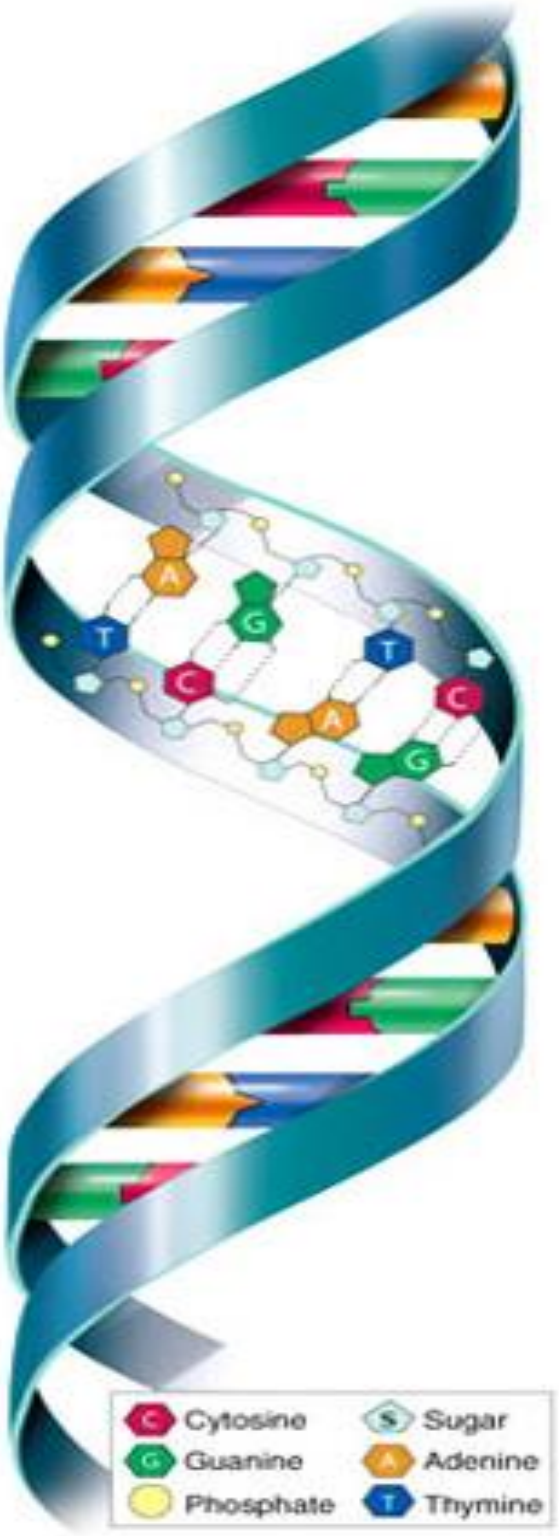
What are genes made of?





The DNA double helix

- Two polymers (strands) line up, then form a **double helix (twisted ladder)**
- The sides of the ladder are the **sugars** and the **phosphate** groups
- The "rungs" of the ladder are the **Nitrogen** bases
- The **bases hydrogen bond** to each other in a specific way called "**base pairing**"



Interphase chromosome from lysed nucleus (SEM)

interphase DNA/Chromosome
is very condense- 500X

Compared to

Mitotic DNA **10,000X !**

- Human DNA can stretch for 2 meters
- A nucleus is between 5-8 micrometers in diameter
- Micro = 10^{-6}

- *How DNA is packed into a cell???*

- *What is the mechanism for DNA compaction?*

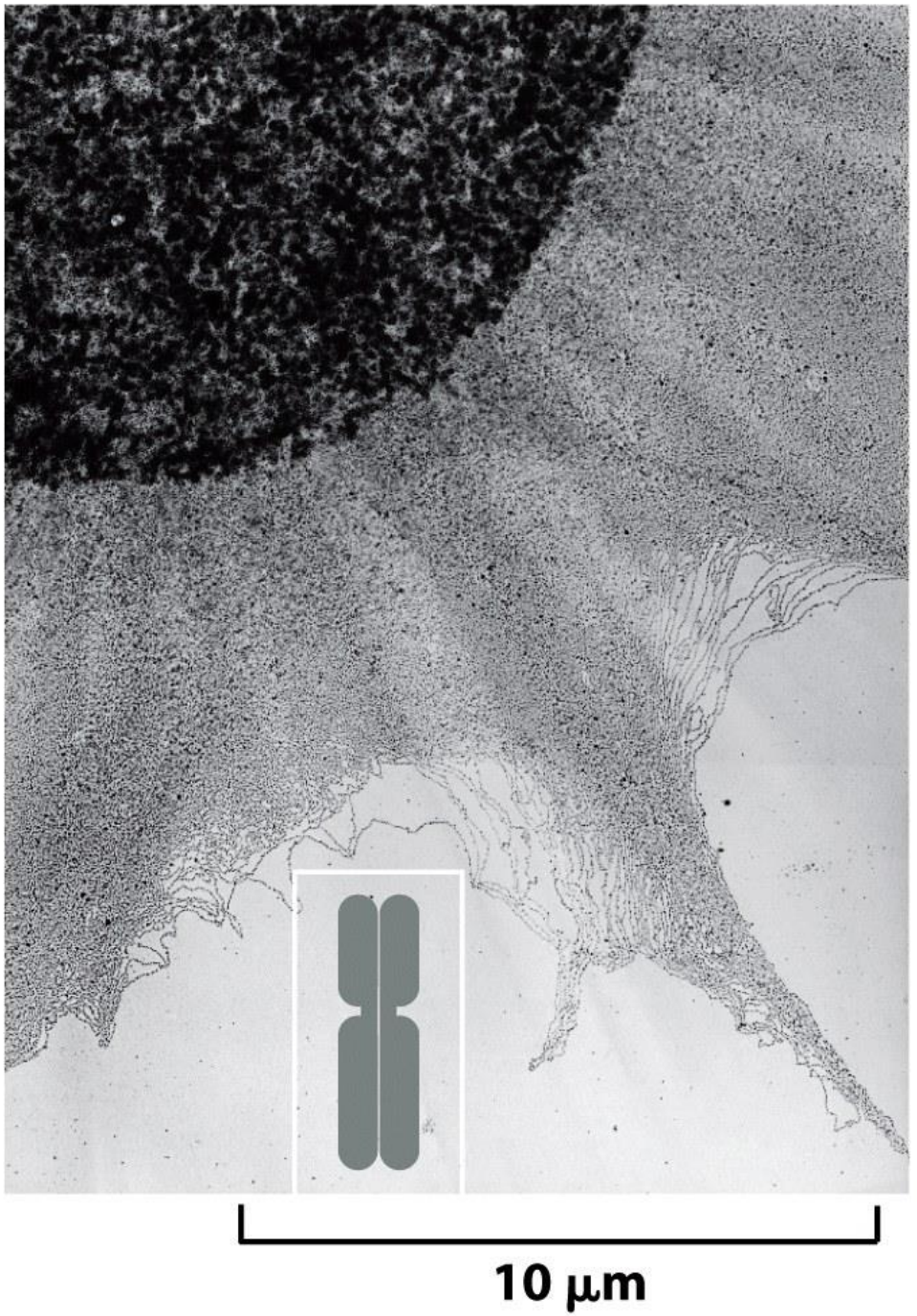
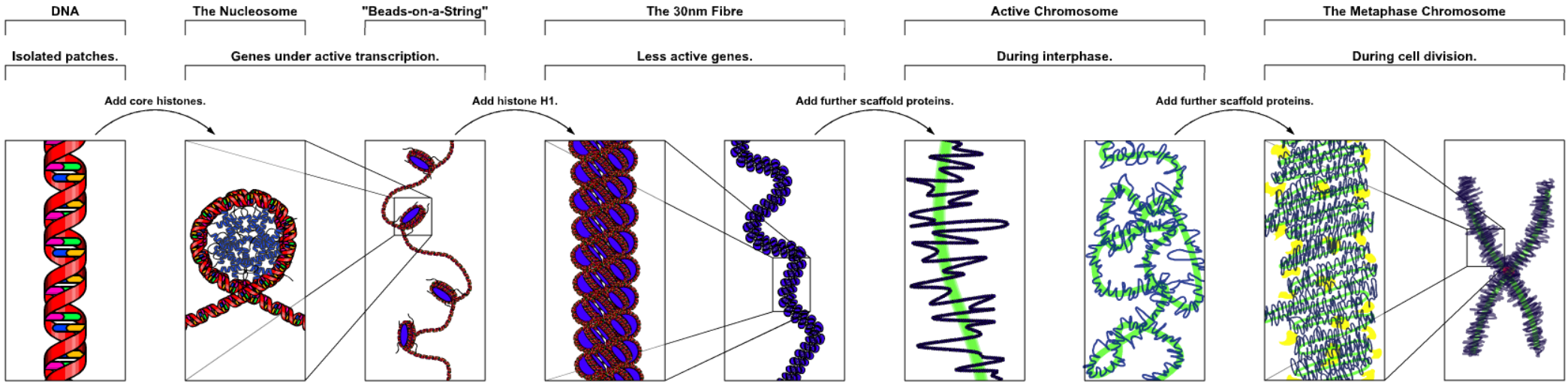
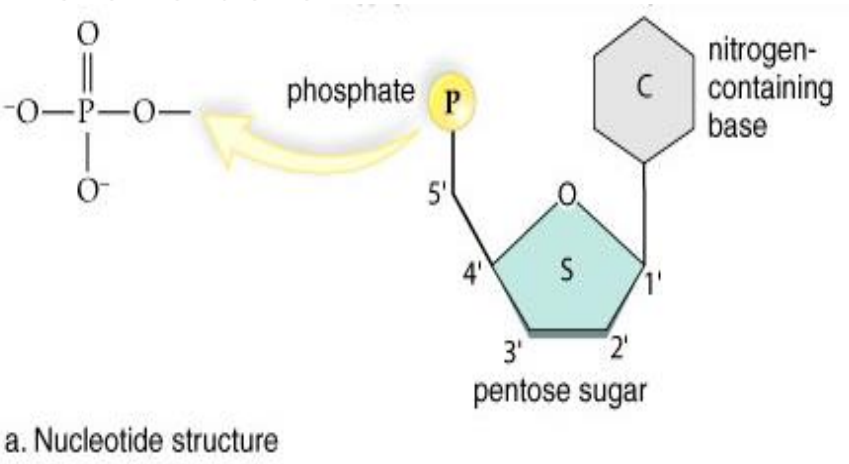


Figure 5-20 *Essential Cell Biology* (© Garland Science 2010)

Chromosomes: Structure

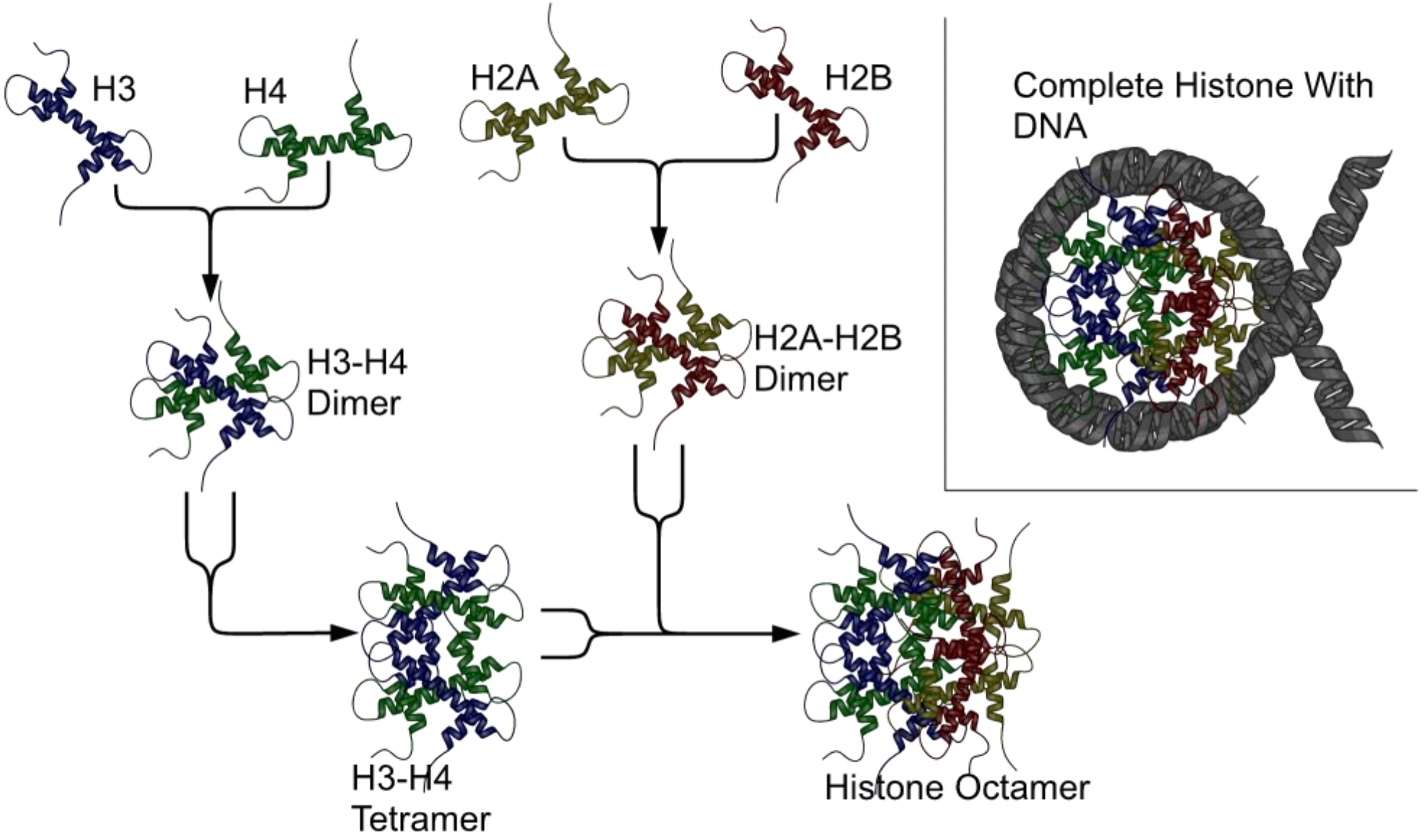


- Chromosomes consist of highly compacted DNA (Genetic Code)
- **DNA** is negatively charged → Phosphate (PO_4^-) backbone
- **Histones** are positively charged proteins that associate with eukaryotic DNA
- **Nucleosomes** are basic units of chromatin structure of DNA (~150 DNA double stranded particles) wound around a histone core



a. Nucleotide structure

Nucleosome Core Particle – Histone Octamer

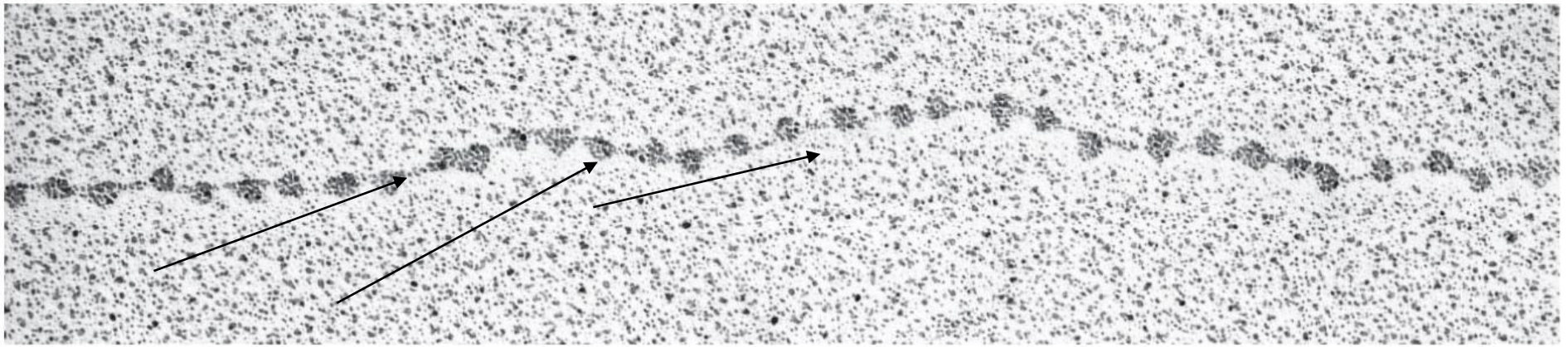


First Level of DNA Compaction (11 nm particle)

~150 bp of DNA (2 nm) wrap around a Histone core

Histone Core -- 2X (H2A, H2B, H3, H4) → 8 proteins in total

"Beads on a string" -- ~6x compaction



Chromatin = DNA plus proteins called histones

Nano = 10^{-9}

30nm chromatin fiber- Role of H1 histone (linker histone)

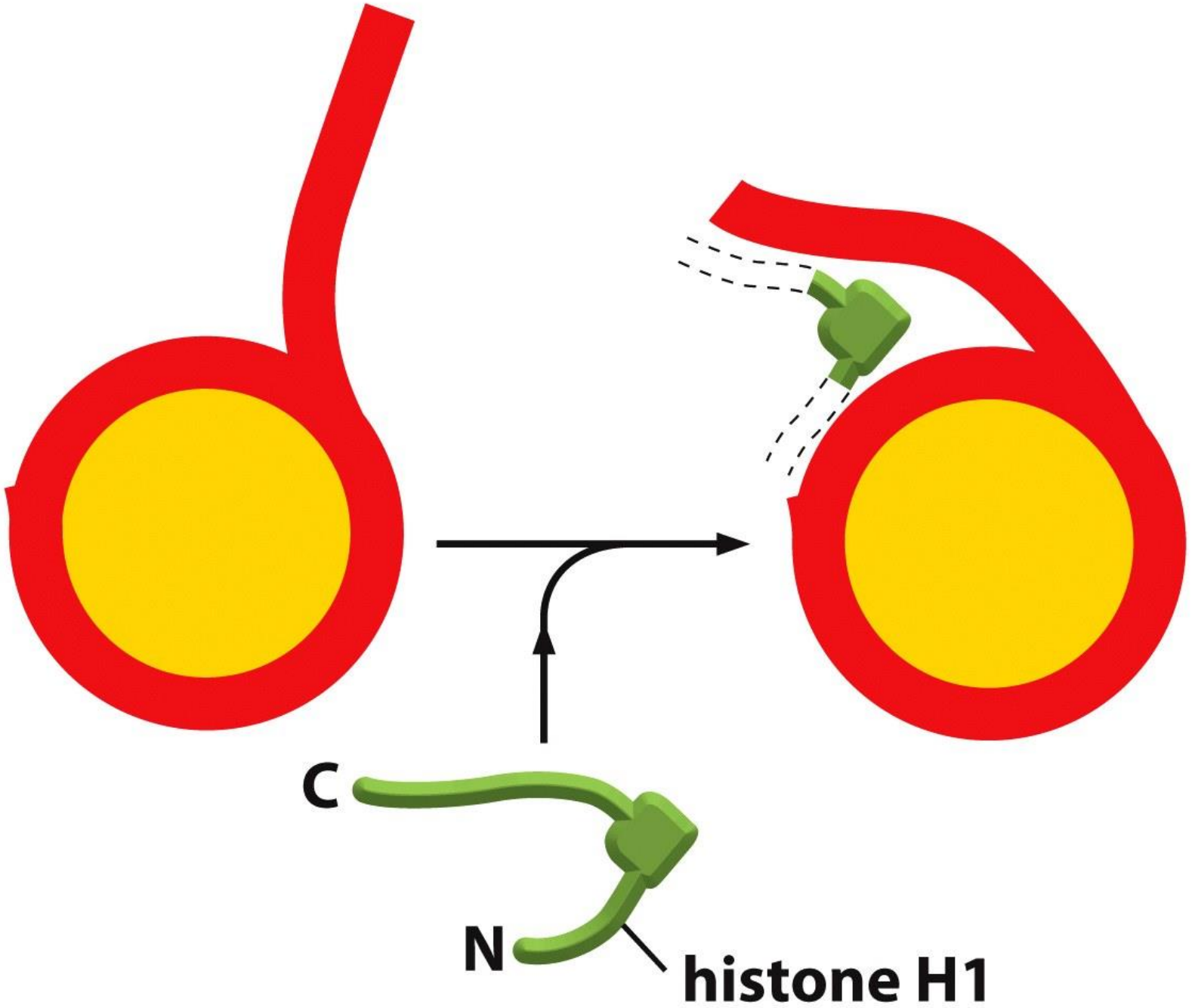
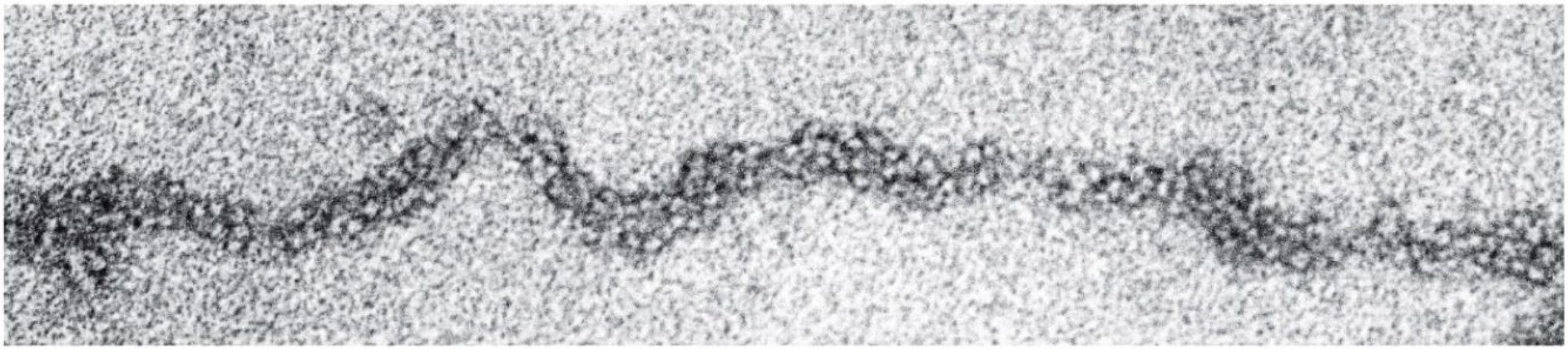


Figure 5-24 *Essential Cell Biology* (© Garland Science 2010)

Second Level of Compaction – Chromosome Fibers (40X)

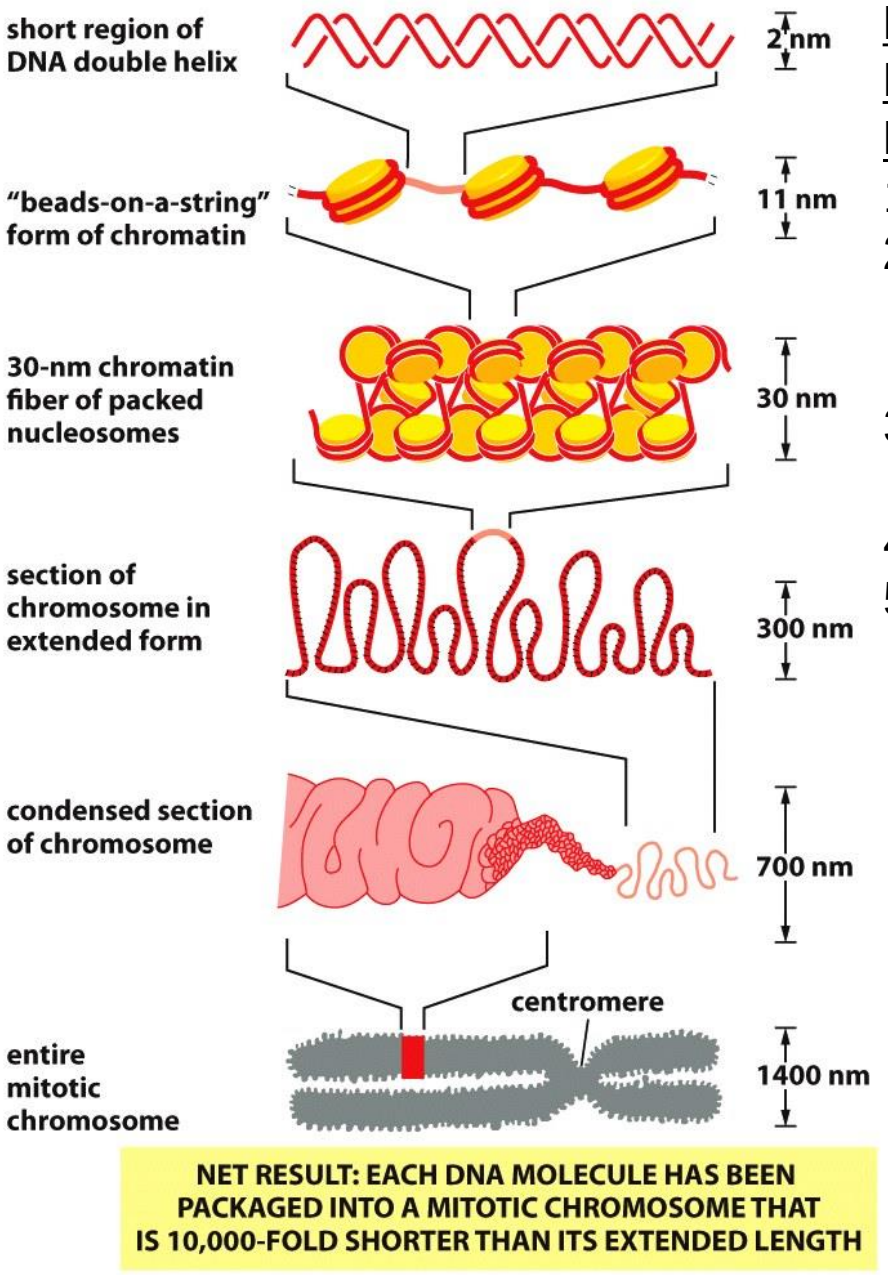


30nm

A) packed chromatin (Uses H1 + Histone Core)

Figure 5-21 *Essential Cell Biology* (© Garland Science 2010)

Mitosis requires More packing



DNA Compaction:
Histone Core Complex: Octomer (2- H2A, H2B, H3, H4)

1. DNA double helix – 2 nm
2. Nucleosome "Beads on a string" – 11 nm (~200 bp)
   147 bp (1.65 turns) around histone core (6X compaction)
3. Chromatin fiber – 30 nm (H1) --- Total (40X compaction)
4. Loops (300 nm) --- Total (500X compaction)
5. Chromatid 700 nm --- Total (10,000X compaction)

What about during interphase?

Figure 5-25 *Essential Cell Biology* (© Garland Science 2010)

Interphase chromosomes occupy distinct segments of nucleus

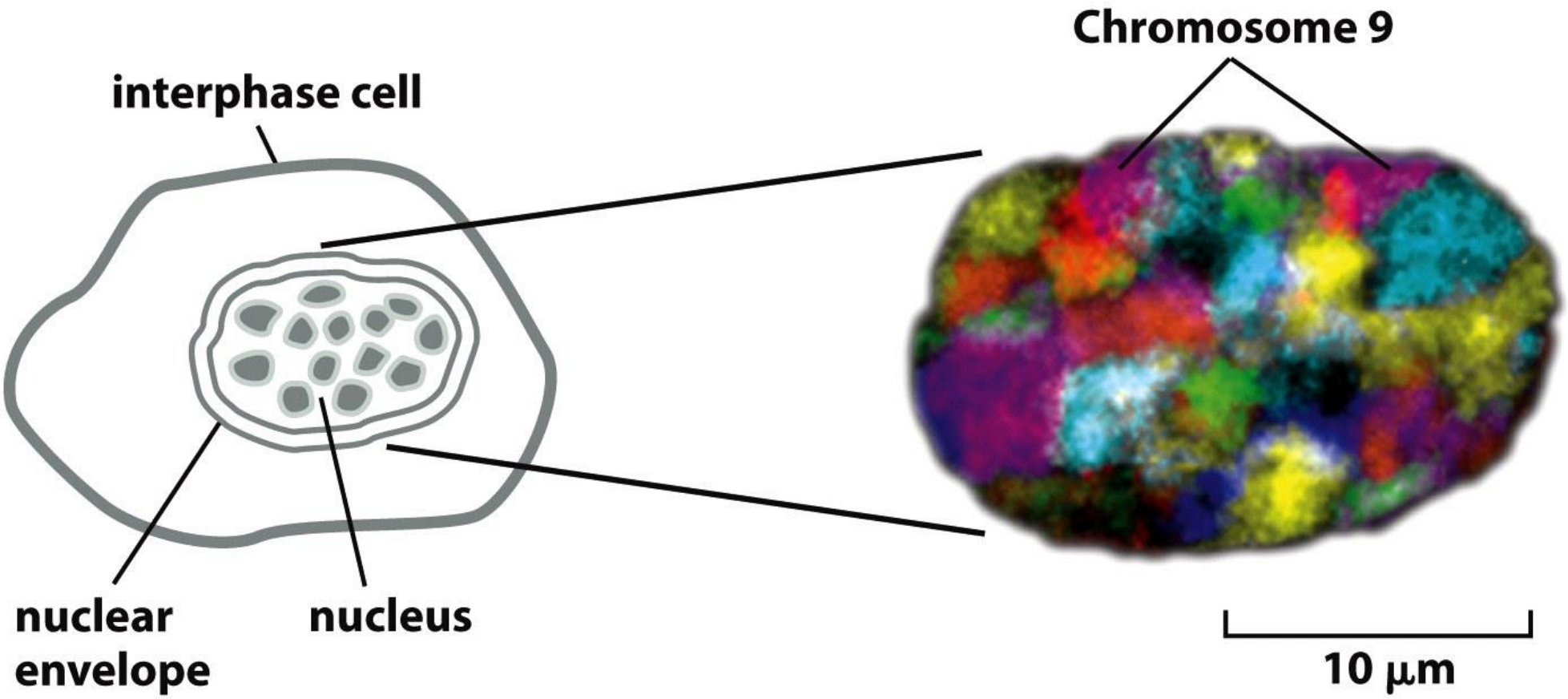
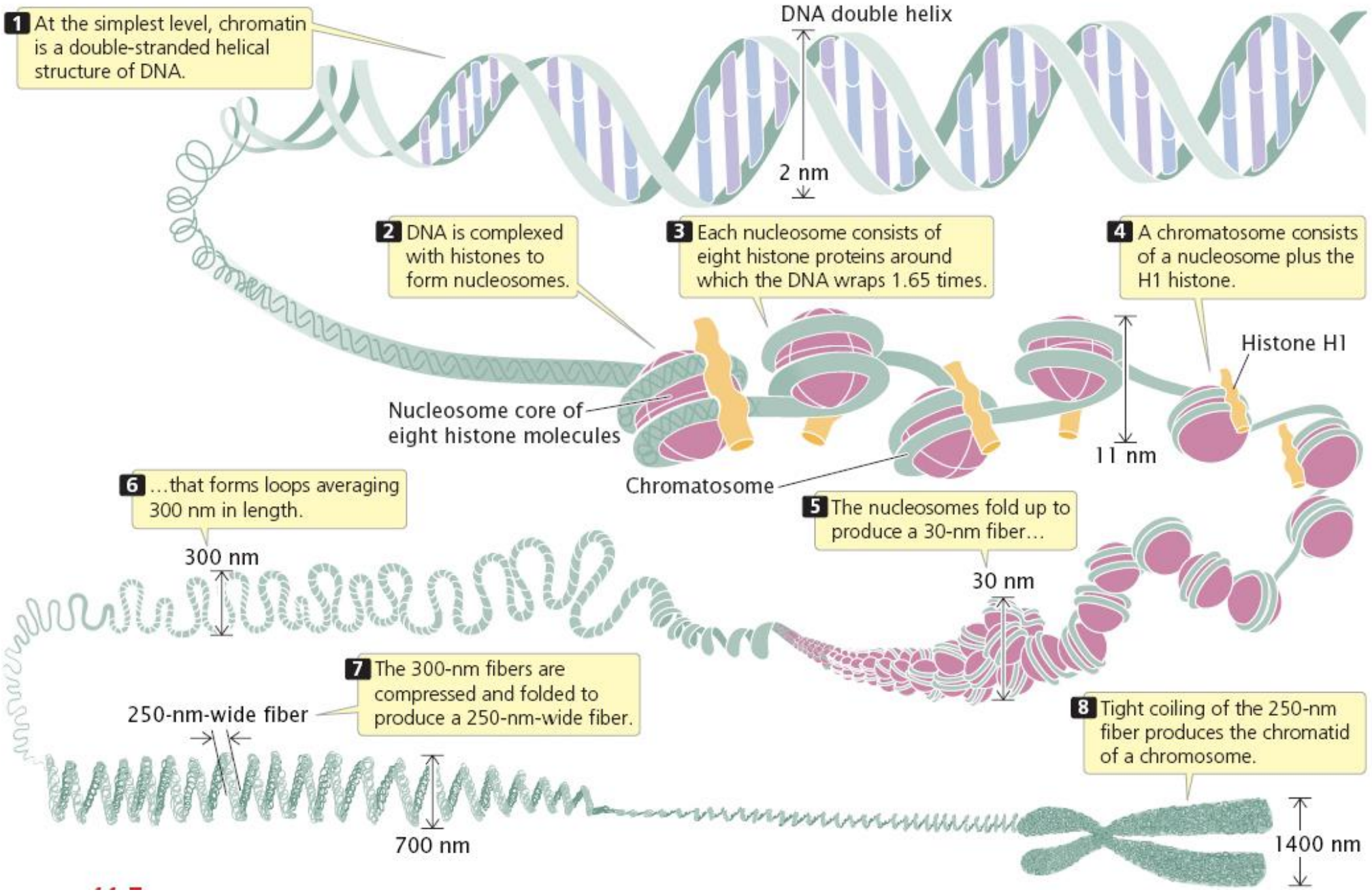
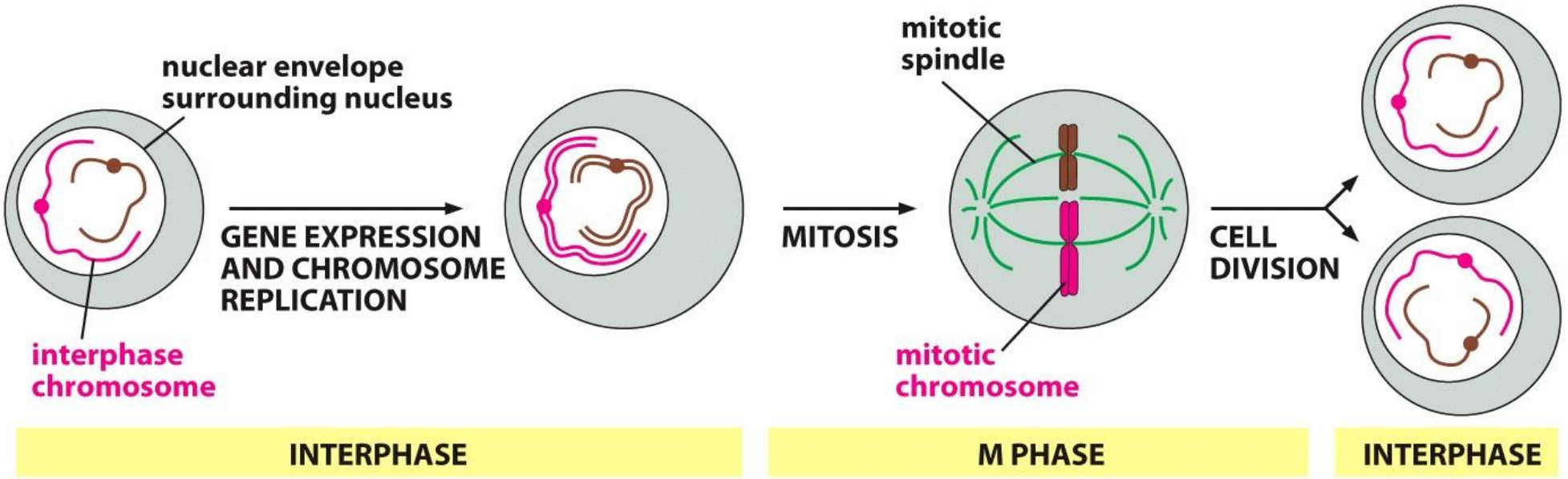


Figure 5-18 *Essential Cell Biology* (© Garland Science 2010)

http://www.nature.com/scitable/topicpage/dna-packaging-nucleosomes-and-chromatin-310



Different states of chromosome compaction during cell cycle



Chromatin and chromosomes

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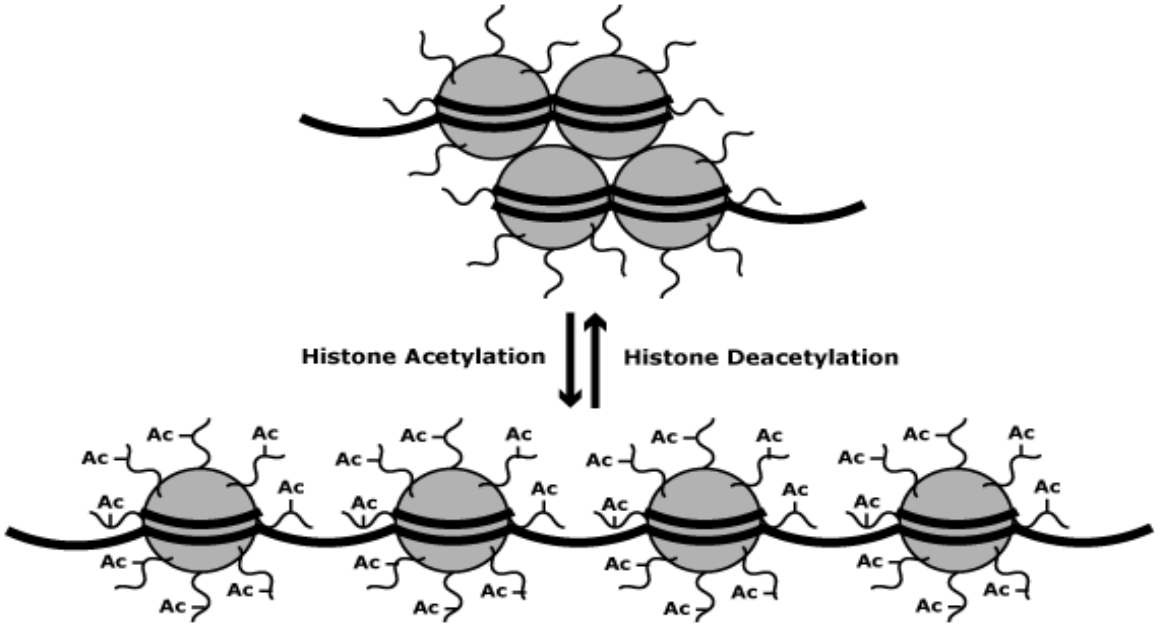
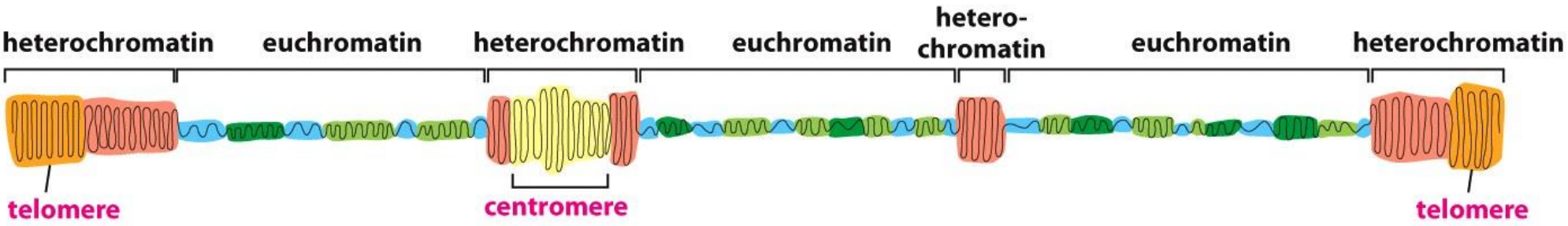
Who cares about DNA compaction?



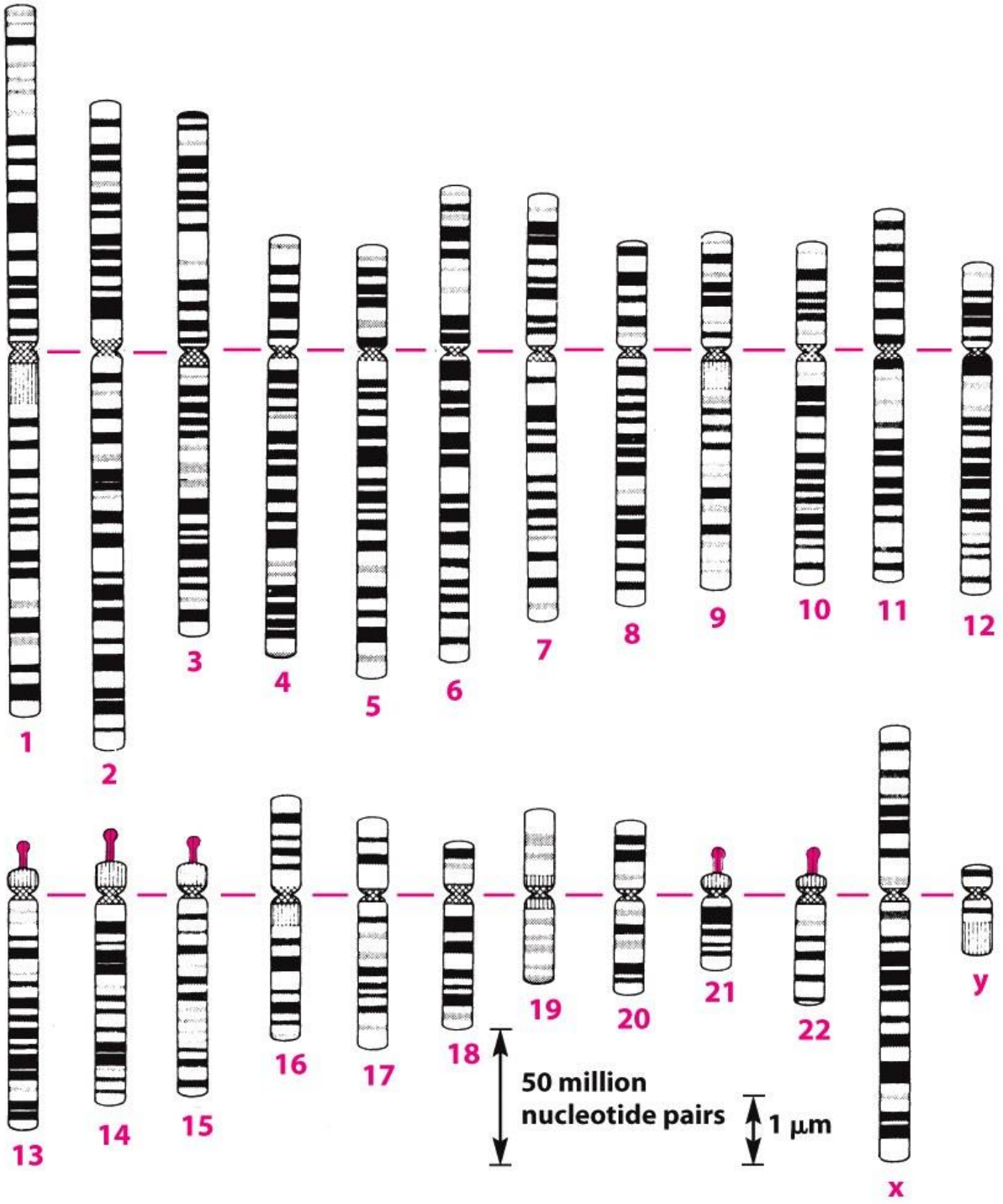


Heterochromatin: condensed chromatin. So condensed genes within cannot be expressed.

The rest of the chromosome is called: **Euchromatin** (true chromatin).

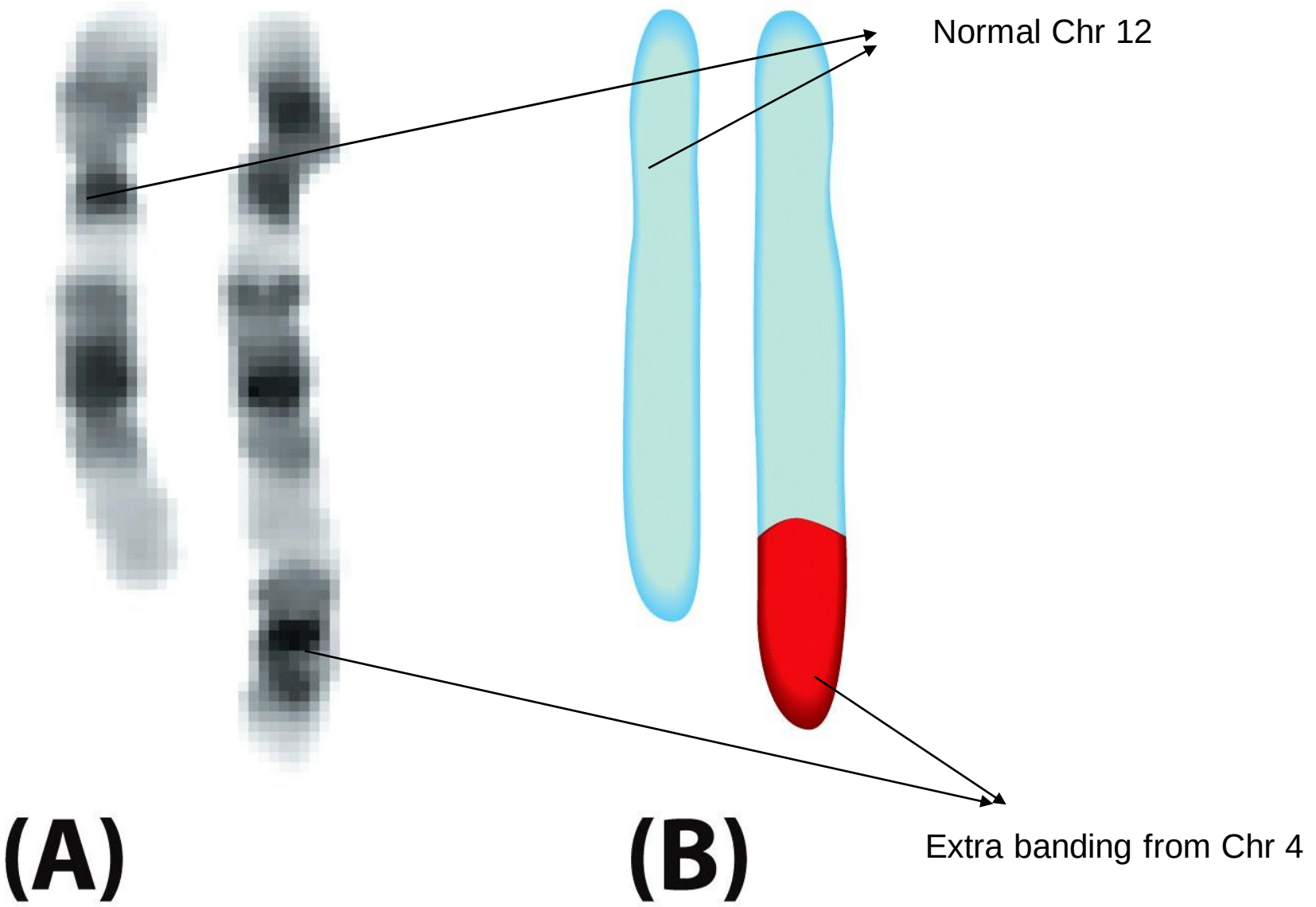
Figure 5-31 *Essential Cell Biology* (© Garland Science 2010)

Human Chromosomes



Abnormal Karyotype

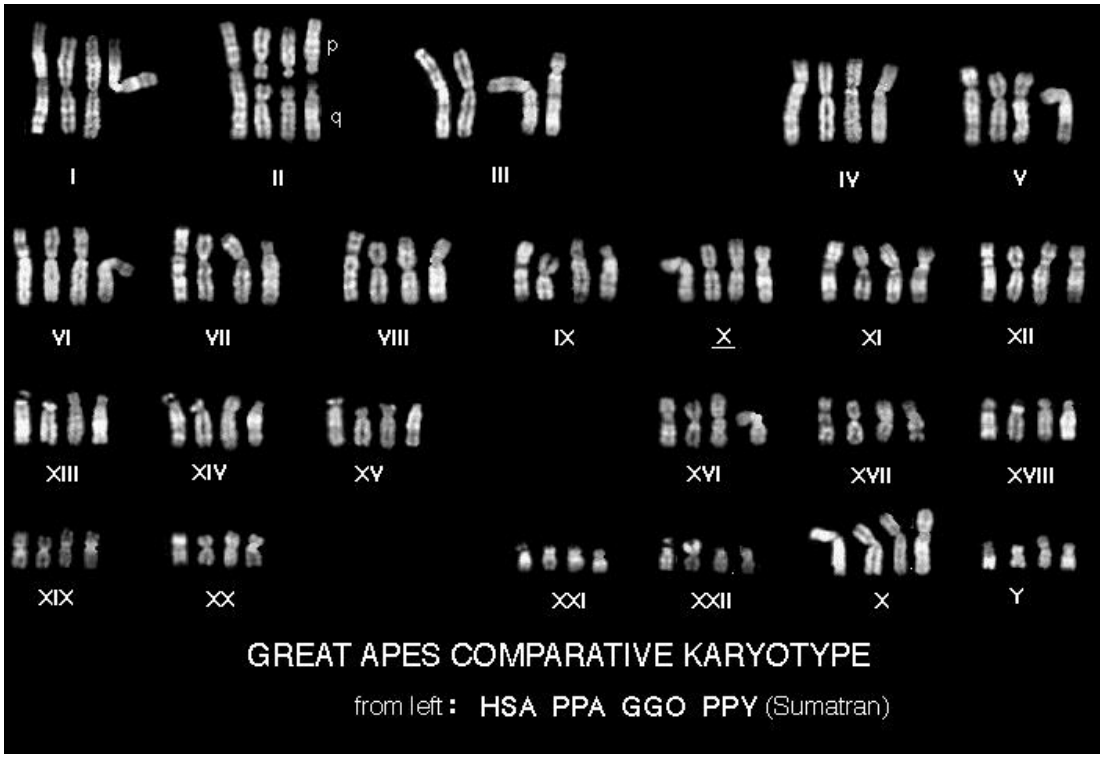
Chromosome 12- ataxia: genetic defect

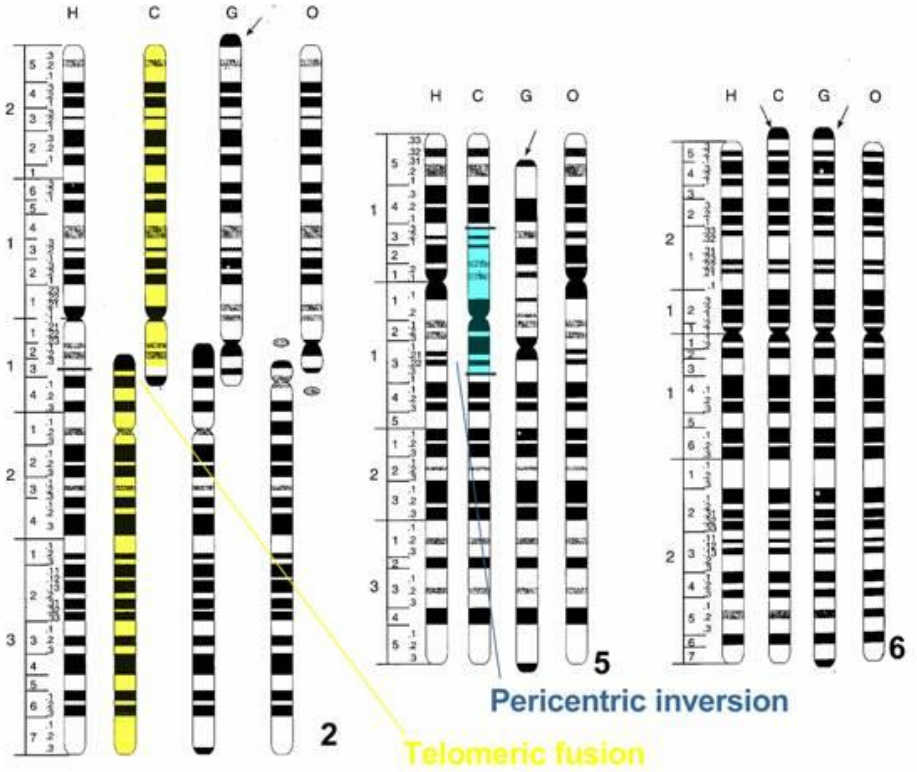


Chromosomal Translocation

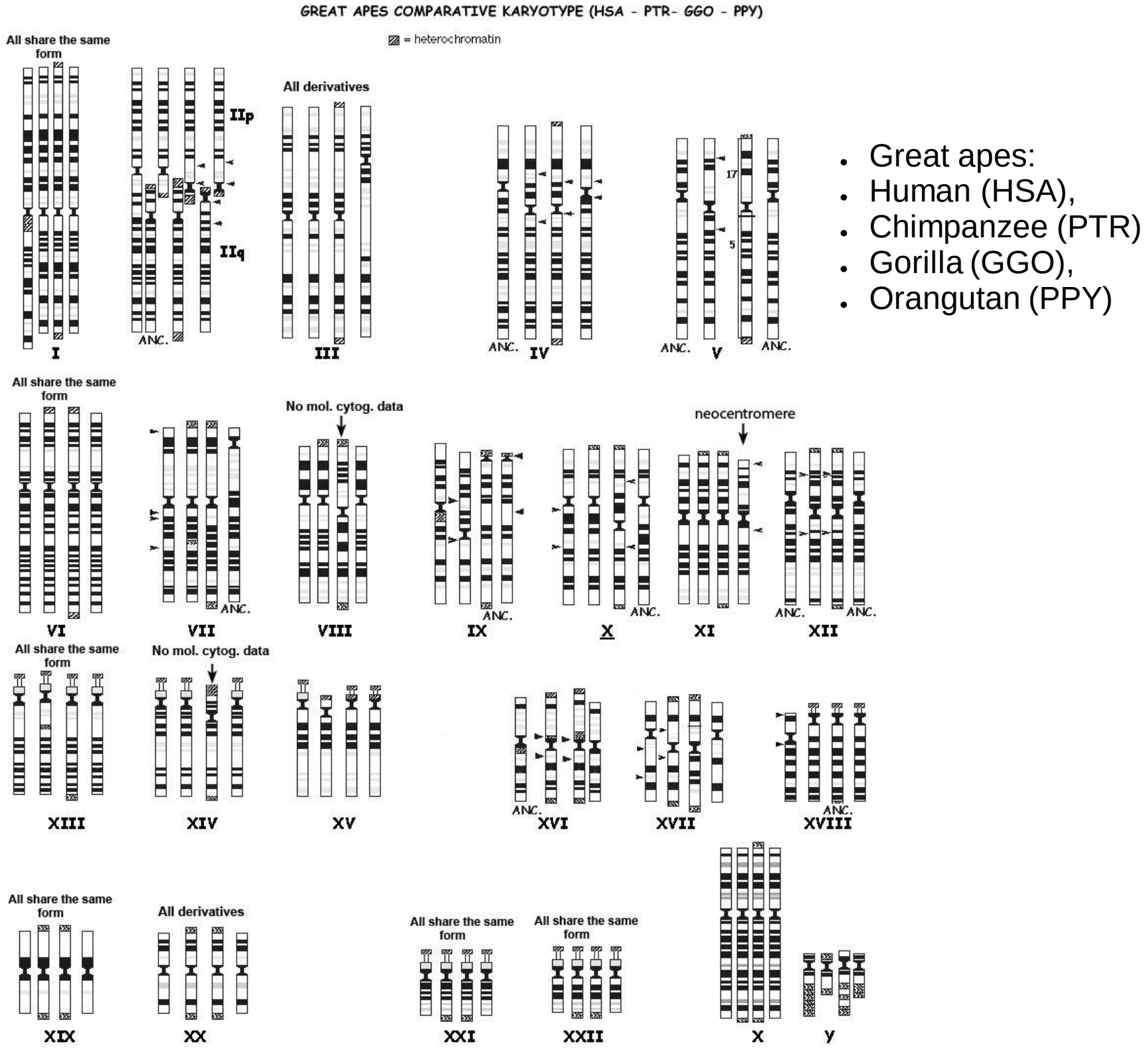
Do other animals also have chromosomes?

Changes in Chromosome Structure



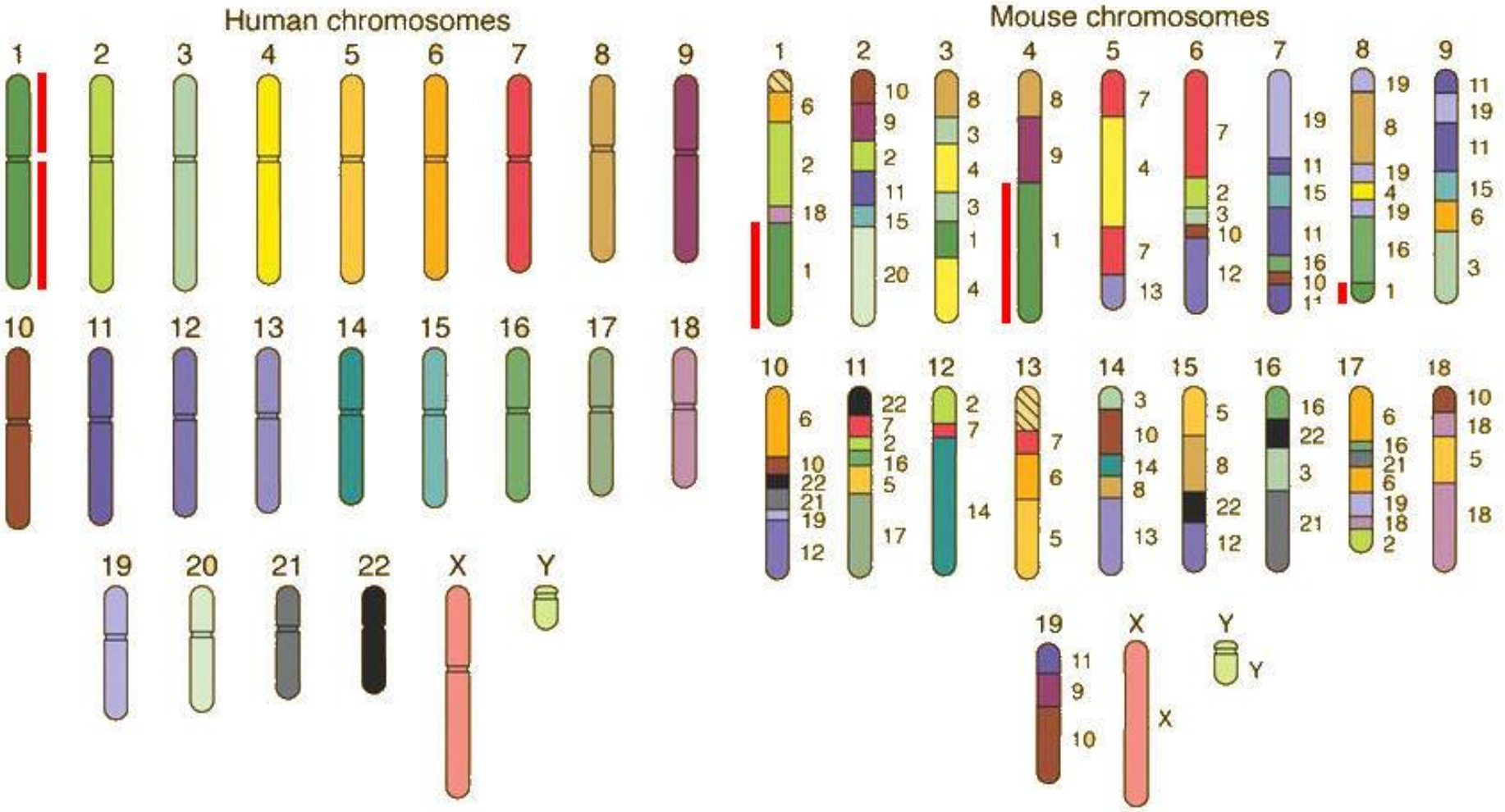


- Great apes: Human, Bonobo, Chimpanzee, Gorilla, Orangutan
- Hominids contain 23 pairs of chromosomes (46 Chromosomes)
- Non-hominid great apes have 24 pairs (48 chromosomes)
- There is abundant evidence that human chromosome 2 arose from a translocation event
  - **<u>Robertsonian translocation</u>** the fusion of 2 acrocentric chromosomes
    - Acrocentric – one arm much shorter than the other



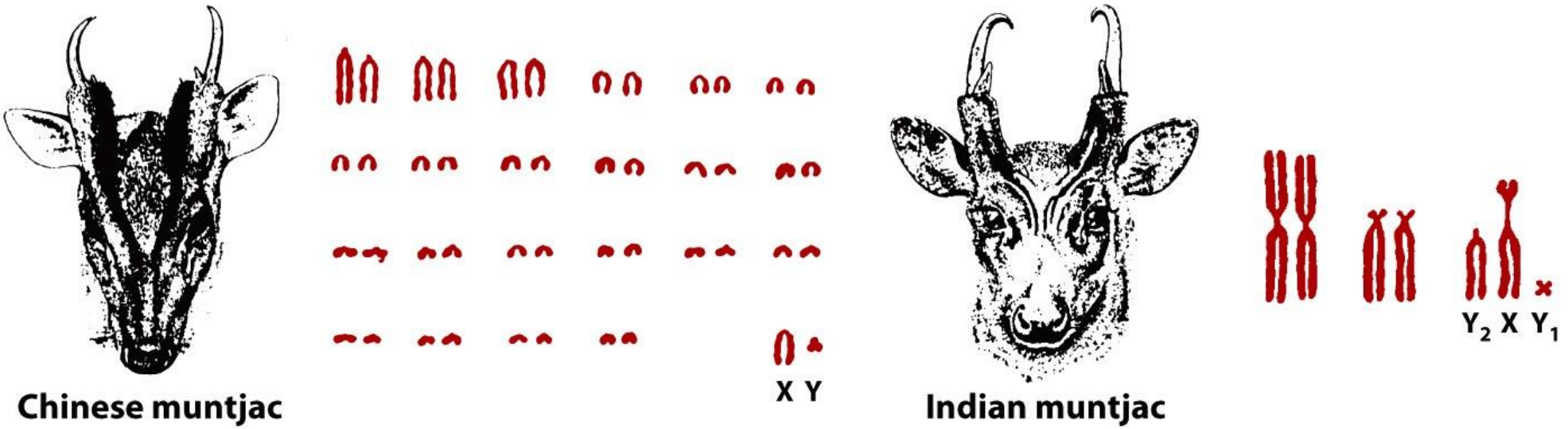
- Great apes:
- Human (HSA),
- Chimpanzee (PTR)
- Gorilla (GGO),
- Orangutan (PPY)

Human and Mouse Synteny Map



Synteny: physical co-localization of genetic loci on the same chromosome of a species or between species on different parts of chromosomes

Closely related species can have different chromosome numbers



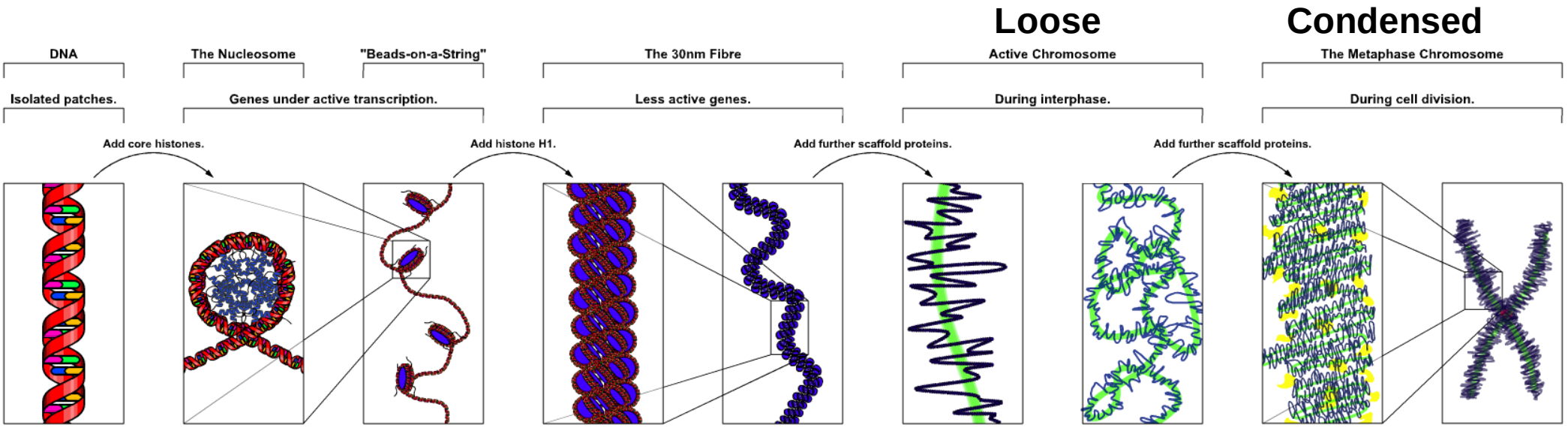
Muntjac deer

Yet the same number of genes!

Can these two mate?

Figure 5-14 *Essential Cell Biology* (© Garland Science 2010)

Chromatin Structure: Gene regulation



- **Histones** are structural proteins responsible for packaging chromosomes
  - Five primary types of histone molecules
  - DNA double helix is wound at intervals around a core of eight histone molecules (called **nucleosome**)
  - Nucleosomes are joined by “linker” DNA.
- Chromosomes are single linear DNA molecules complexed with protein
  - **Euchromatin** actively genes (loosely wound)
  - **Heterochromatin** is inactive genes (tightly packed)

Histone Code -- Acetyl, phosphate or methyl group additions

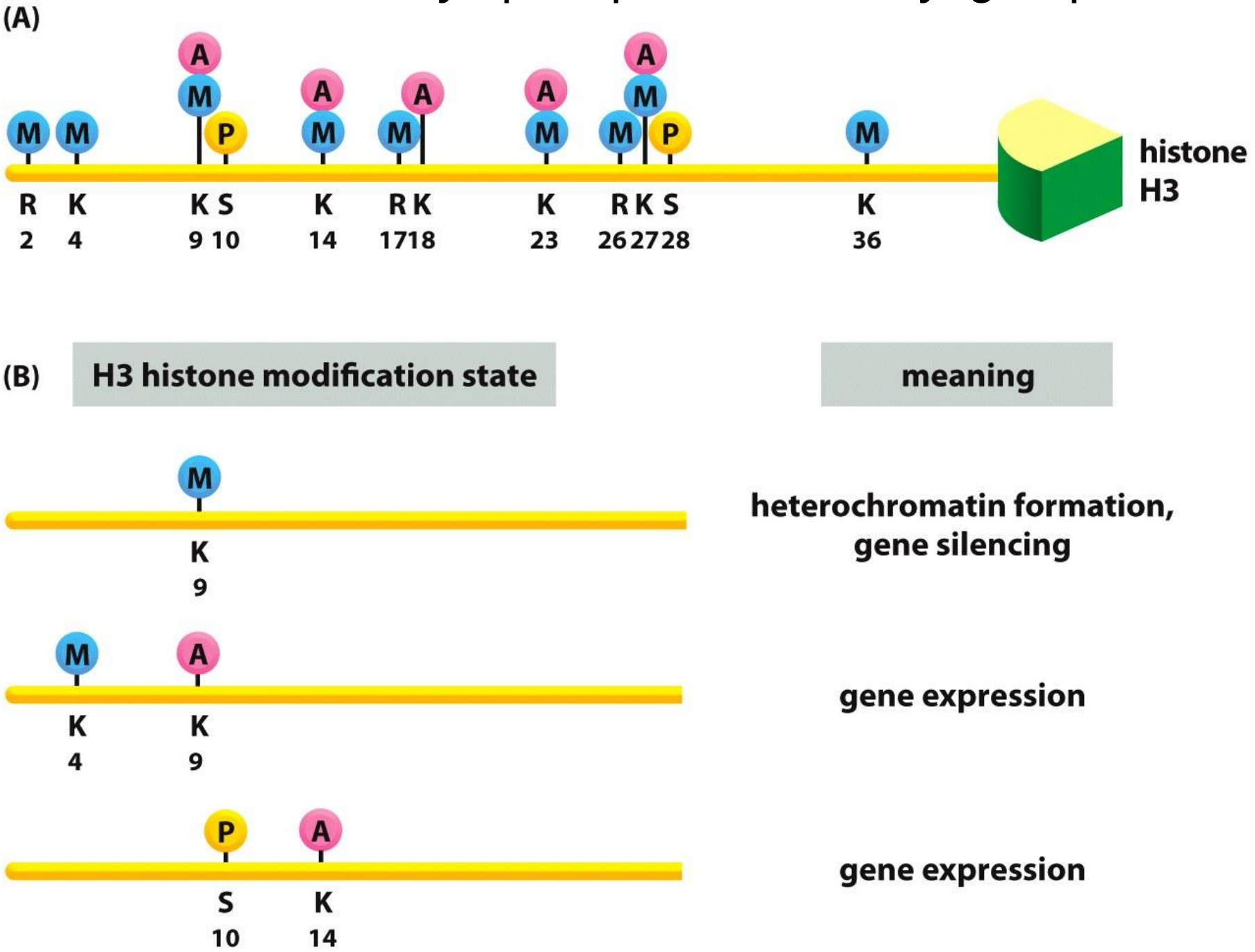
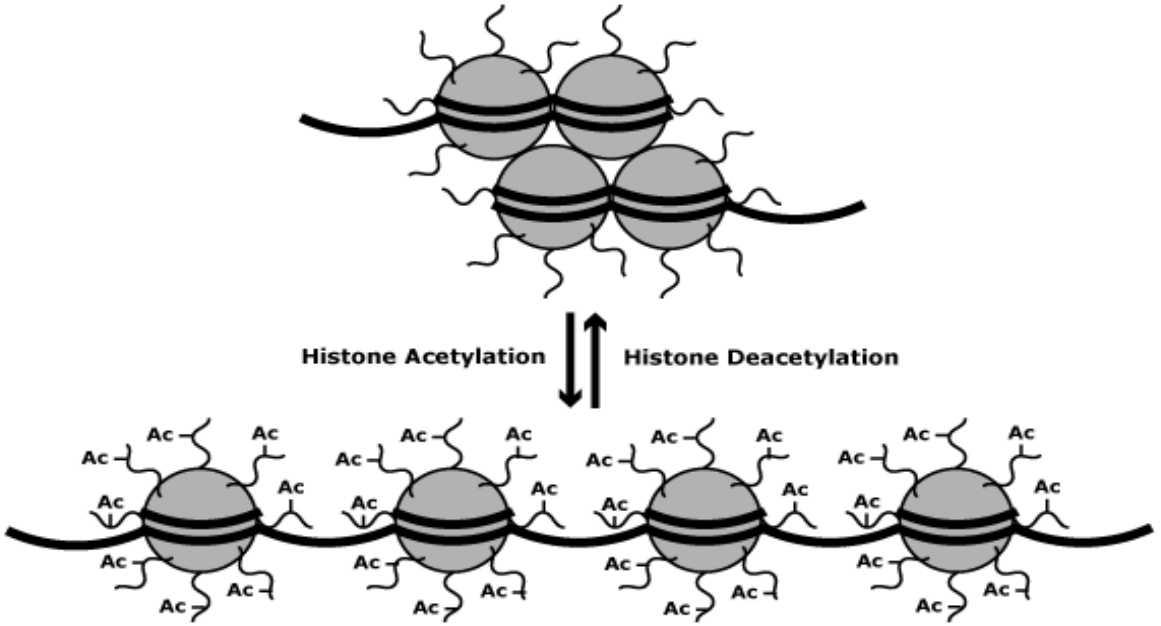
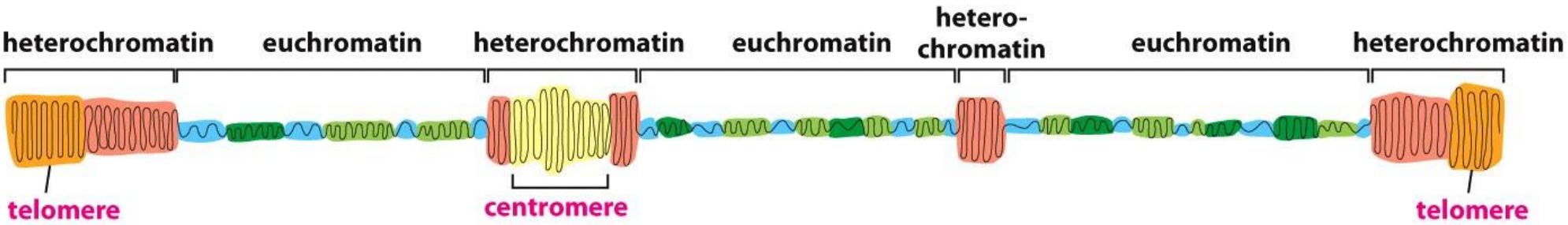


Figure 5-28 *Essential Cell Biology* (© Garland Science 2010)

Variations in chromatin structure in a single interphase chromosome



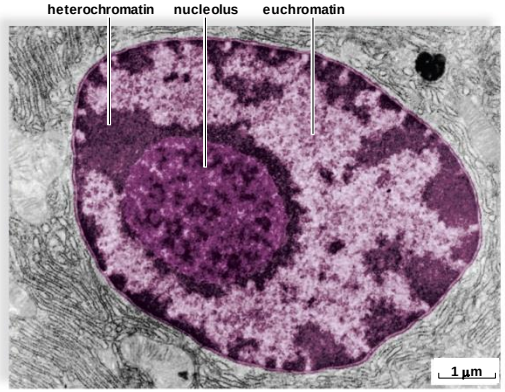


Heterochromatin: condensed chromatin. So condensed genes within cannot be expressed.

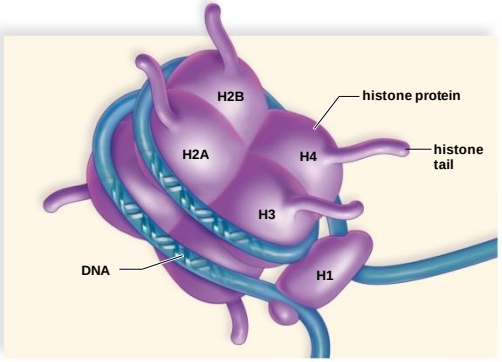
The rest of the chromosome is called: **Euchromatin** (true chromatin).

Figure 5-31 *Essential Cell Biology* (© Garland Science 2010)

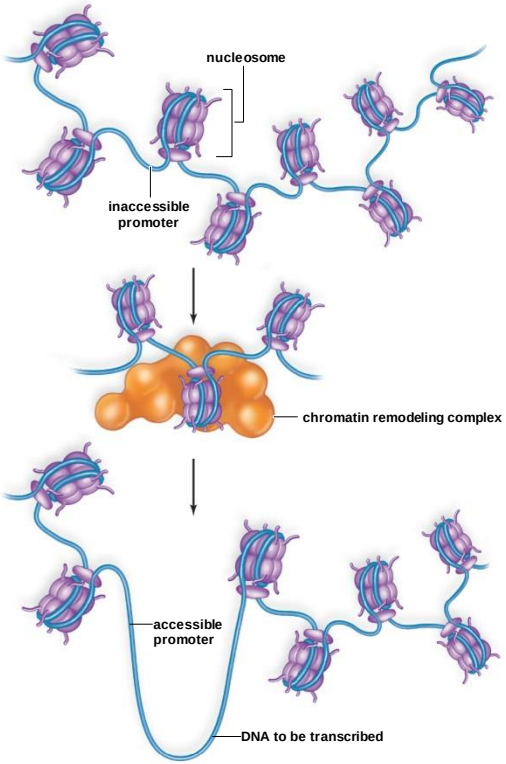
Chromatin Structure: Gene regulation



a. Darkly stained heterochromatin and lightly stained euchromatin



b. A nucleosome

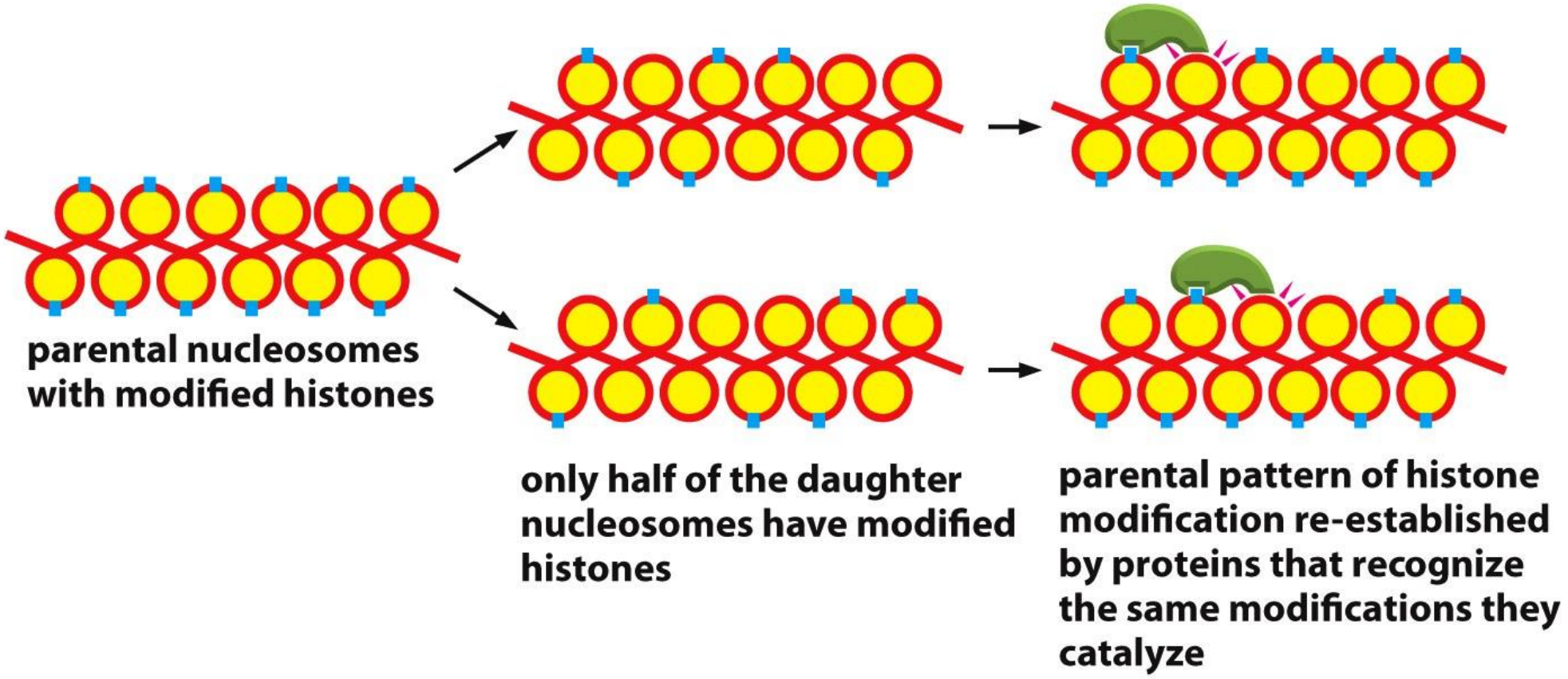


c. DNA unpacking

a: Courtesy Stephen Wolfe

- Euchromatin
  - Loosely coiled DNA that is active
- Heterochromatin
  - Tightly packed DNA that is inactive
  - **Facultative** → can be activated
  - **Constitutive** → always off like centromeres
- Barr Bodies
  - Females have two X chromosomes, but only one is active
  - Other is tightly packed along its entire length
  - Inactive X chromosome is Barr body
  - Barr body is facultative heterochromatin

During DNA replication:
nucleosome histones are randomly distributed-



This type of inheritance is called:
epigenetic inheritance (part of histone code) .

epi= above)

Figure 5-32 *Essential Cell Biology* (© Garland Science 2010)

Chr. X inactivation in mammals by use of heterochromatin

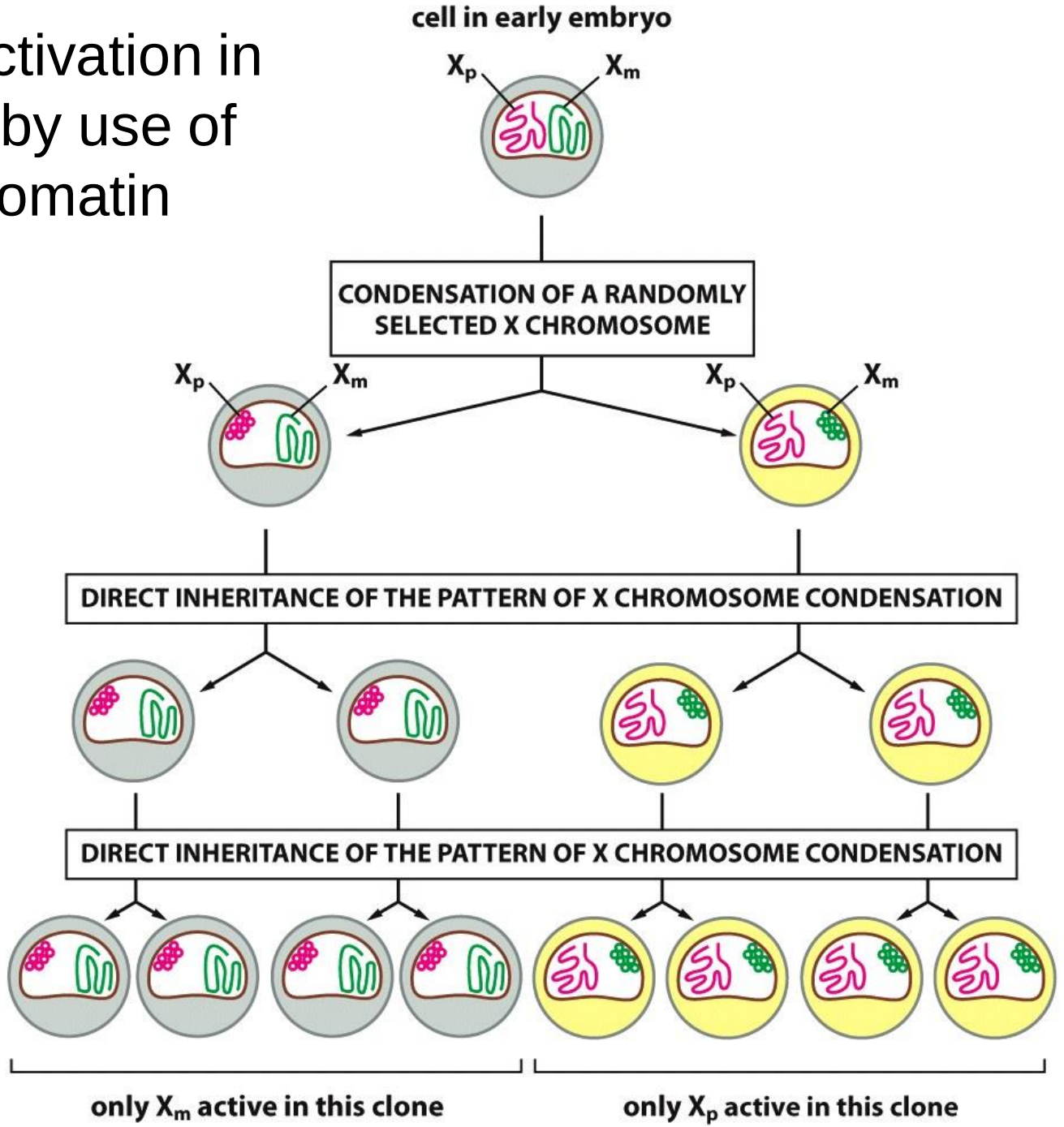


Figure 5-30 *Essential Cell Biology* (© Garland Science 2010)

Recap: Lecture 23

1. DNA Compaction:

Human genome spans 2 meters, fits into nucleus (5-8 μm diameter)

Active genes **500X** compacted, Inactive mitotic DNA (**10,000X**)

2. Histone Core Complex: Octomer (2- H2A, H2B, H3, H4)

DNA double helix – 2 nm

Nucleosome "Beads on a string" – 11 nm (~200 bp)

147 bp (1.65 turns) around histone core (6X compaction)

Chromatin fiber – 30 nm (H1) --- Total (40X compaction)

Loops (300 nm) --- Total (500X compaction)

Chromatid 700 nm --- Total (10,000X compaction)

3. Chromosome Organization:

A. Chromosome vs chromatid

B. p arm, q arm, centromere

C.Ori (replication), Telomeres

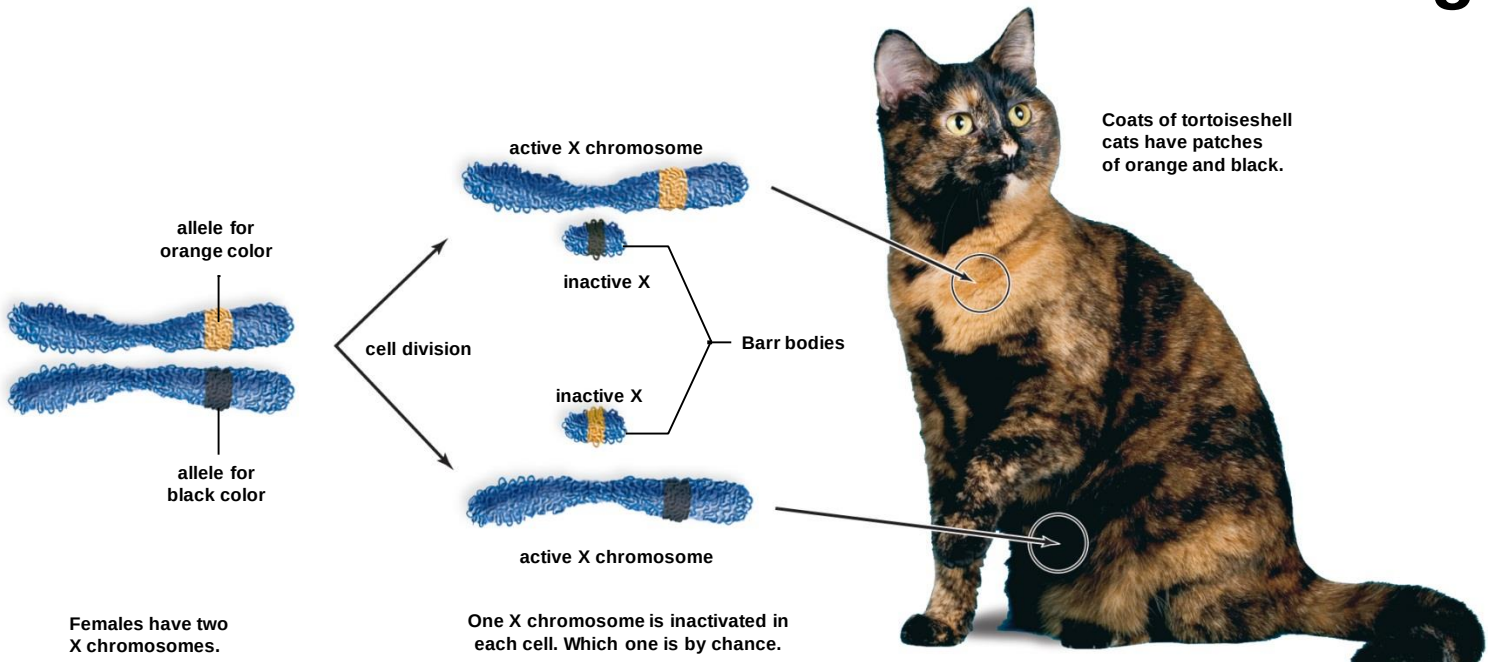
D.Heterochromatin/Euchromatin

4. Epigenetics

1. Histone Code (M, A, P) – H3
2. X-chromosome inactivation (Barr bodies)

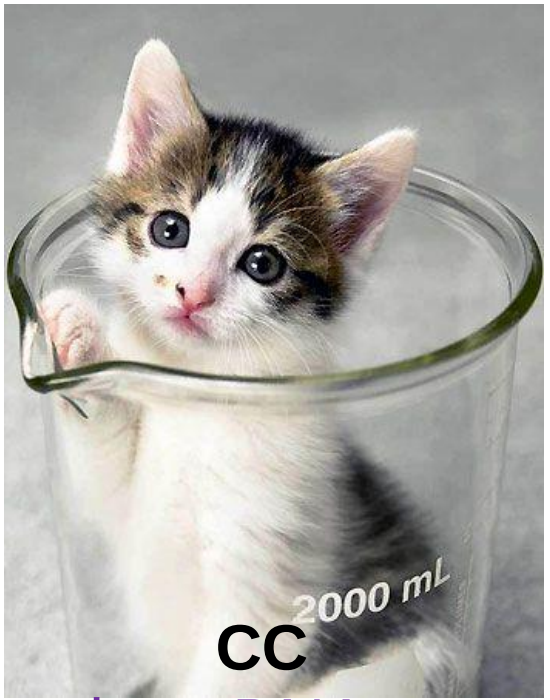
Who cares about DNA compaction?

Chromatin Structure: Gene regulation



Epigenetics -heritable changes in gene expression or cellular phenotype caused by mechanisms other than changes in the underlying DNA sequence

Rainbow



CC's coloration resulted from a lack of mosaicism

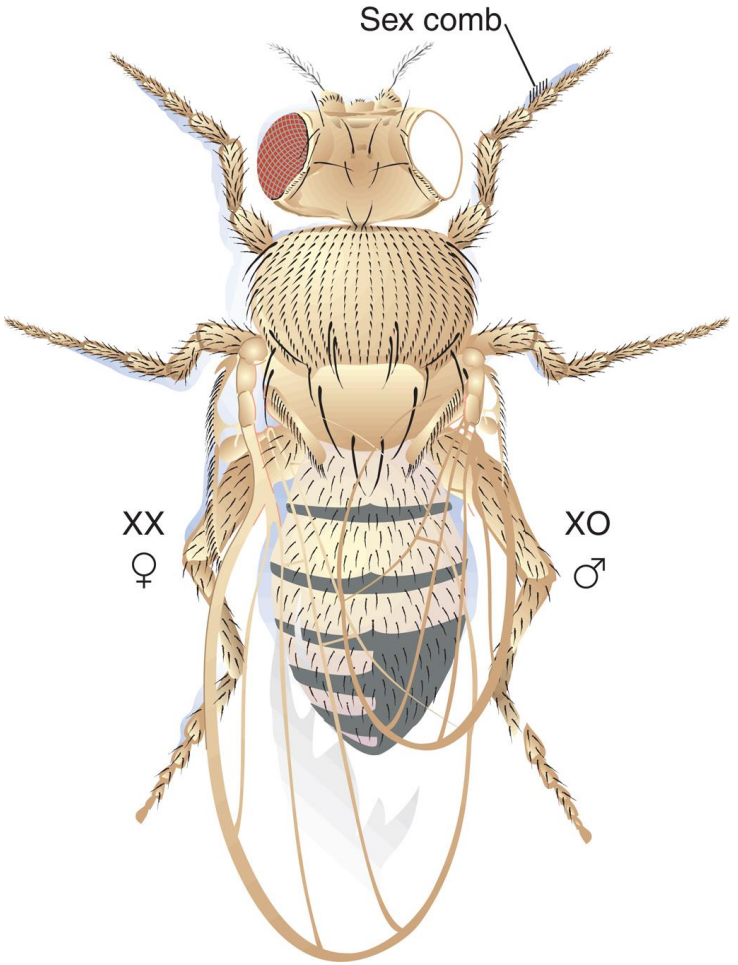
Cute cats care about DNA compaction

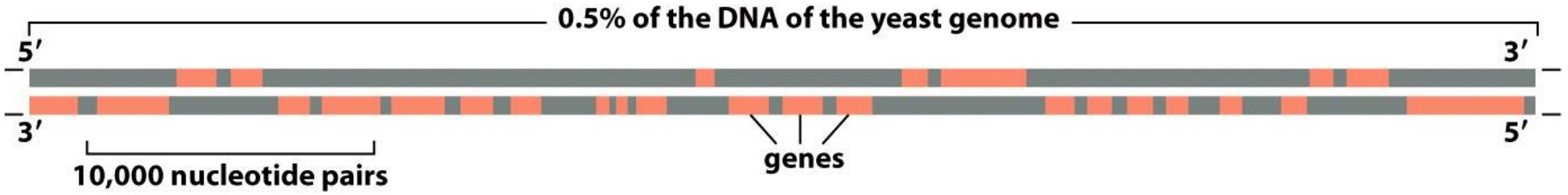
Mistakes in chromosome segregation can occur in somatic cells

(c) A gynandromorph

Mosaic organism

- Aneuploid cells can survive and undergo further rounds of mitosis, producing clones of aneuploid cells
- Side-by-side existence of aneuploid and normal tissues





Yeast contains about 6300 genes, spread over 16 Chromosomes

(for human ~23000 genes)

Genes can be encoded on either of the 2 strands

Figure 5-13 *Essential Cell Biology* (© Garland Science 2010)