

# Bio 102

## Course Outline

- Cell division: Cell division in bacteria and eukaryotes. Discovery of chromosomes. Mitosis and cytokinesis. Cell cycle control.
- Meiosis: Meiosis produces haploid cells from diploid cells. Discovery of reductional division. Features of meiosis: synapsis, homologous recombination, reductional division. Chromosomal basis of inheritance
- The transplantation experiments. The Griffith experiments. The Avery-Chase experiments. The structure of DNA. DNA replication. The Meselson-Stahl experiment. The replication process. Eukaryotic DNA replication.
- The central dogma in biology: The genetic code. Discovery of the genetic code. Organization of prokaryotic and eukaryotic genes and chromosomes. Transcription. Translation. Differences between prokaryotic and eukaryotic gene expression.
- Control of Gene expression: Transcriptional regulation in bacteria. The operon. Repressors, promoters and activators. Transcriptional regulation in eukaryotes. Effect of chromosome structure. Post-transcriptional control in eukaryotes.
- Cellular mechanisms of Development: Overview of development. Vertebrate development, Insect development, Plant development. Multicellular organisms employ the same mechanism of development. Cell movement and induction. Determination. Pattern formation. Expression of homeotic genes. Programmed cell death.
- Gene Technology. Recombinant DNA technology. Restriction endonucleases. Gene cloning, techniques, Plasmids, Vectors, Expression vectors, cloning vectors, cDNA libraries, genomic libraries, DNA sequencing, PCR.
- Genomics: Genome sequencing projects. The history of the human genome sequencing project. Strategies for genome sequencing. Uses and challenges in genomics.

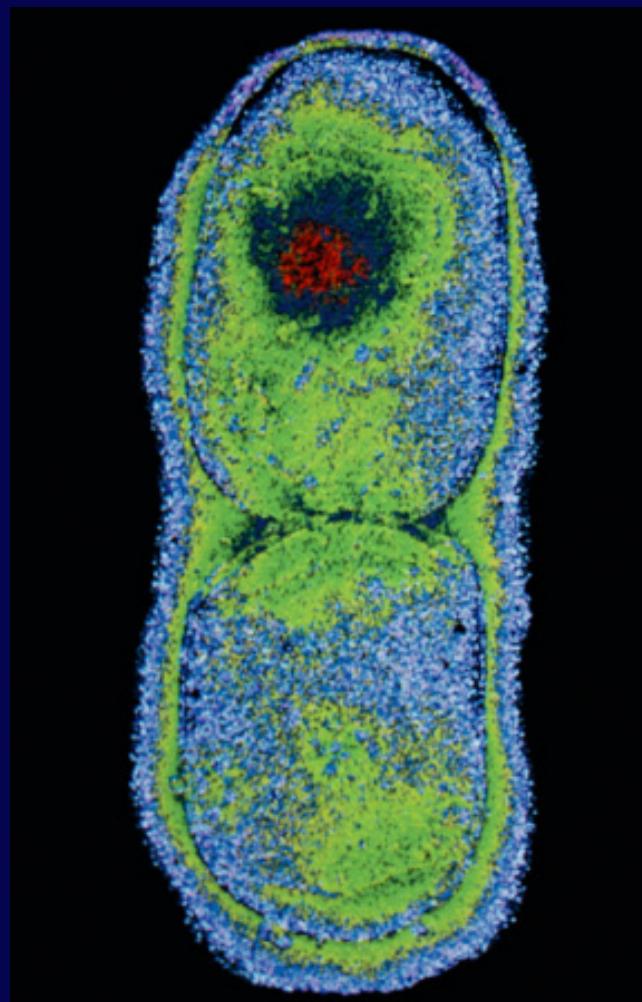
## Recommended Reading

- D. Sadava, W. K. Purves, G. H. Orians, and H. C. Heller, *Life: the science of biology*, 8th Edn., Sinauer Assoc. & Freeman & Co. (2008).
- N. A. Campbell, J. B. Reece, R. B. Jackson, M. L. Cain, L. A. Urry, S. A. Wasserman, P. V. Minorsky, *Biology*, 8th Edn. Benjamin-Cummings Pub Co. (2007).

# Evaluation

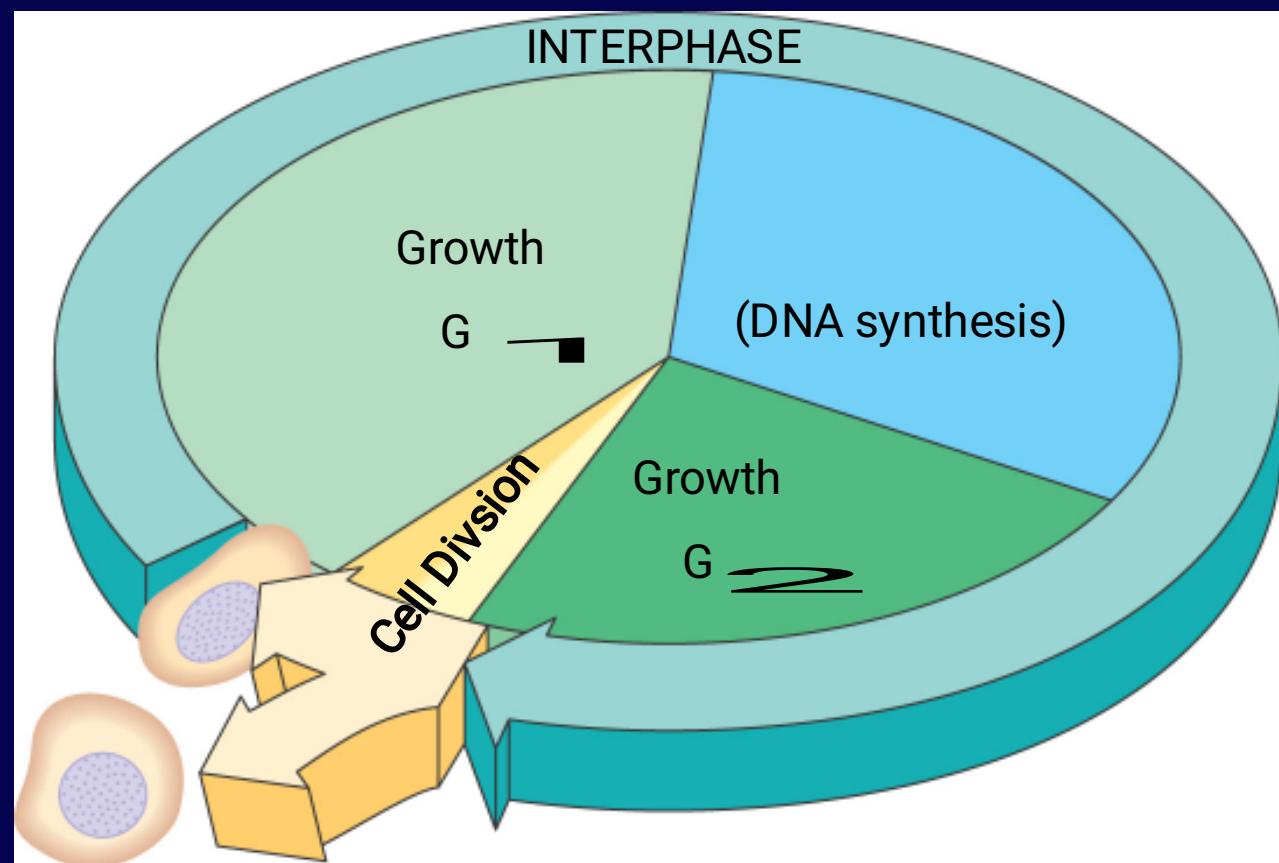
- 1<sup>st</sup> Mid Sem-1 (25 marks)
- 2<sup>nd</sup> Mid Sem-1 (25 marks)
- Qizzes-2 (10 marks)
- Final Sem-1 (40 marks)

# The Cell Cycle and How Cells Divide



# Phases of the Cell Cycle

- The cell cycle consists of
  - Interphase – normal cell activity
  - The mitotic phase – cell division



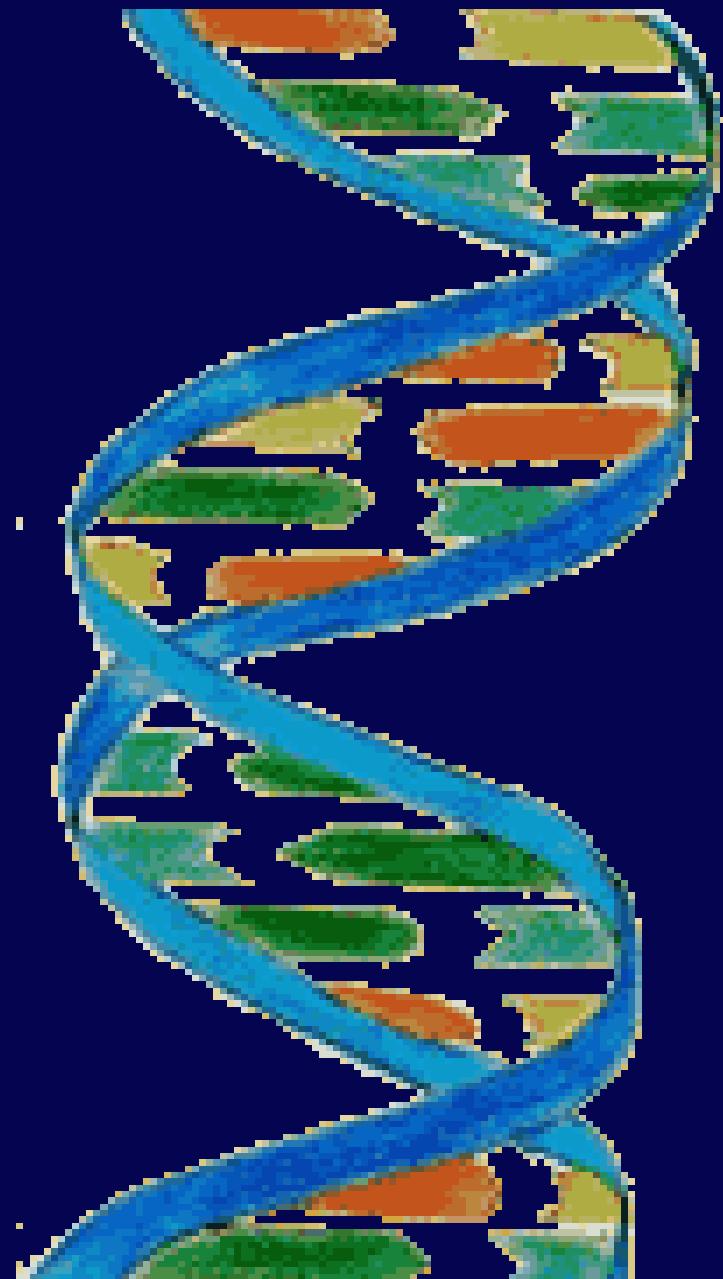
# **Cellular Division**

# Cell Division

- ✓ All cells are derived from pre-existing cells
- ✓ New cells are produced for growth and to replace damaged or old cells
- ✓ Differs in prokaryotes (bacteria) and eukaryotes (protists, fungi, plants, & animals)

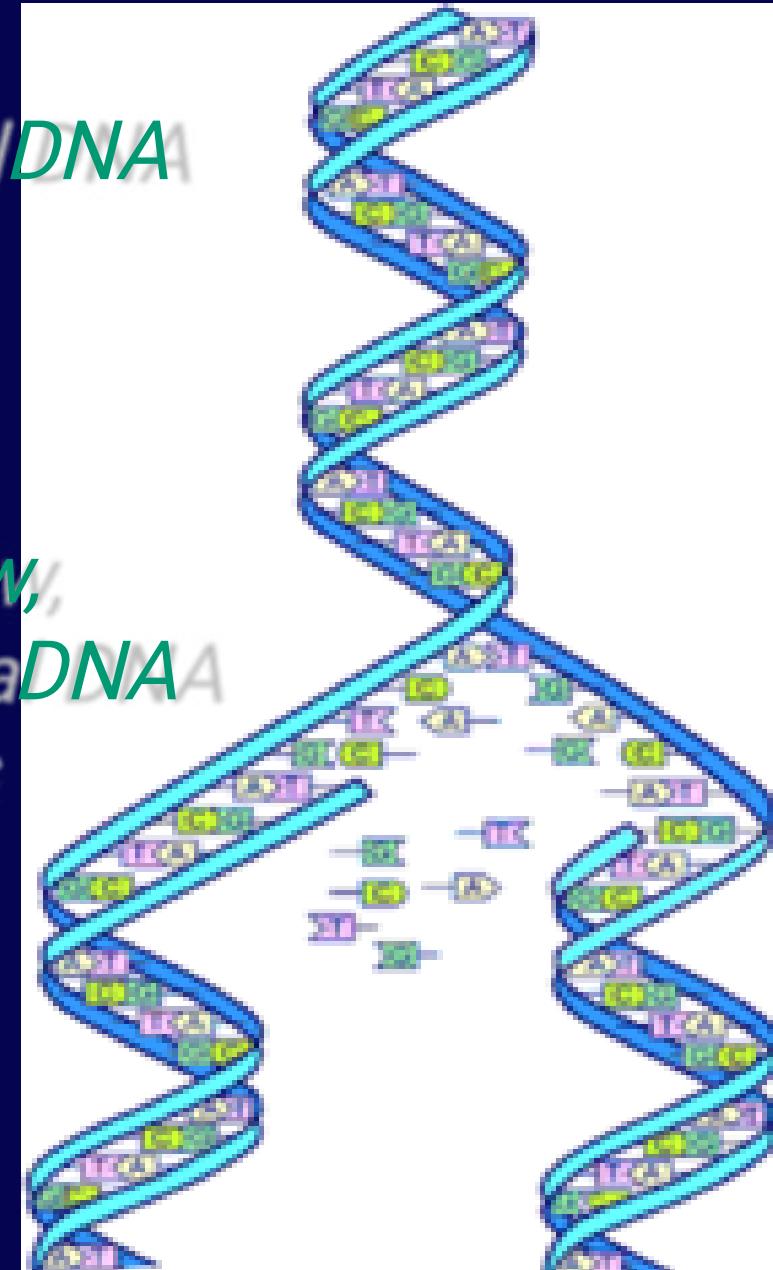
# Keeping Cells Identical

The instructions for making cell parts are encoded in the DNA, so each new cell must get a complete set of the DNA molecules

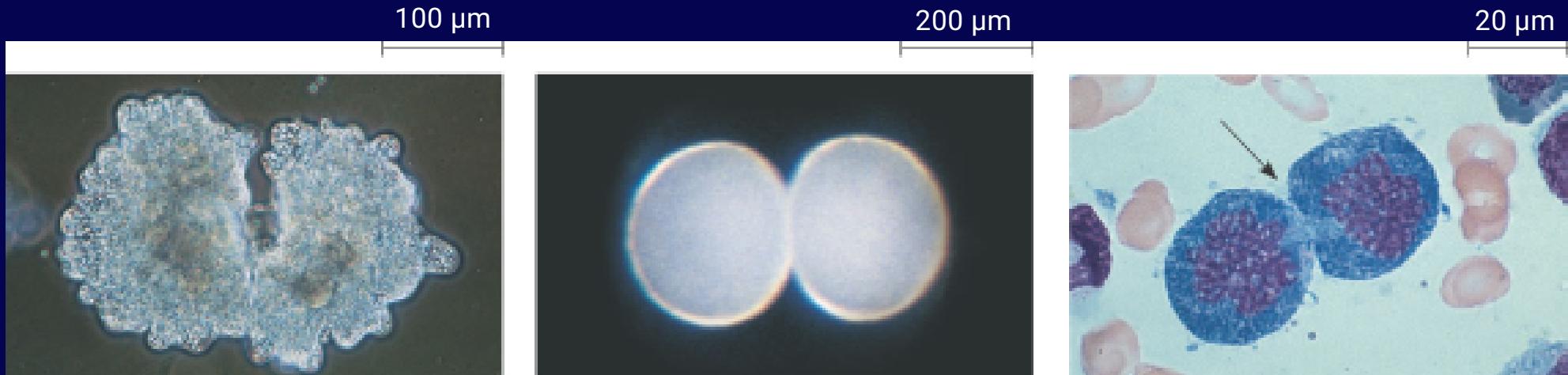


# DNA Replication

- ✓ DNA must be copied or **replicated before** cell division
  - ✓ Each new cell will then have an **identical copy** of the DNA
- Original DNA strand*
- Two new, identical DNA strands*



# Functions of Cell Division



**(a) Reproduction.** An amoeba, a single-celled eukaryote, is dividing into two cells. Each new cell will be an individual organism (LM).

**(b) Growth and development.** This micrograph shows a sand dollar embryo shortly after the fertilized egg divided, forming two cells (LM).

**(c) Tissue renewal.** These dividing bone marrow cells (arrow) will give rise to new blood cells (LM).

# Cell Division

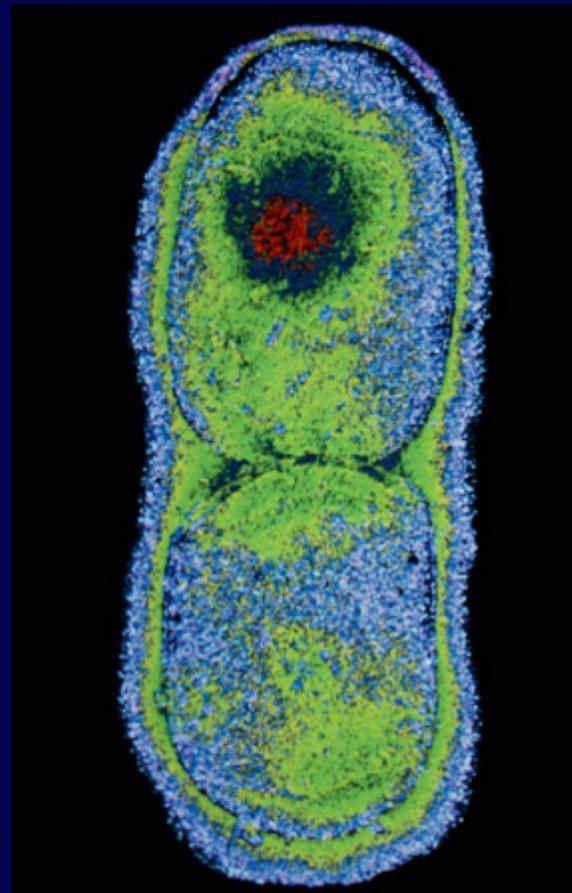
- An integral part of the cell cycle
- Results in genetically identical daughter cells
- Cells duplicate their genetic material
  - Before they divide, ensuring that each daughter cell receives an exact copy of the genetic material, DNA

# Cell Reproduction

# Types of Cell Reproduction

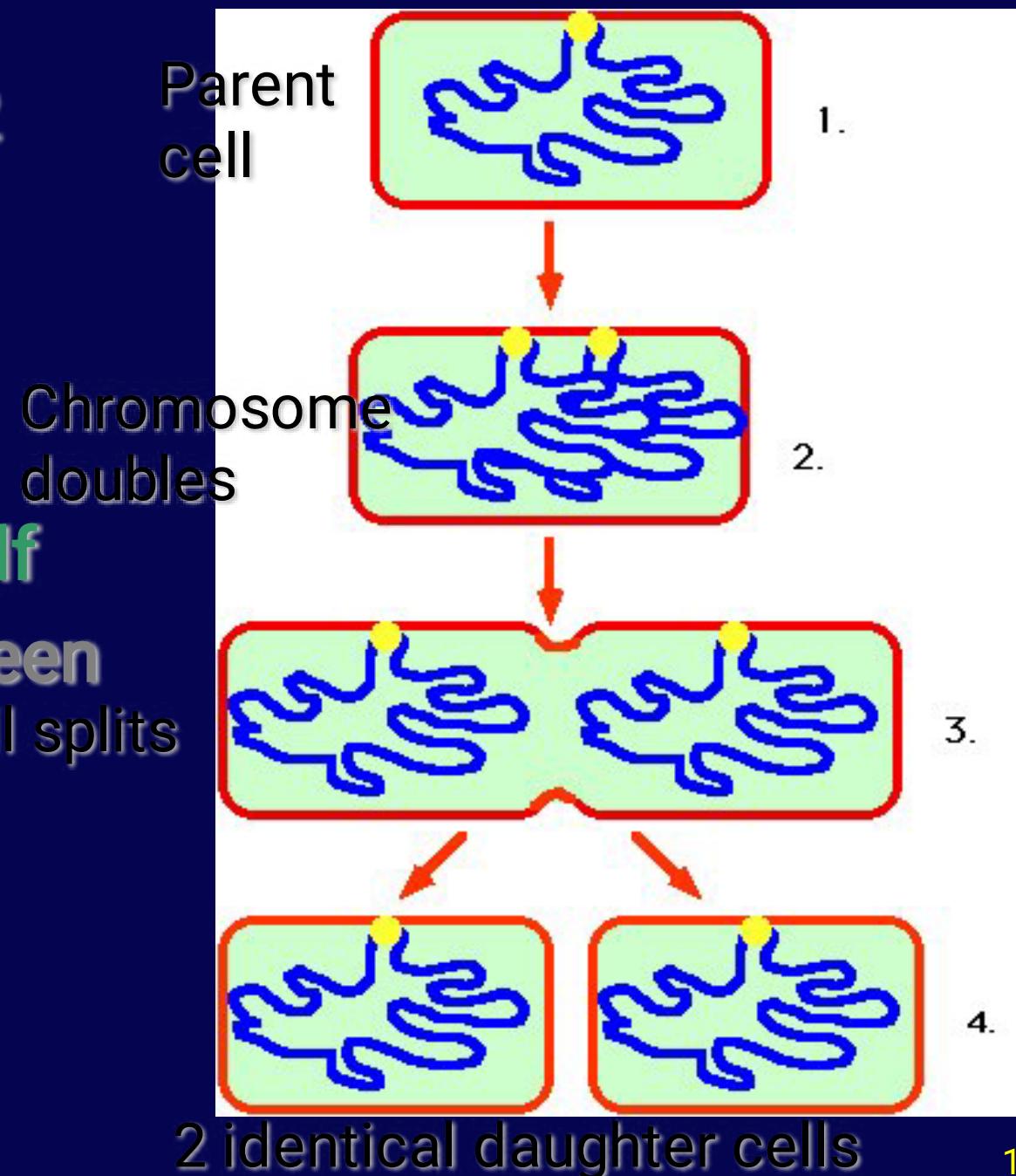
- ✓ **Asexual reproduction** involves a single cell dividing to make 2 new, identical daughter cells
- ✓ **Mitosis & binary fission** are examples of asexual reproduction
- ✓ **Sexual reproduction** involves two cells (egg & sperm) joining to make a new cell (**zygote**) that is NOT identical to the original cells
- ✓ **Meiosis** is an example

# Cell Division in Prokaryotes

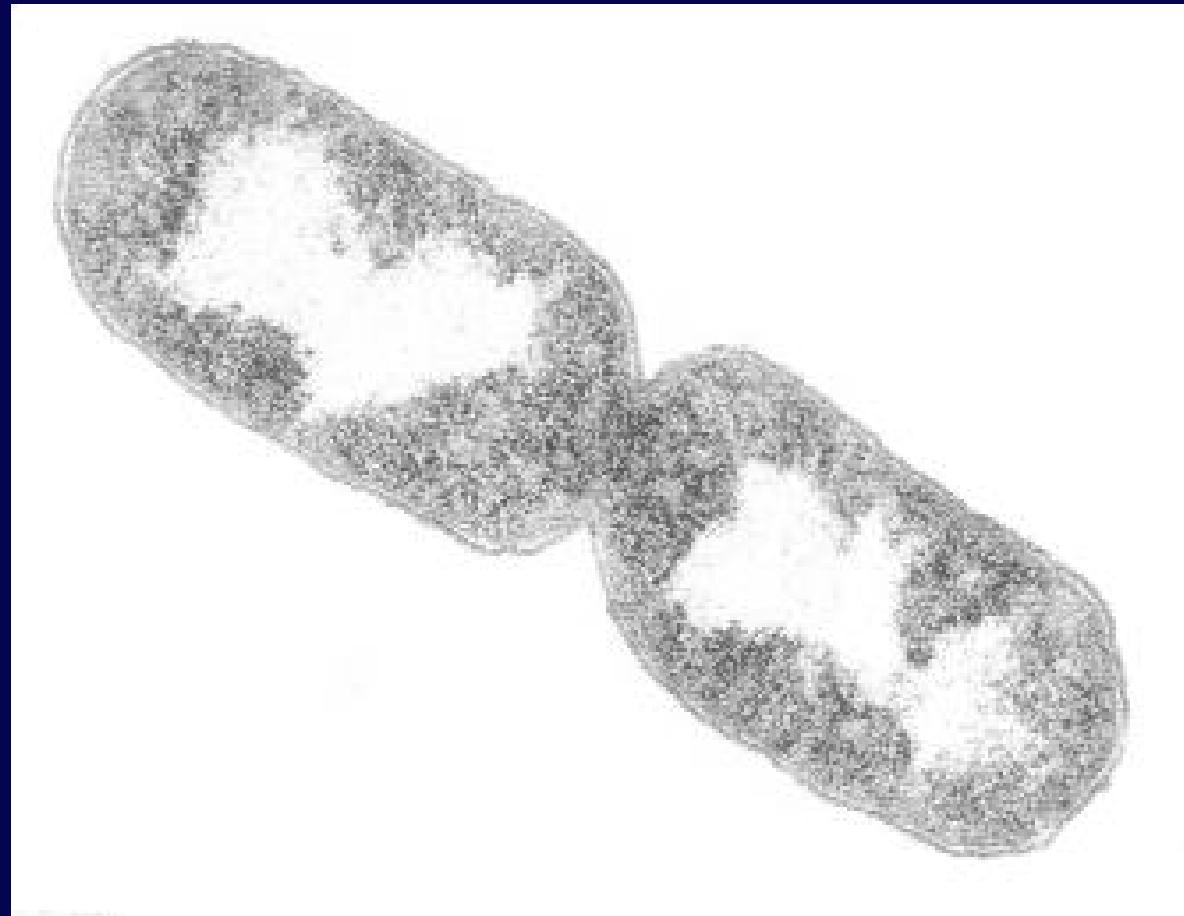


# Cell Division in Prokaryotes

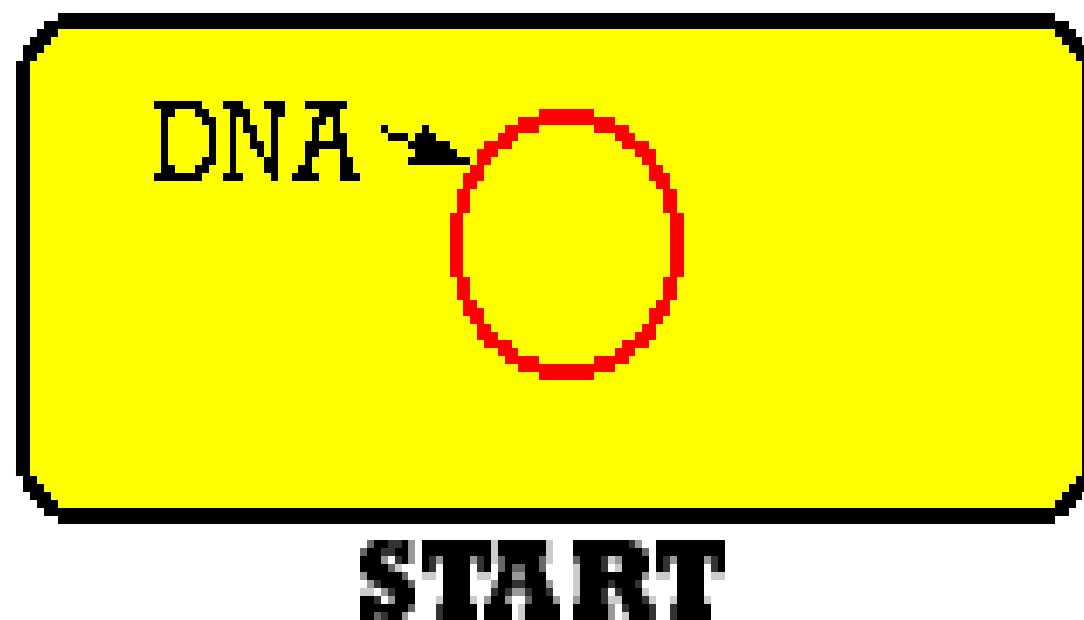
- ✓ Prokaryotes such as **bacteria** divide into 2 identical cells by the process of **binary fission**
- ✓ **Single chromosome** makes a copy of itself
- ✓ Cell wall forms between the chromosomes dividing the cell



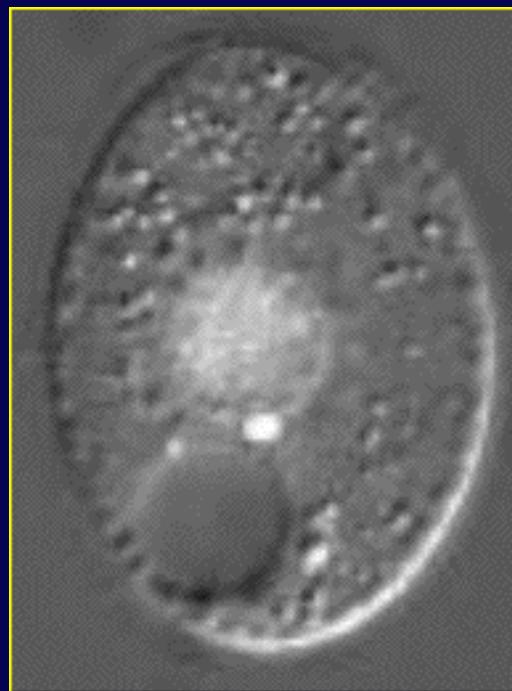
# Prokaryotic Cell Undergoing Binary Fission



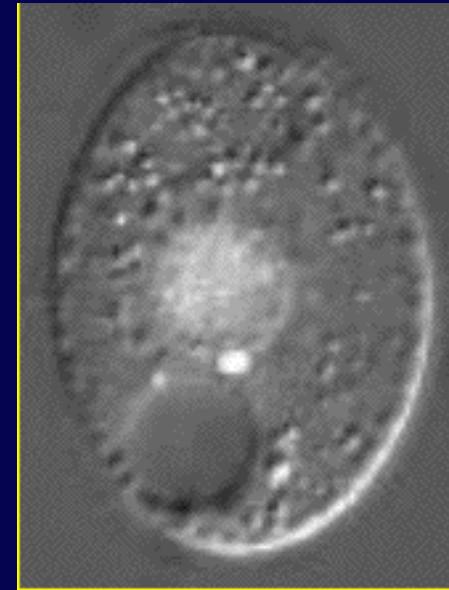
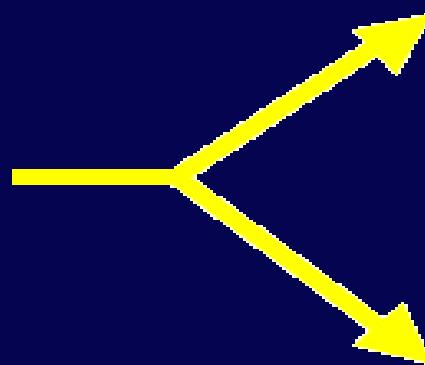
# Animation of Binary Fission



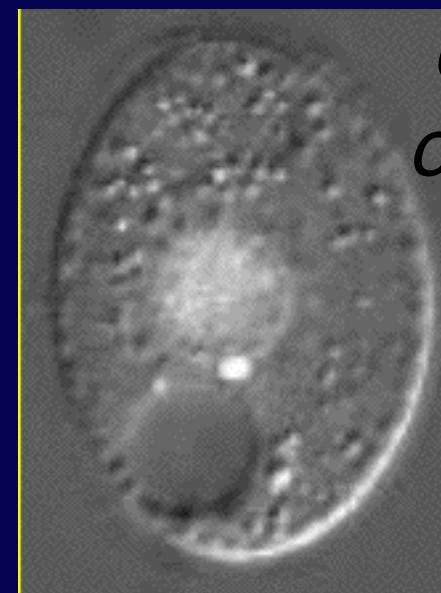
# Identical Daughter Cells



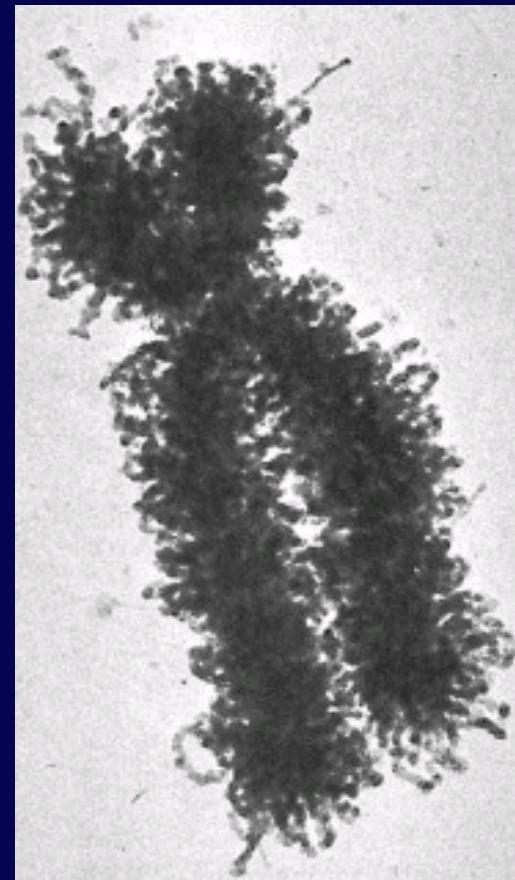
*Parent Cell*



*Two identical daughter cells*

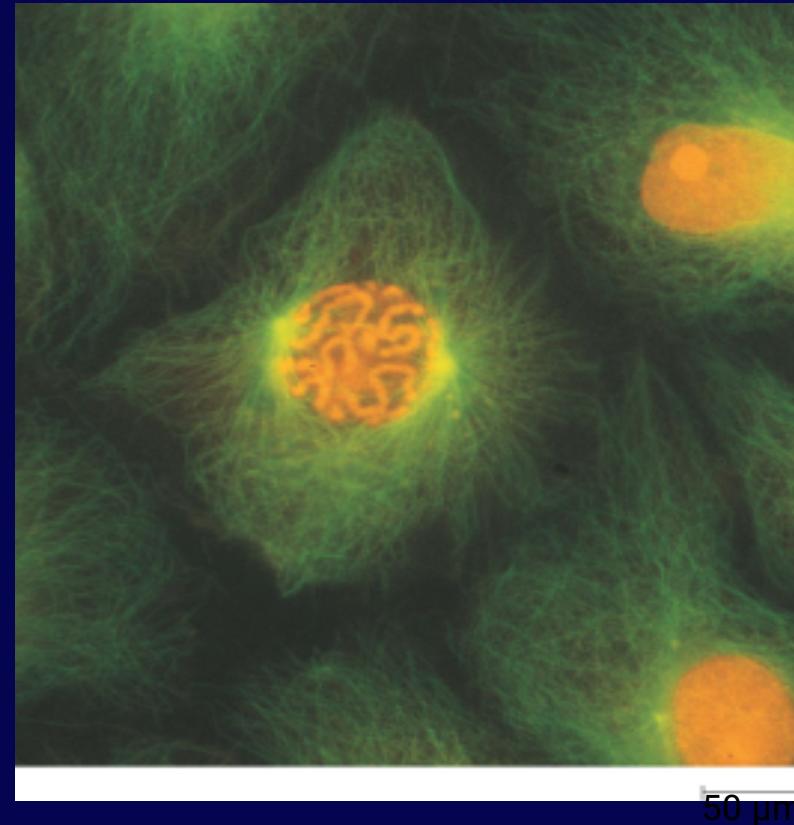


# Chromosomes



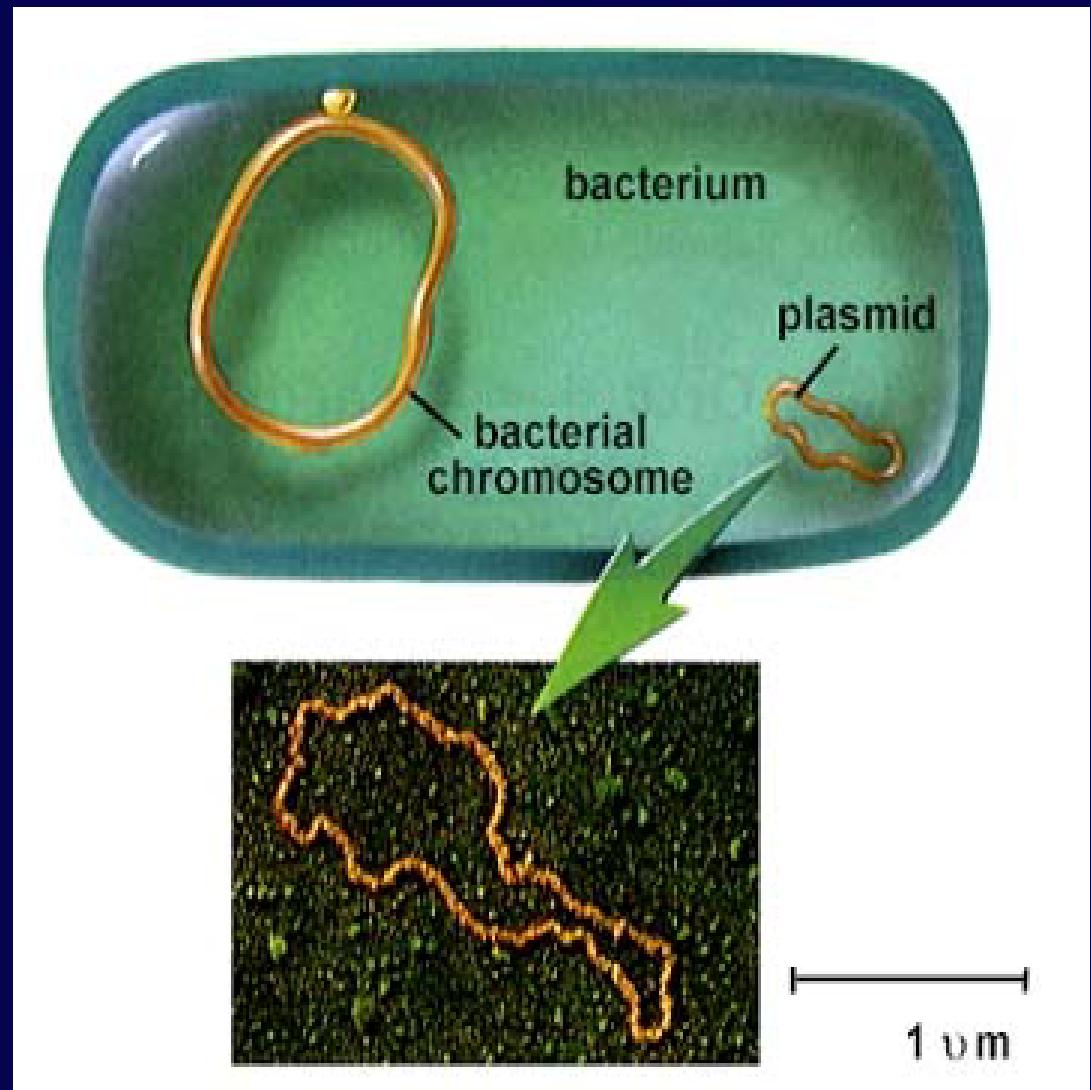
# DNA

- Genetic information - genome
- Packaged into chromosomes



# Prokaryotic Chromosome

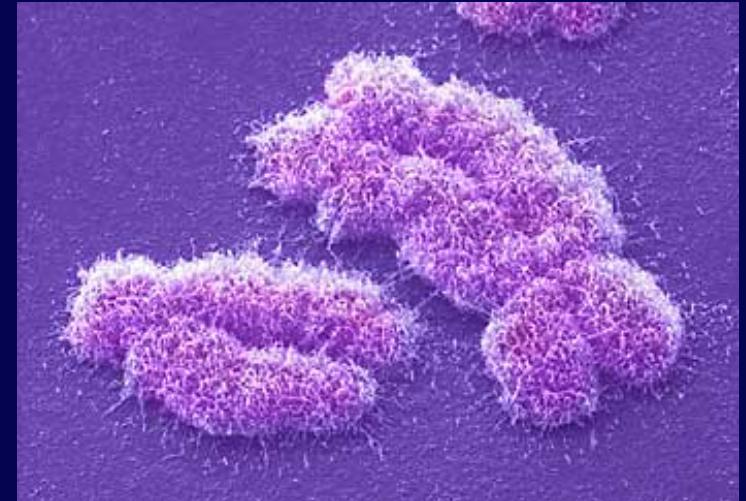
- ✓ The DNA of prokaryotes (bacteria) is **one, circular chromosome attached to the inside of the cell membrane**



# Chromosomes in eukaryotes and prokaryotes are different

PROKARYOTES	EUKARYOTES
single chromosome plus plasmids	many chromosomes
circular chromosome	linear chromosomes
made only of DNA	made of chromatin, a nucleoprotein (DNA coiled around histone proteins)
found in cytoplasm	found in a nucleus
copies its chromosome and divides immediately afterwards	copies chromosomes, then the cell grows, then goes through mitosis to organise chromosomes in two equal groups

# Chromosomes in eukaryotes



- Found in the nucleus
- Condensed and visible during cell division
- At the beginning of mitosis they can be seen to consist of two threads (sister chromatids) joined by a centromere
- The sister chromatids are identical copies
- During mitosis the sister chromatids separate and are placed into two nuclei

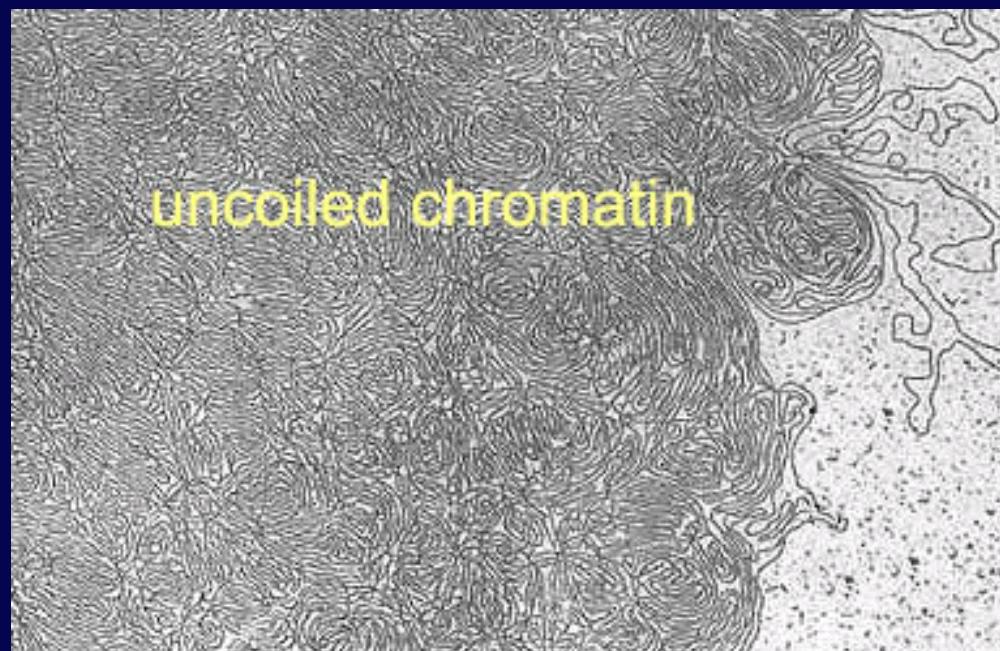
# Eukaryotic Chromosomes

- ✓ All **eukaryotic** cells store genetic information in chromosomes
- ✓ Most eukaryotes have between **10** and **50 chromosomes** in their body cells
- ✓ Human body cells have **46 chromosomes** or **23 identical pairs**



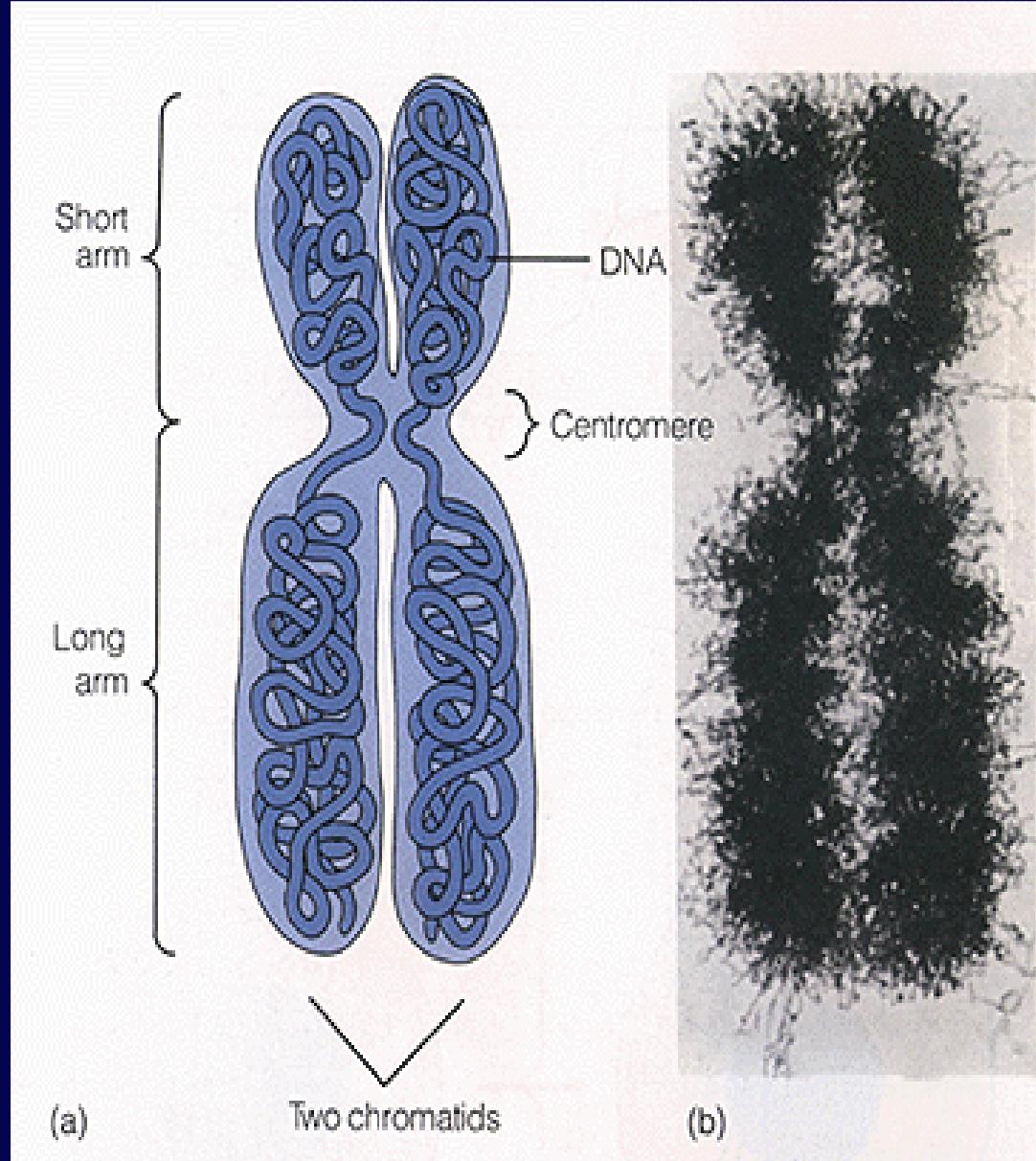
# Eukaryotic Chromosomes

- ✓ Each chromosome is composed of a single, tightly coiled DNA molecule
- ✓ Chromosomes can't be seen when cells aren't dividing and are called chromatin



# Chromosomes in Dividing Cells

- ✓ Duplicated chromosomes are called **chromatids** & are held together by the **centromere**



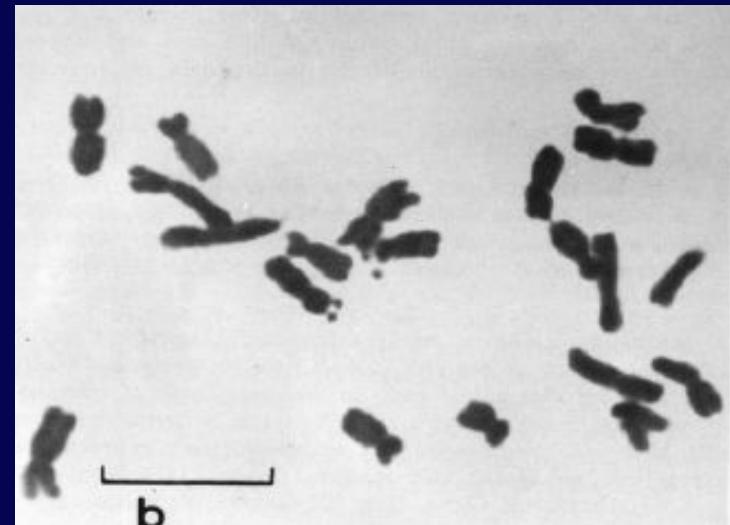
Called Sister Chromatids

# Numbers of chromosomes

- Constant for each cell in the body (except sex cells which only have half sets).
- Constant throughout the life of an individual (you don't lose or gain chromosomes)
- Constant for all members of a species



Mouse



Maize

Organism	Chromosome numbers
Human	46
Chimpanzee	48
House Mouse	40
Maize	20

# Human chromosomes

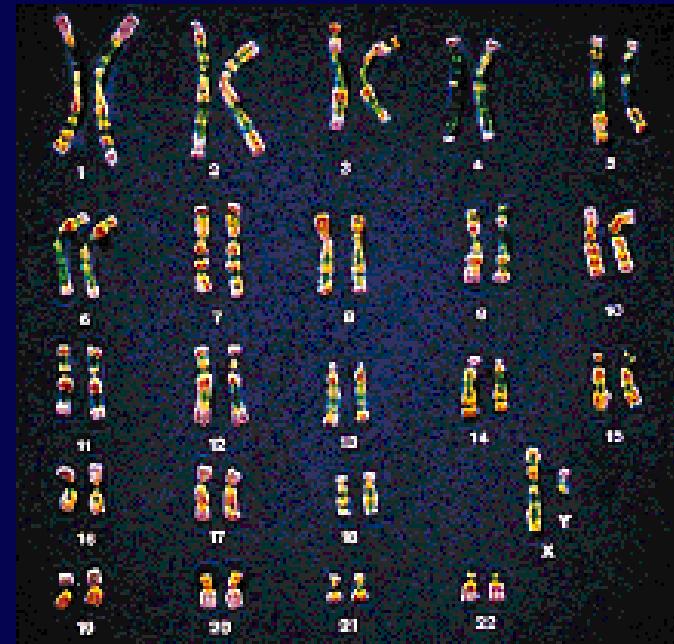


# Identifying chromosomes

Chromosomes can be identified by:

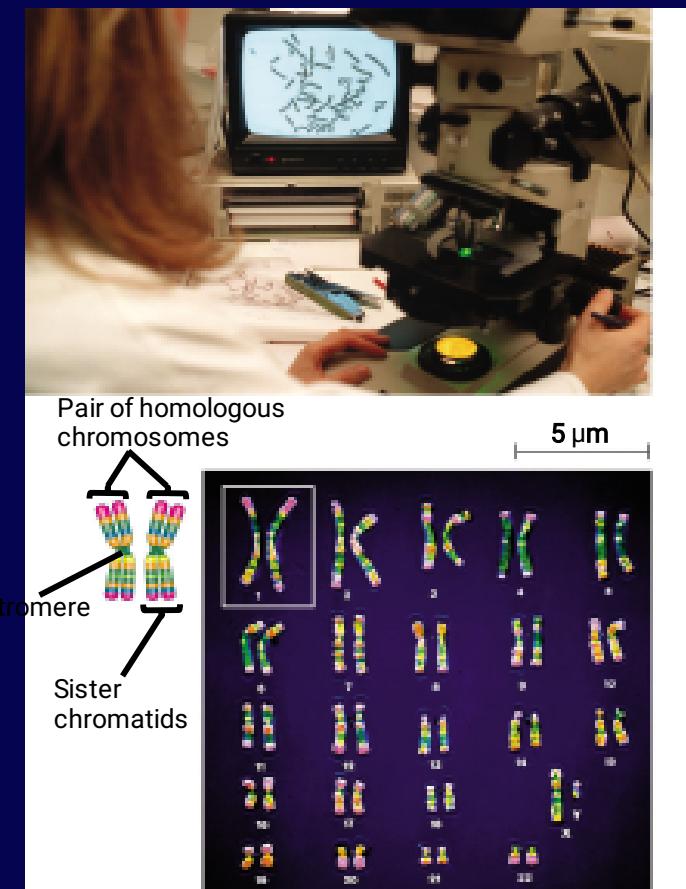
- Their size
- Their shape (the position of the centromere)
- NB Chromosomes are flexible
- Banding patterns produced by specific stains (Giemsa)

Chromosomes are analysed by organising them into a **KARYOTYPE**



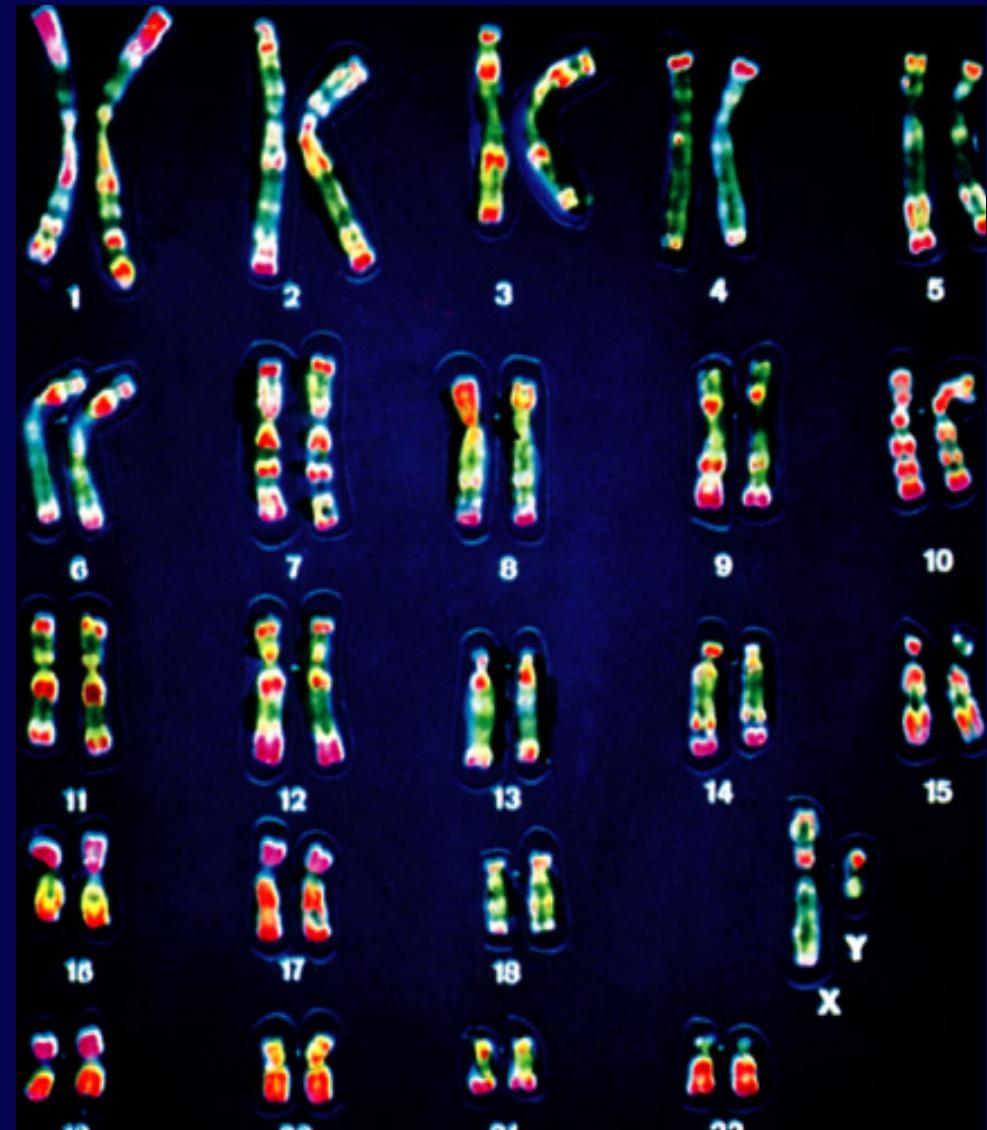
# Karyotype

- An ordered, visual representation of the chromosomes in a cell
- Chromosomes are photographed when they are highly condensed, then photos of the individual chromosomes are arranged in order of decreasing size:
- In humans each somatic cell has 46 chromosomes, made up of two sets, one set of chromosomes comes from each parent

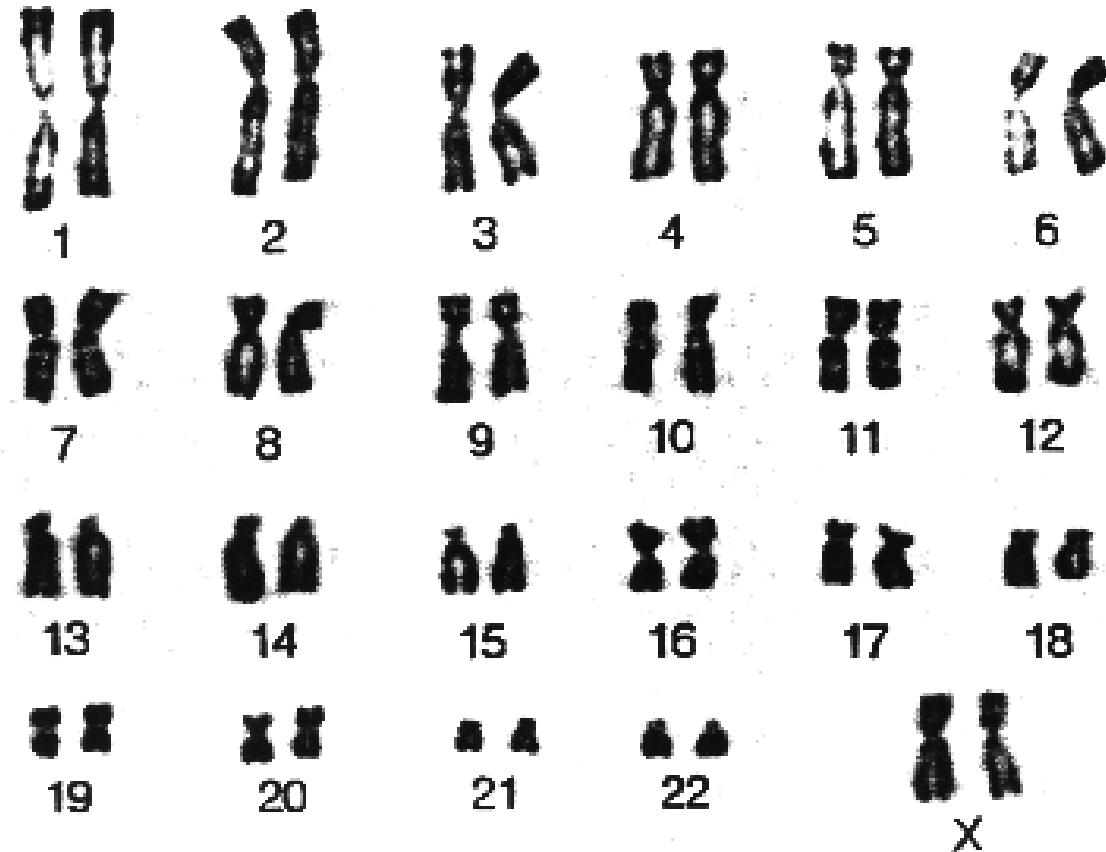


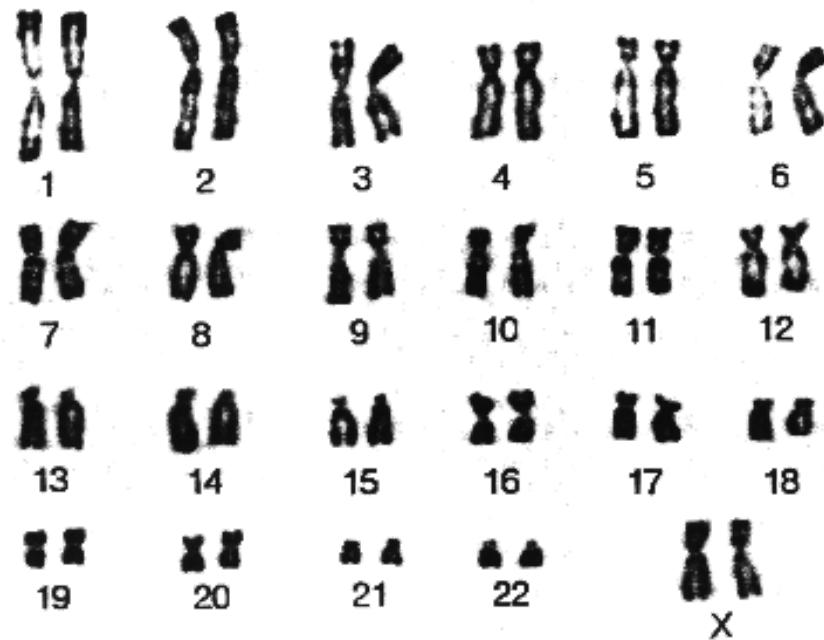
# Karyotype

- ✓ A **picture** of the chromosomes from a human cell **arranged in pairs by size**
- ✓ First 22 pairs are called **autosomes**
- ✓ Last pair are the **sex chromosomes**
- ✓ **XX** female or **XY** male

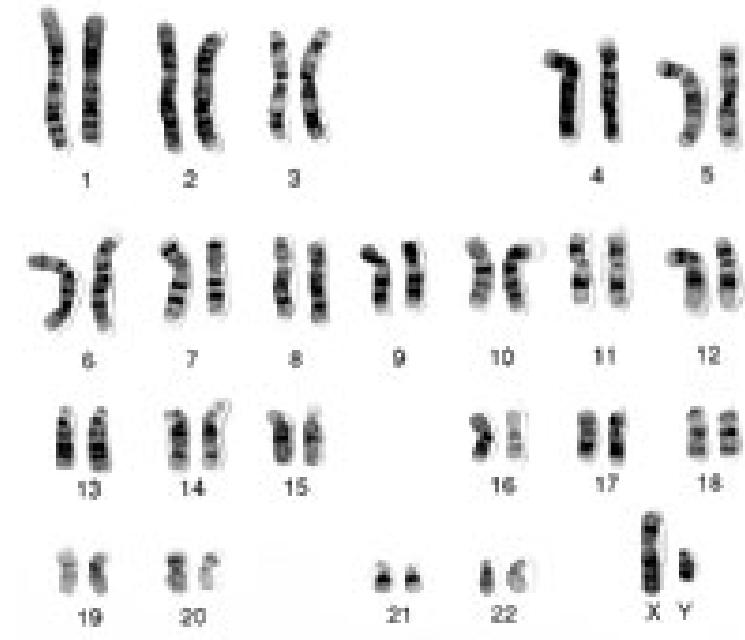


# The chromosomes of a human female





Female



Male

# DNA And Chromosomes

- An average eukaryotic cell has about 1,000 times more DNA than an average prokaryotic cell.
- The DNA in a eukaryotic cell is organized into several linear chromosomes, whose organization is much more complex than the single, circular DNA molecule in a prokaryotic cell

# Chromosomes

- All eukaryotic cells store genetic information in chromosomes.
  - Most eukaryotes have between 10 and 50 chromosomes in their body cells.
  - Human cells have 46 chromosomes.
  - 23 nearly-identical pairs

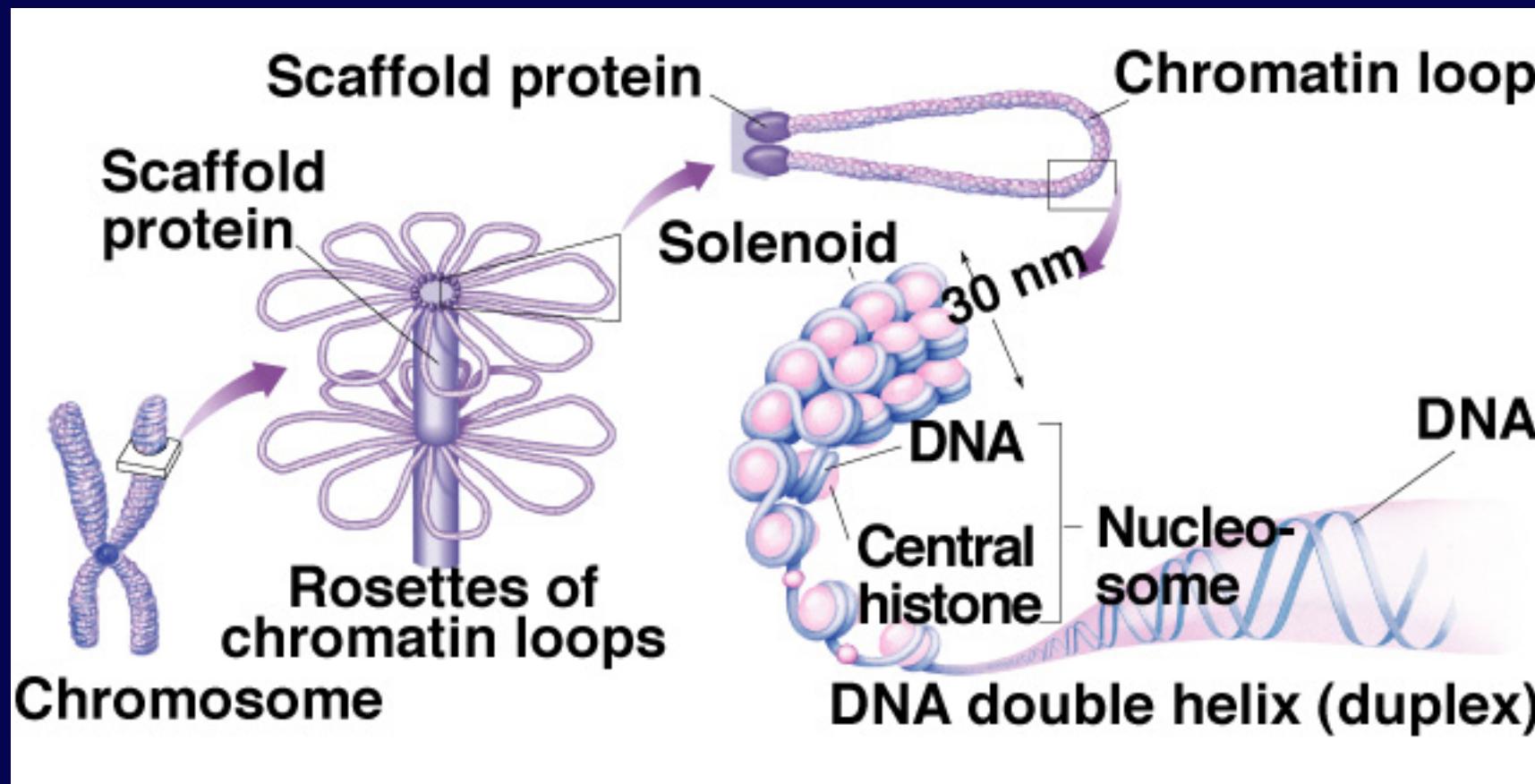


# Structure of Chromosomes

- Chromosomes are composed of a complex of DNA and protein called **chromatin** that condenses during cell division
- DNA exists as a single, long, double-stranded fiber extending chromosome's entire length.
- Each unduplicated chromosome contains one DNA molecule, which may be several inches long

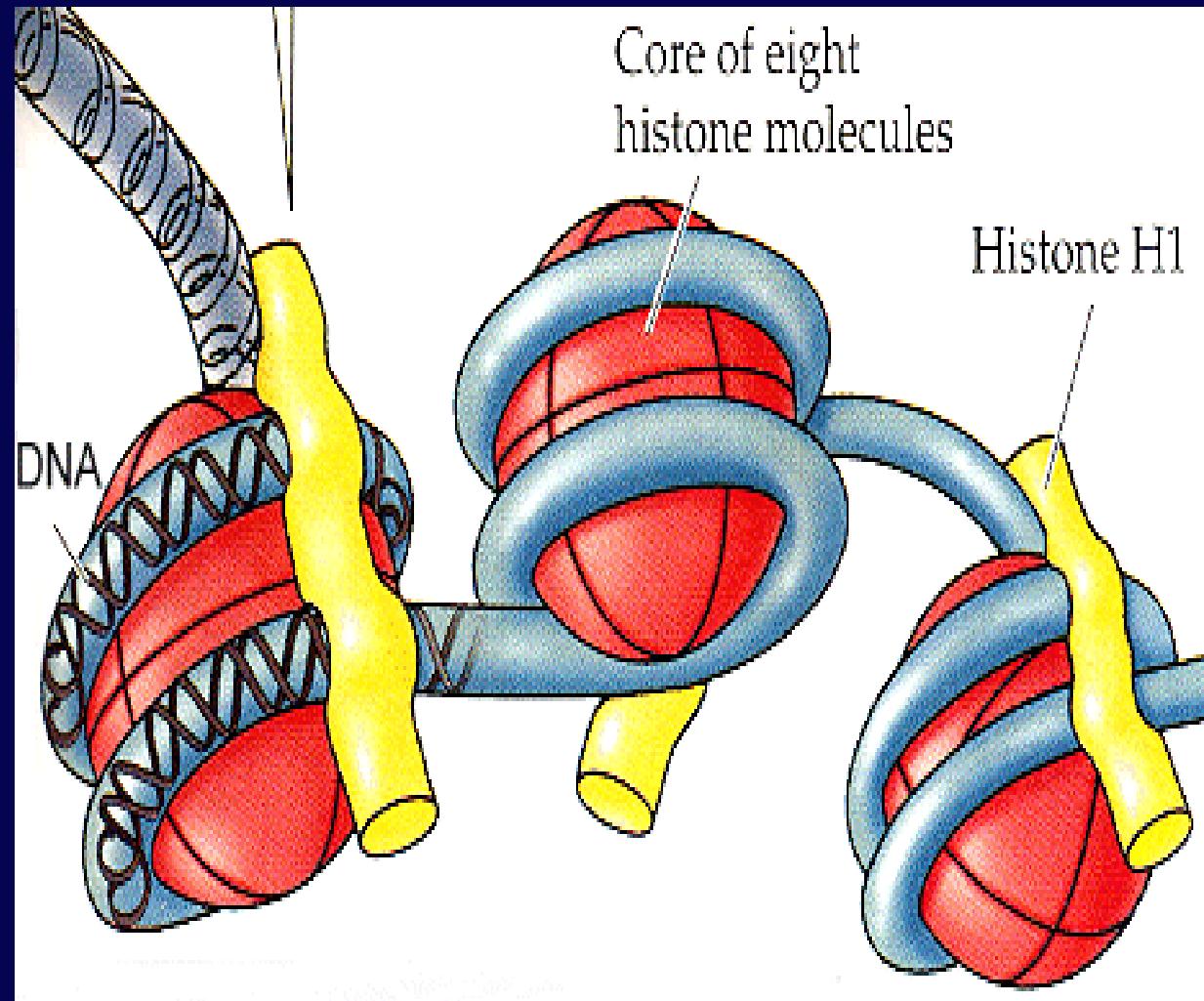
# Structure of Chromosomes

- Every 200 nucleotide pairs, the DNA wraps twice around a group of 8 histone proteins to form a nucleosome.
- Higher order coiling and supercoiling also help condense and package the chromatin inside the nucleus:



# Compacting DNA into Chromosomes

- ✓ DNA is tightly coiled around proteins called histones

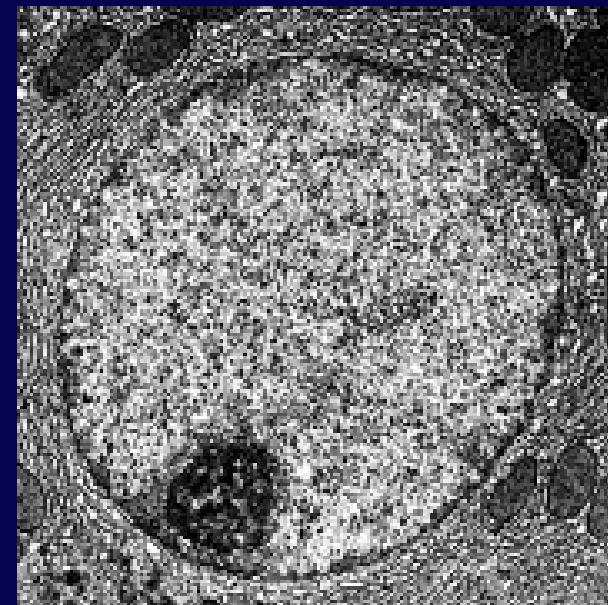


# Structure of Chromosomes

- The degree of coiling can vary in different regions of the chromatin:
- **Heterochromatin** refers to highly coiled regions where genes aren't expressed.
- **Euchromatin** refers to loosely coiled regions where genes can be expressed.

# Structure of Chromosomes

- Prior to cell division each chromosome duplicates itself.
- During this time, only the heterochromatin is visible, as dense granules inside the nucleus.
- There is also a dense area of RNA production called the nucleolus:

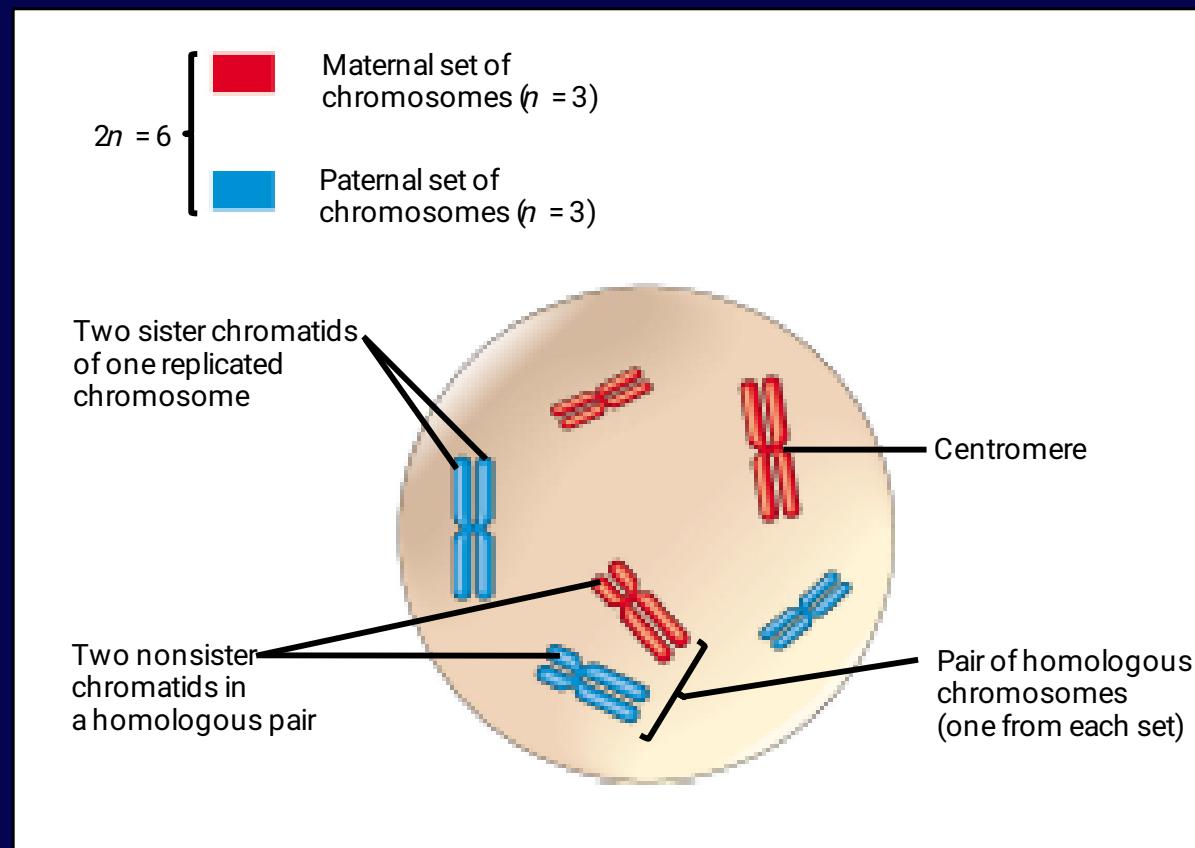


# Chromosomes

- Non-homologous chromosomes
  - Look different
  - Control different traits
- Sex chromosomes
  - Are distinct from each other in their characteristics
  - Are represented as X and Y
  - Determine the sex of the individual, XX being female, XY being male
- In a diploid cell, the chromosomes occur in pairs. The 2 members of each pair are called homologous chromosomes or homologues.

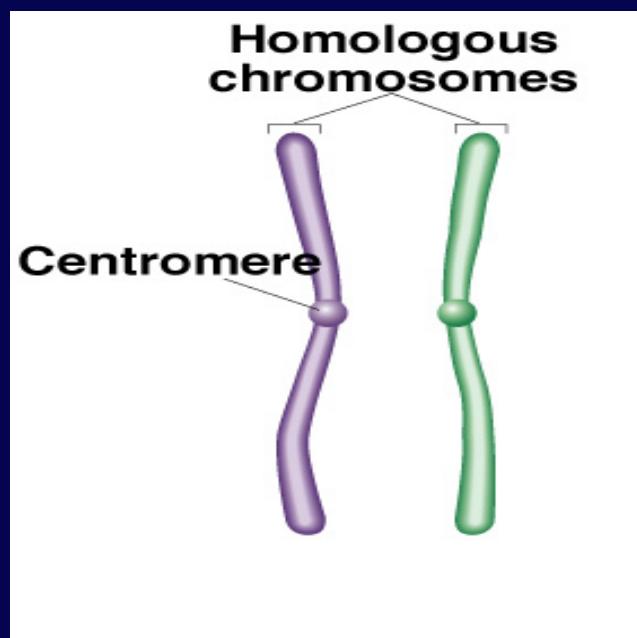
# Chromosomes

- A diploid cell has two sets of each of its chromosomes
- A human has 46 chromosomes ( $2n = 46$ )
- In a cell in which DNA synthesis has occurred all the chromosomes are duplicated and thus each consists of two identical sister chromatids



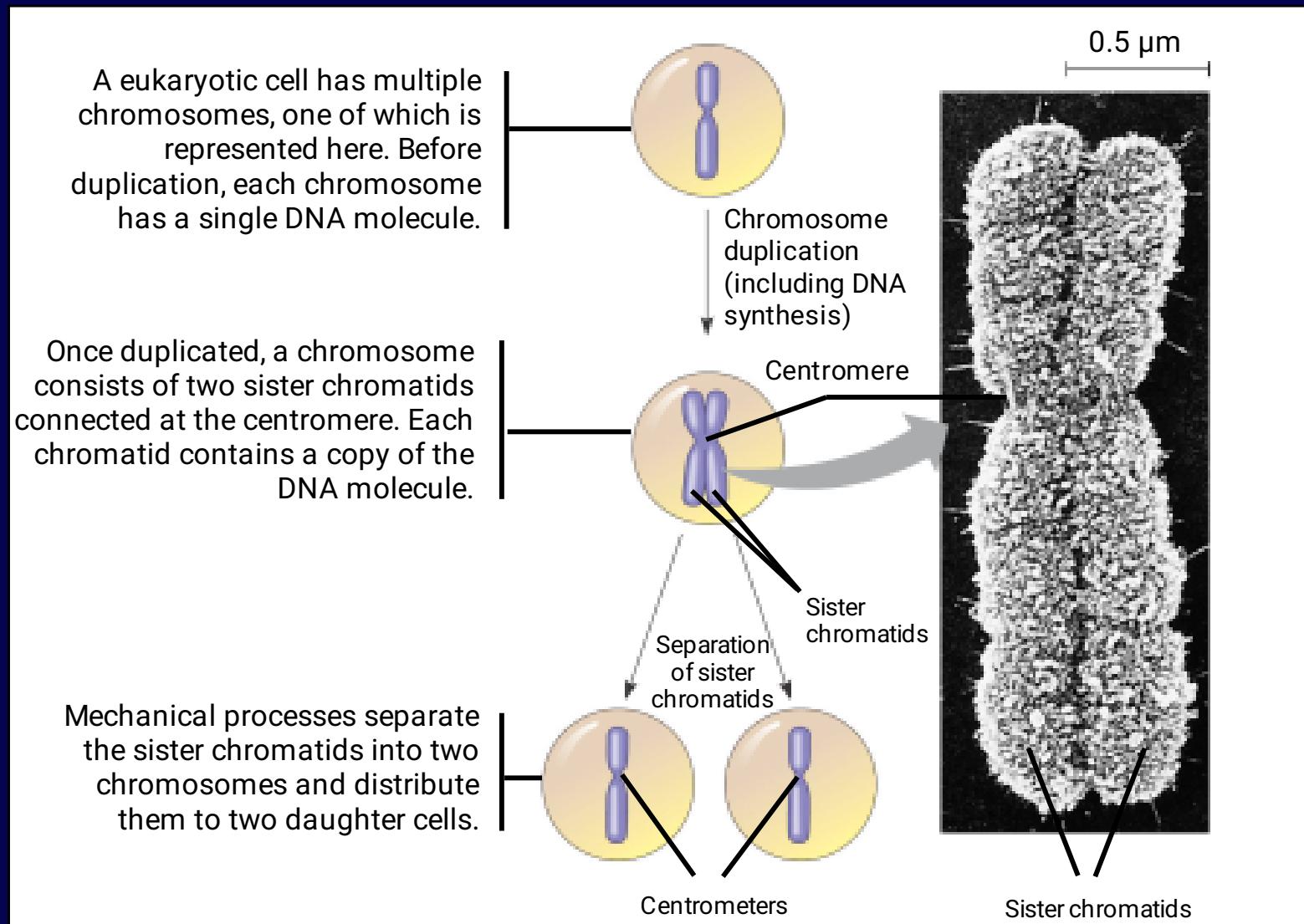
# Homologues

- Homologous chromosomes:
  - Look the same
  - Control the same traits
  - May code for different forms of each trait
  - Independent origin - each one was inherited from a different parent



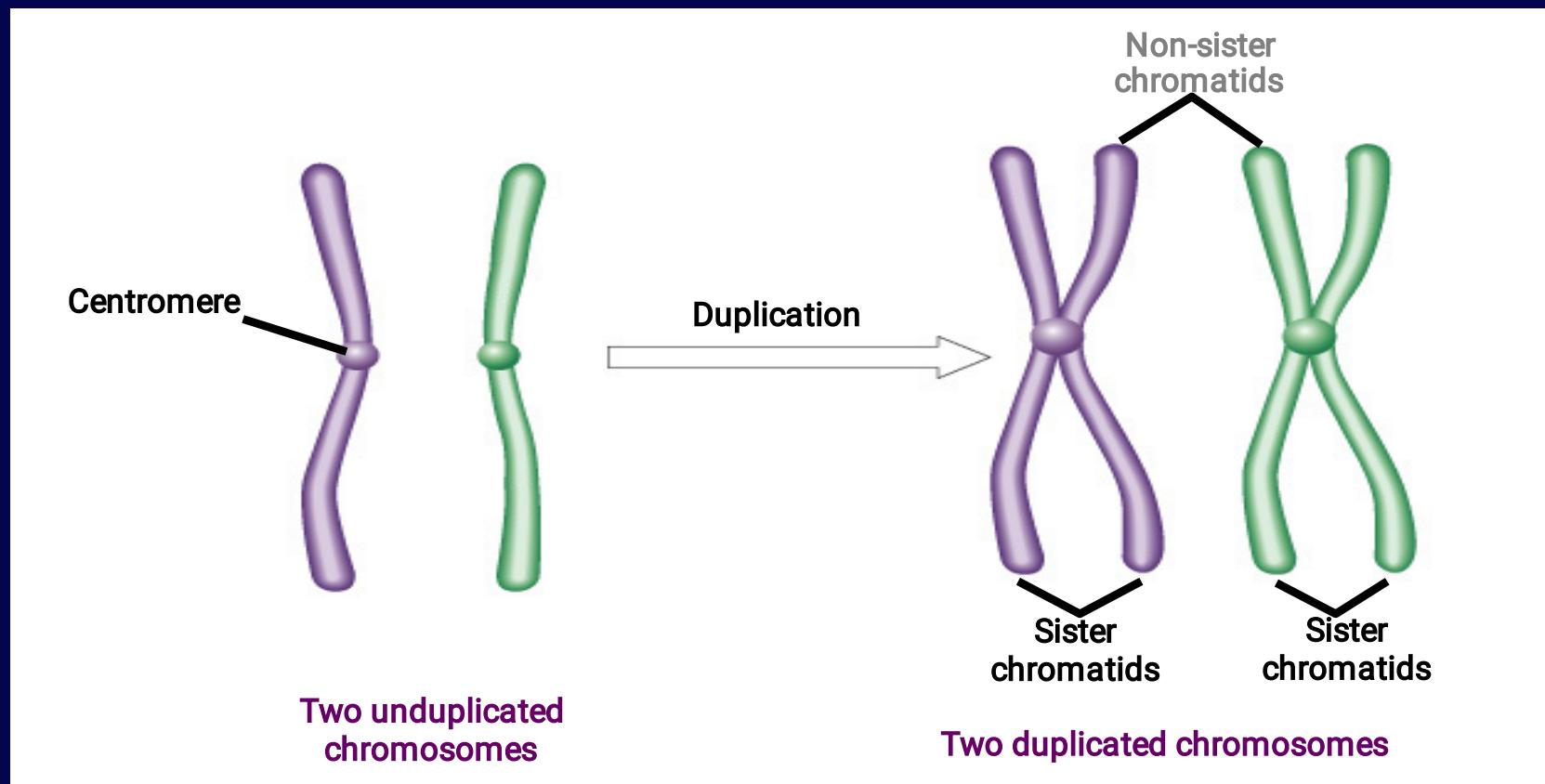
# Chromosome Duplication

- In preparation for cell division, DNA is replicated and the chromosomes condense
- Each duplicated chromosome has two sister chromatids, which separate during cell division



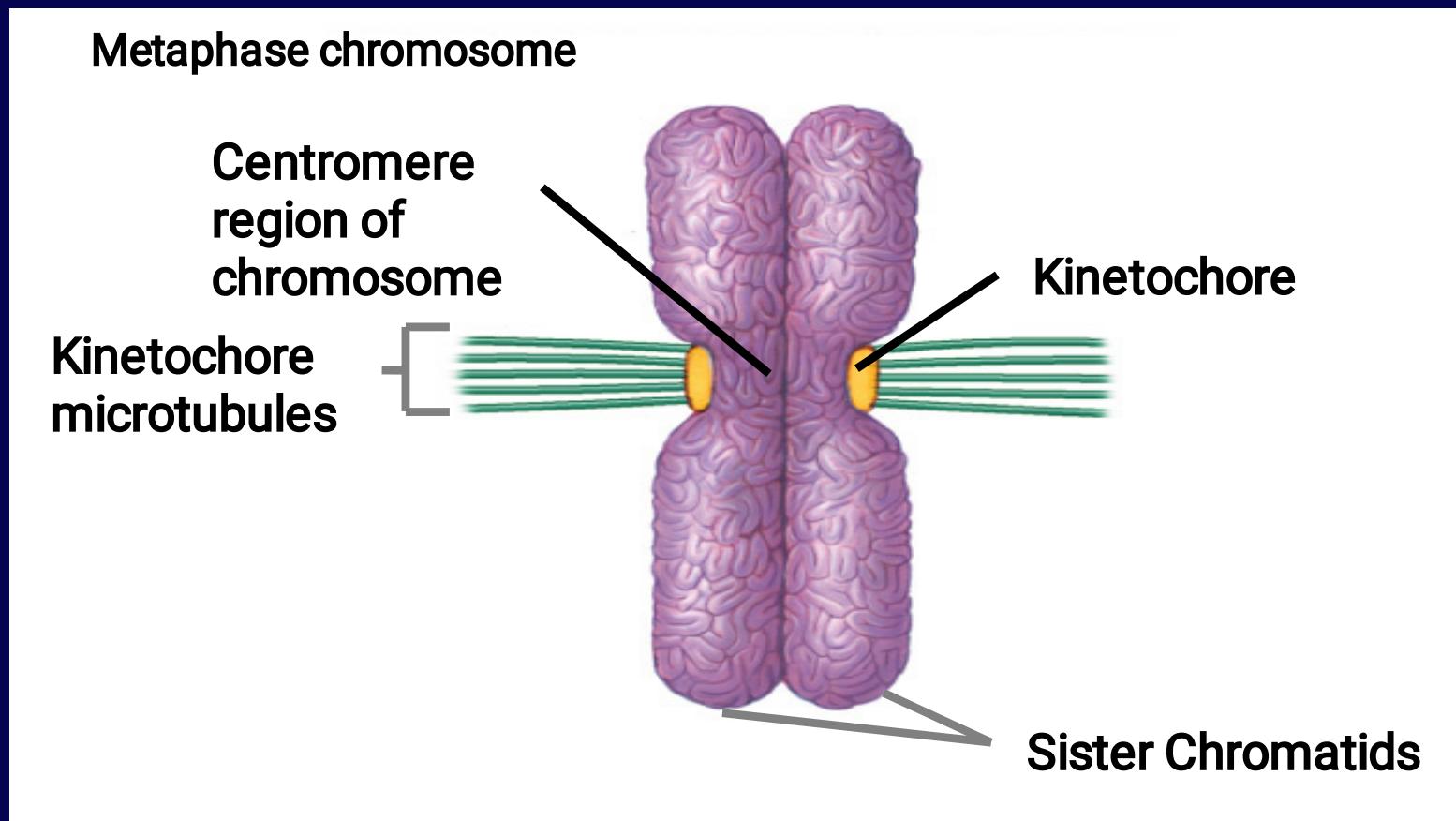
# Chromosome Duplication

- Because of duplication, each condensed chromosome consists of 2 identical chromatids joined by a centromere.
- Each duplicated chromosome contains 2 identical DNA molecules (unless a mutation occurred), one in each chromatid:



# Structure of Chromosomes

- The centromere is a constricted region of the chromosome containing a specific DNA sequence, to which is bound 2 discs of protein called kinetochores.
- Kinetochores serve as points of attachment for microtubules that move the chromosomes during cell division:



# Structure of Chromosomes

- Diploid - A cell possessing two copies of each chromosome (human body cells).
  - . Homologous chromosomes are made up of sister chromatids joined at the centromere.
- Haploid - A cell possessing a single copy of each chromosome (human sex cells).

