# 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 endoncleases. 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.

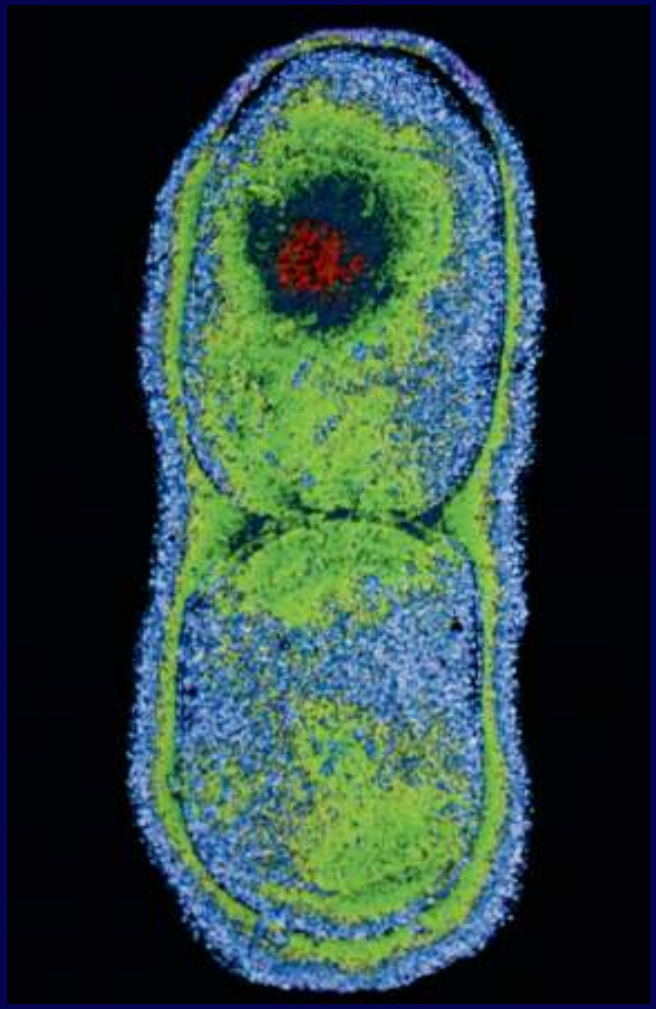
**Recommended Reading**


- 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

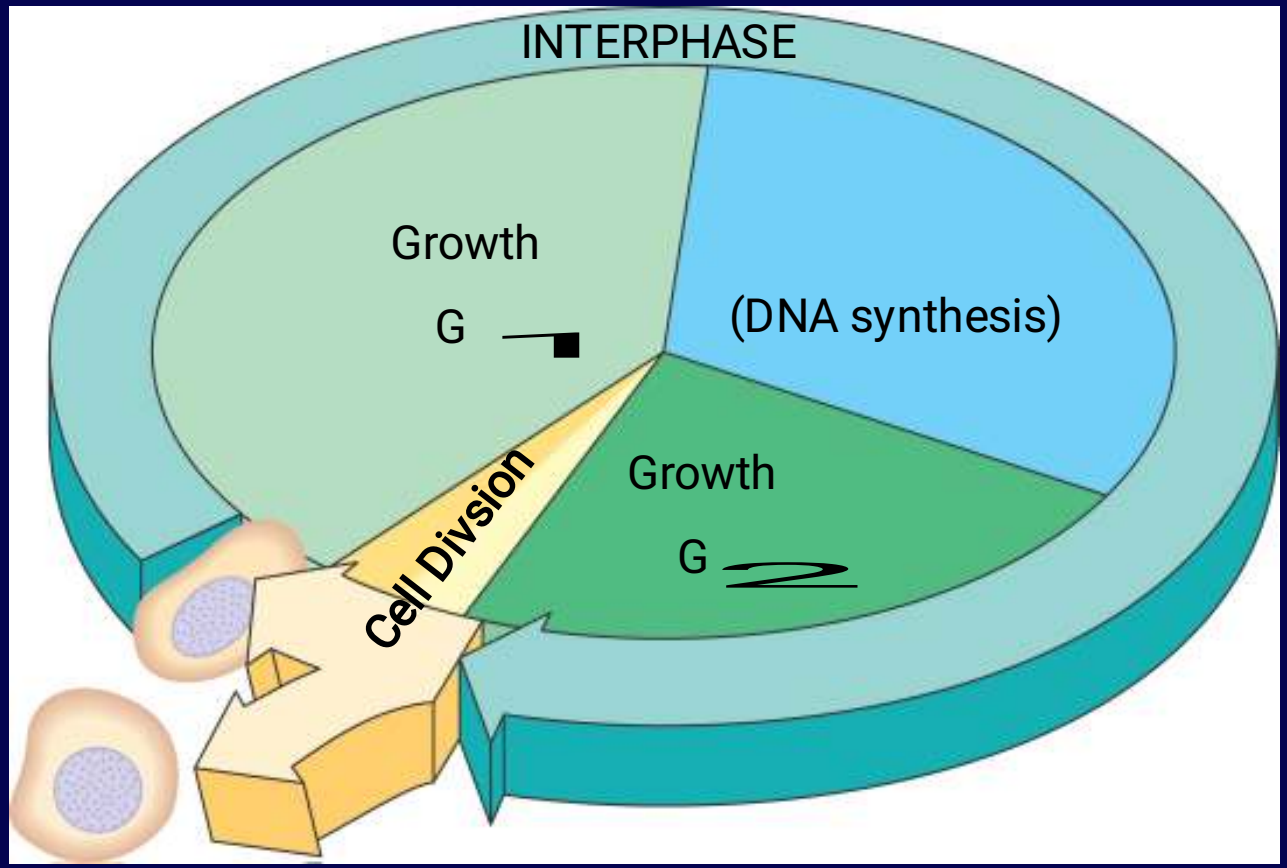
- 1st Mid Sem-1 (25 marks)
- 2nd Mid Sem-1 (25 marks)
- Qizzes-2 (10 marks)
- Final Sem-1 (40 marks)

# 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 divsion



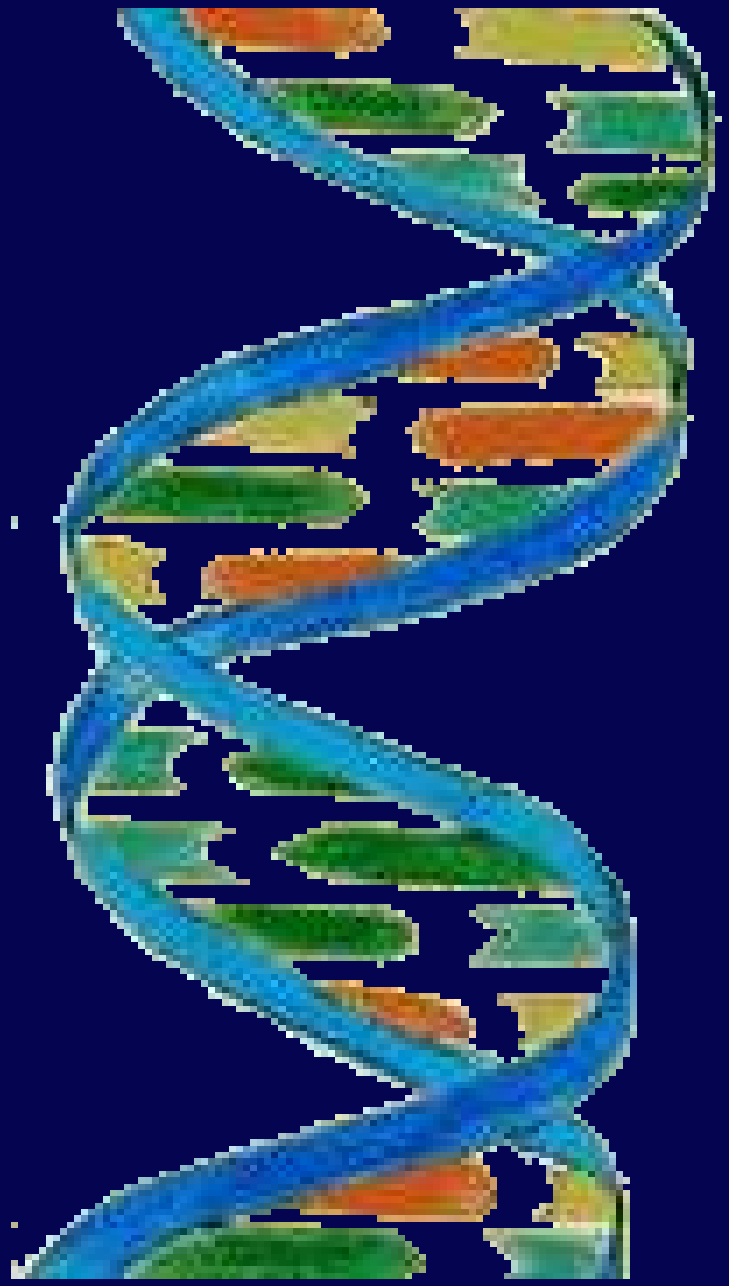
# Cellular Division

# 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)

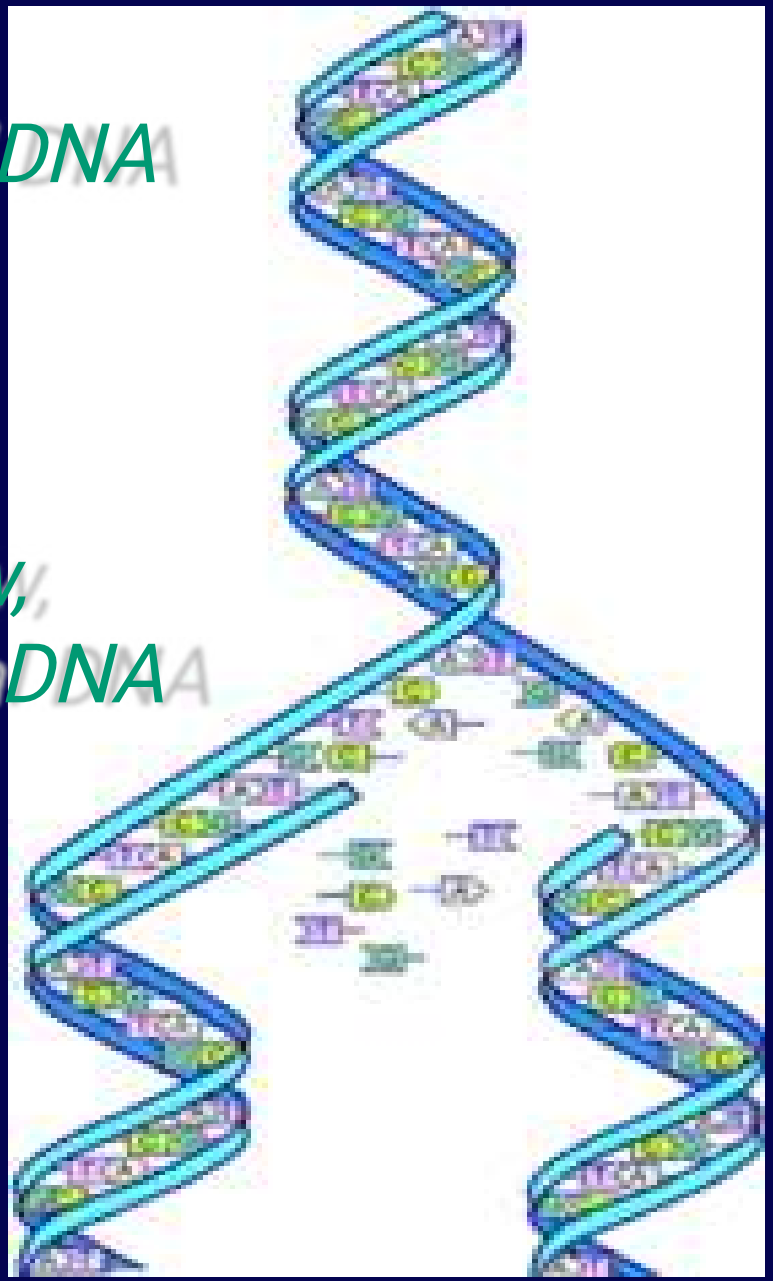
# Keeping Cells Identical

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

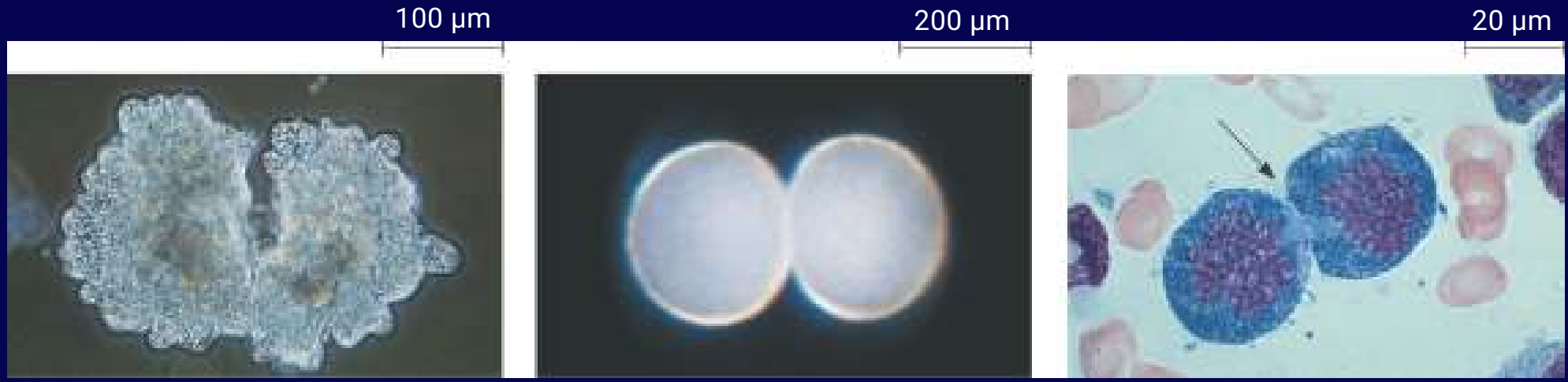


# DNA Replication

- DNA must be copied or replicated before cell division
- Each new cell will then have an identical copy of the DNA



# 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

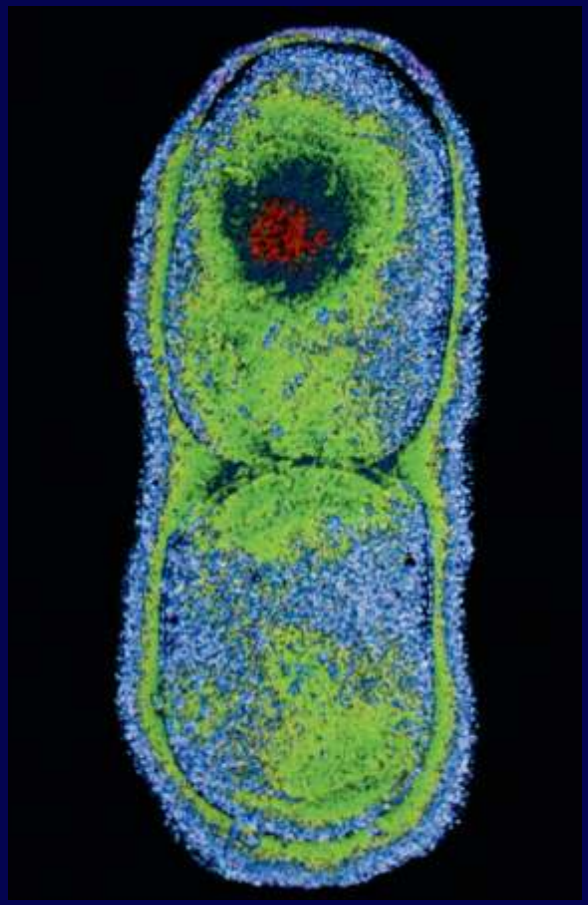
- An integral part of the cell cycle
- Results in genetically identical daughter cells
- Cells duplicate their genetic material
  - Before they divide, ensuring that each daughter cell receives an exact copy of the genetic material, DNA

# Cell Reproduction

# Types of Cell Reproduction

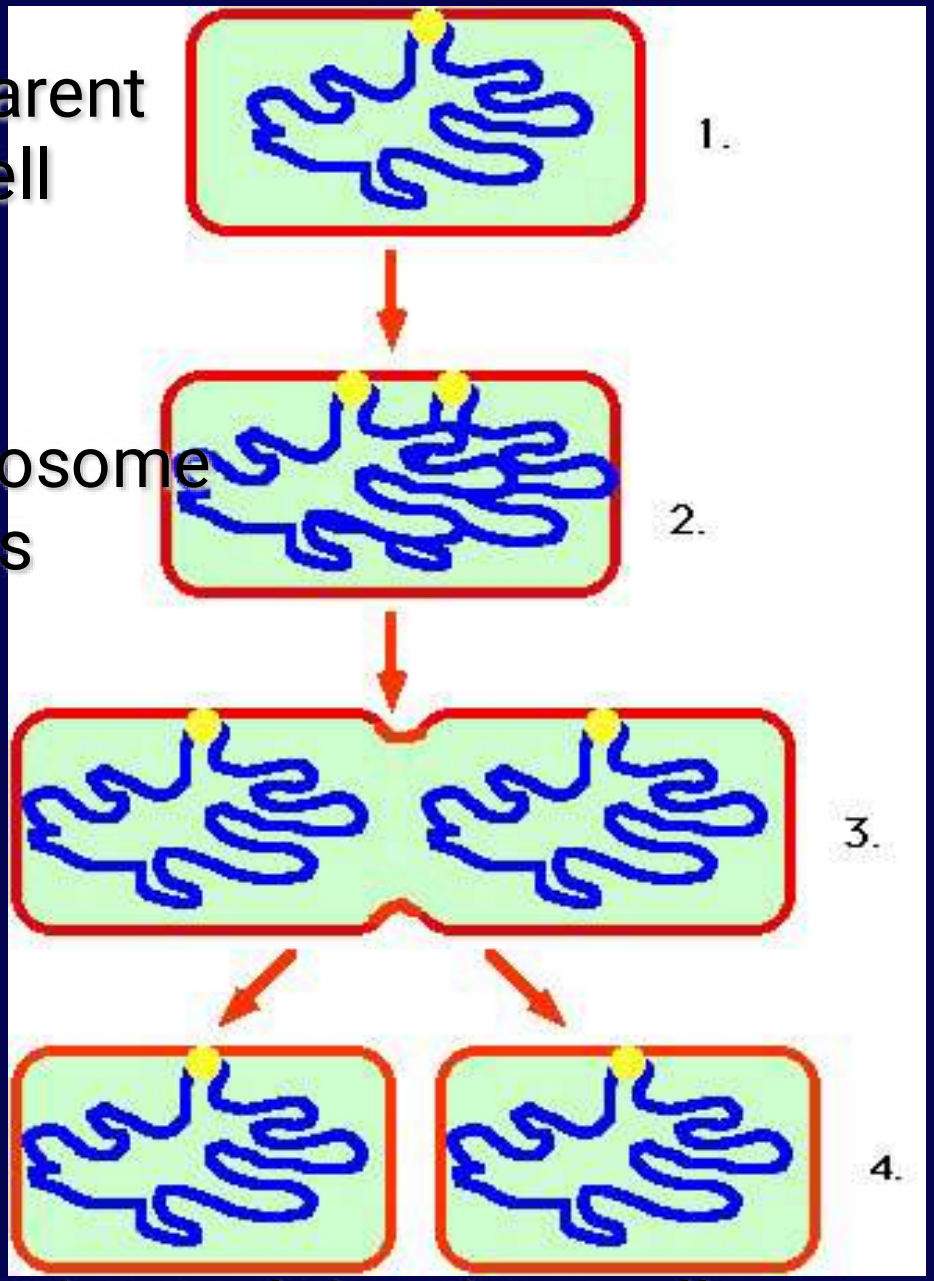
- Asexual reproduction involves a single cell dividing to make 2 new, identical daughter cells
- Mitosis & binary fission are examples of asexual reproduction
- Sexual reproduction involves two cells (egg & sperm) joining to make a new cell (zygote) that is NOT identical to the original cells
- Meiosis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

# Cell Division in Prokaryotes

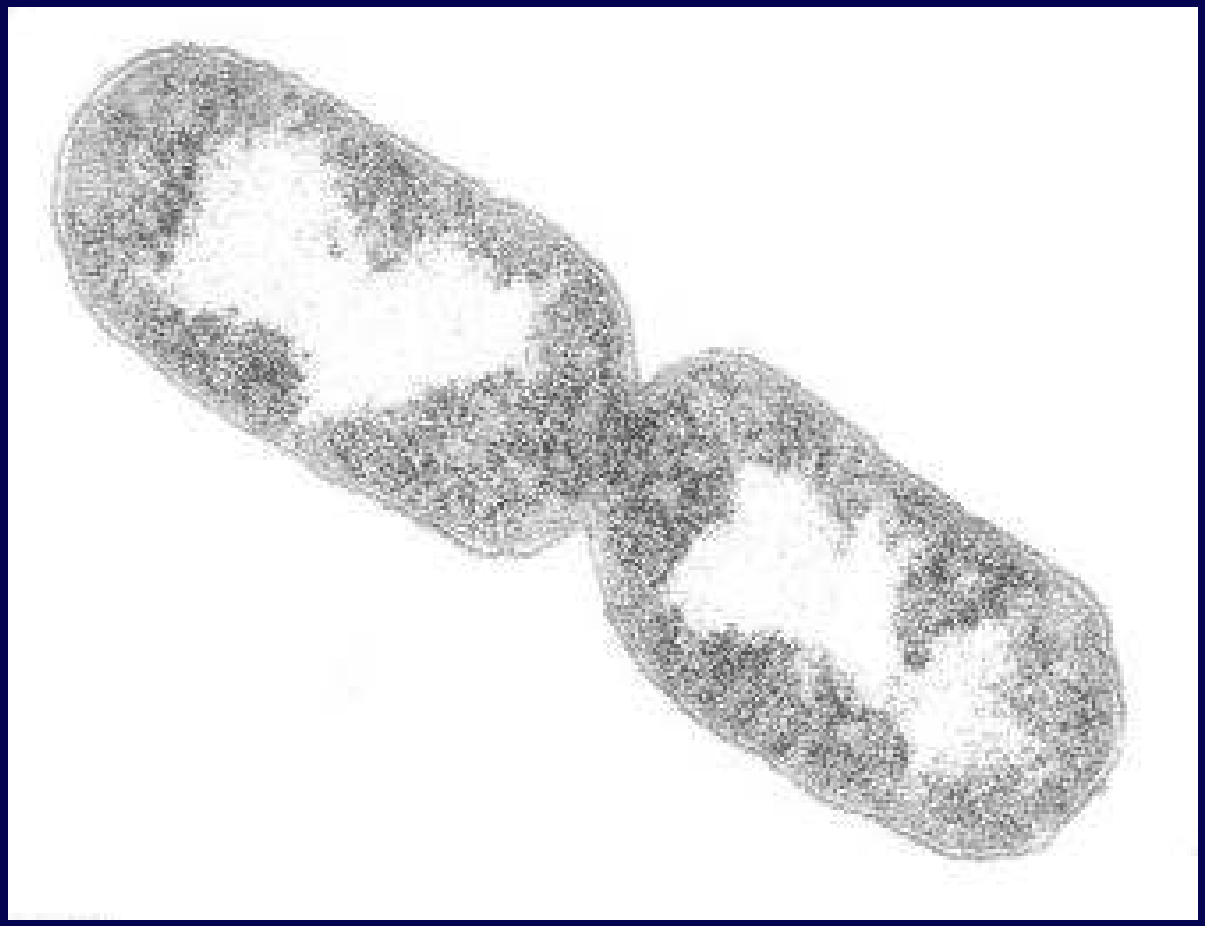


# Cell Division in Prokaryotes

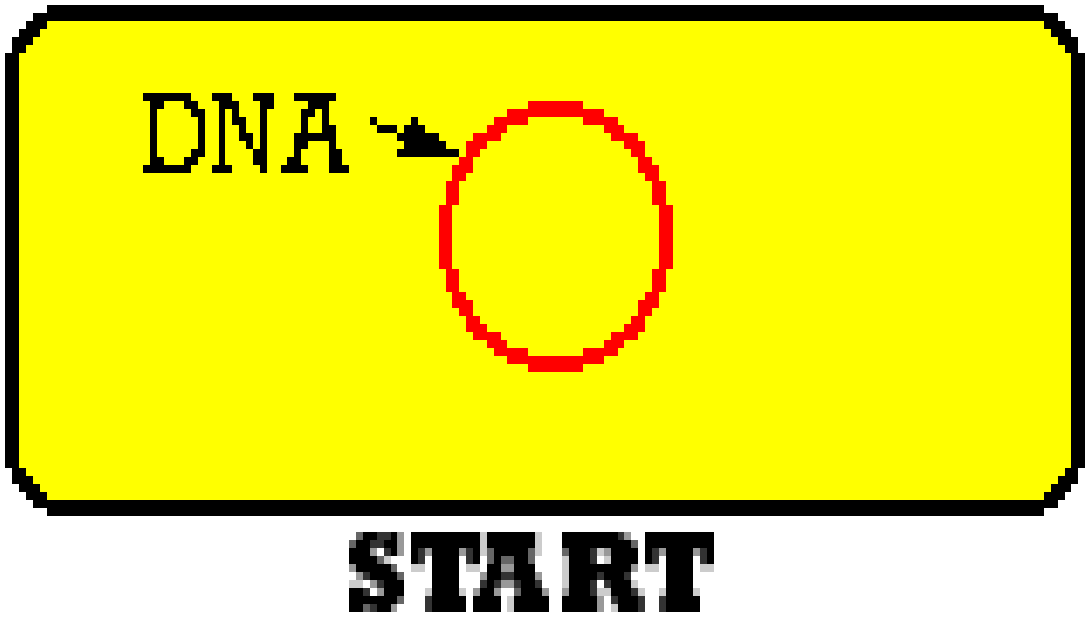
- Prokaryotes such as bacteria divide into 2 identical cells by the process of binary fission
- Single chromosome makes a copy of itself
- Cell wall forms between the chromosomes dividing the cell



# Prokaryotic Cell Undergoing Binary Fission

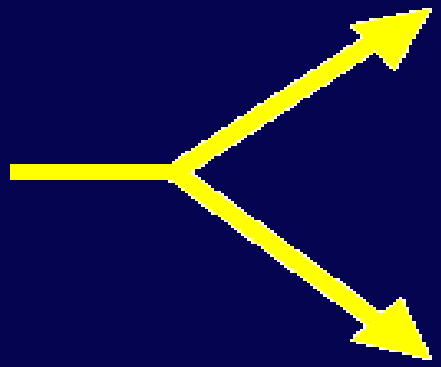


# Animation of Binary Fission



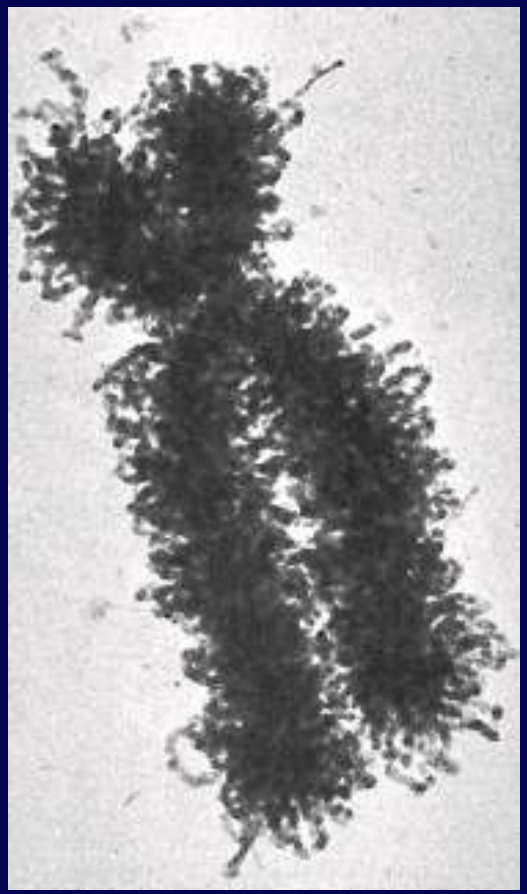
# Identical Daughter Cells

Parent Cell



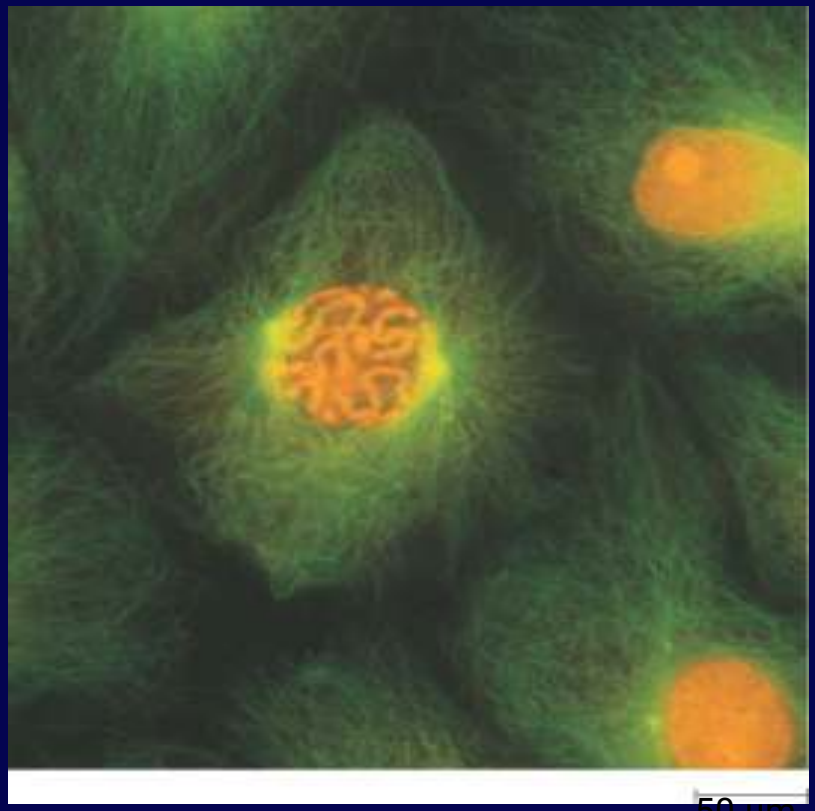
Two identical daughter cells

# Chromosomes



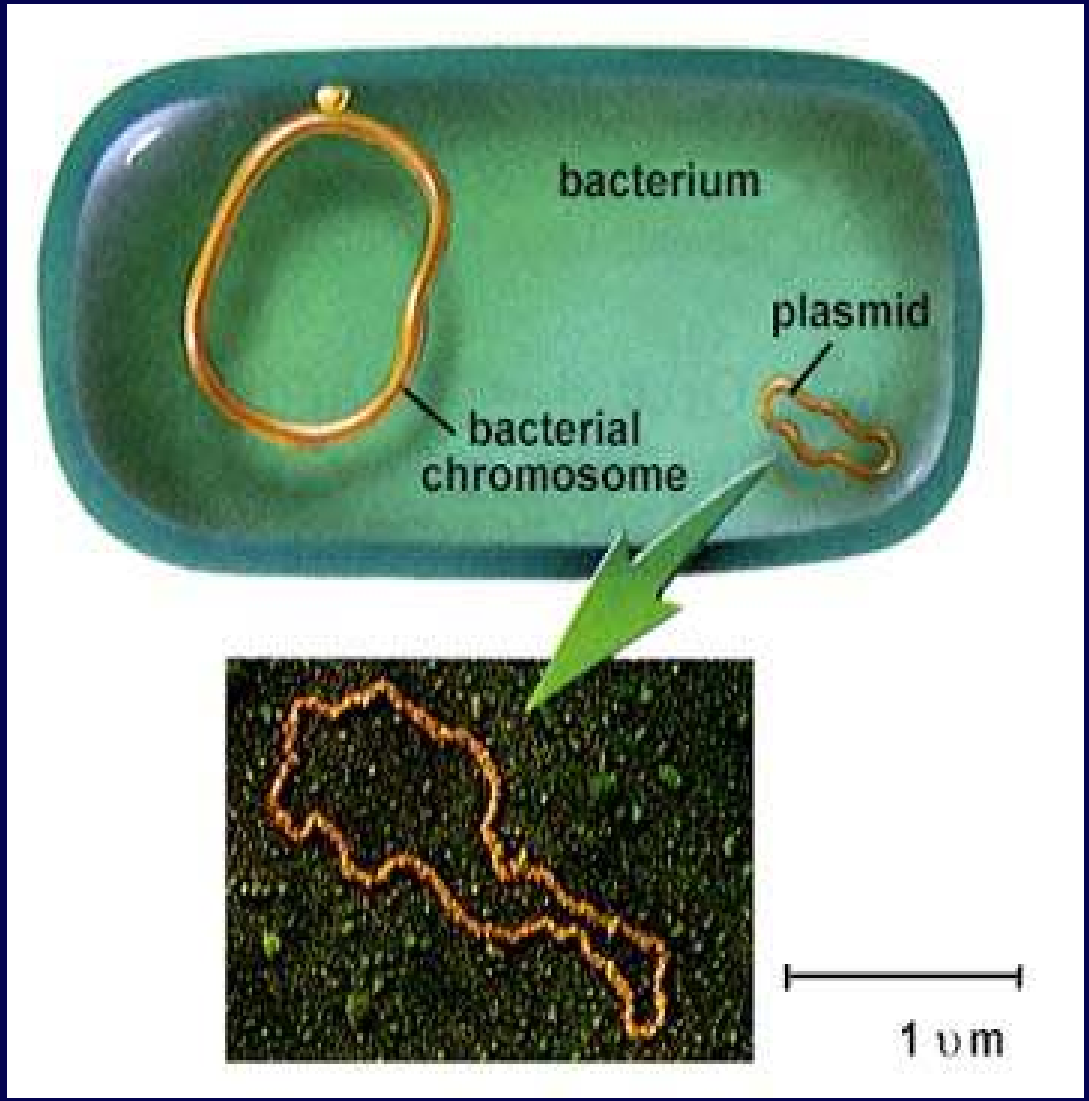
# DNA

- Genetic information - genome
- Packaged into chromosomes



# Prokaryotic Chromosome

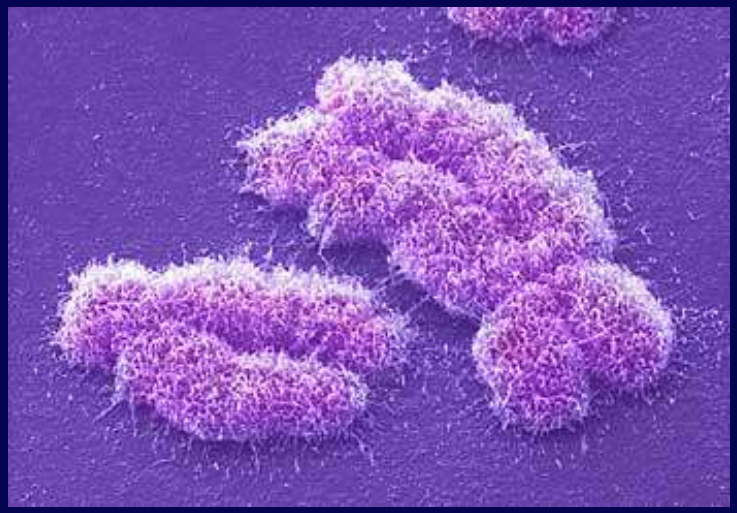
- The DNA of prokaryotes (bacteria) is one, circular chromosome attached to the inside of the cell membrane



# 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



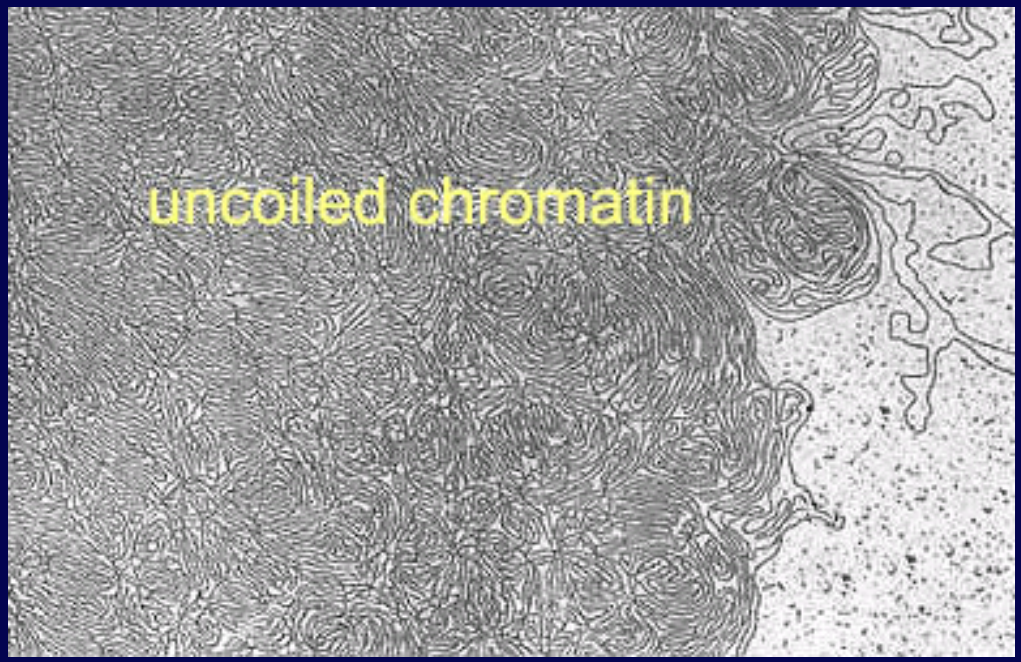
- Found in the nucleus
- Condensed and visible during cell division
- At the beginning of mitosis they can be seen to consist of two threads (sister chromatids) joined by a centromere
- The sister chromatids are identical copies
- During mitosis the sister chromatids separate and are placed into two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

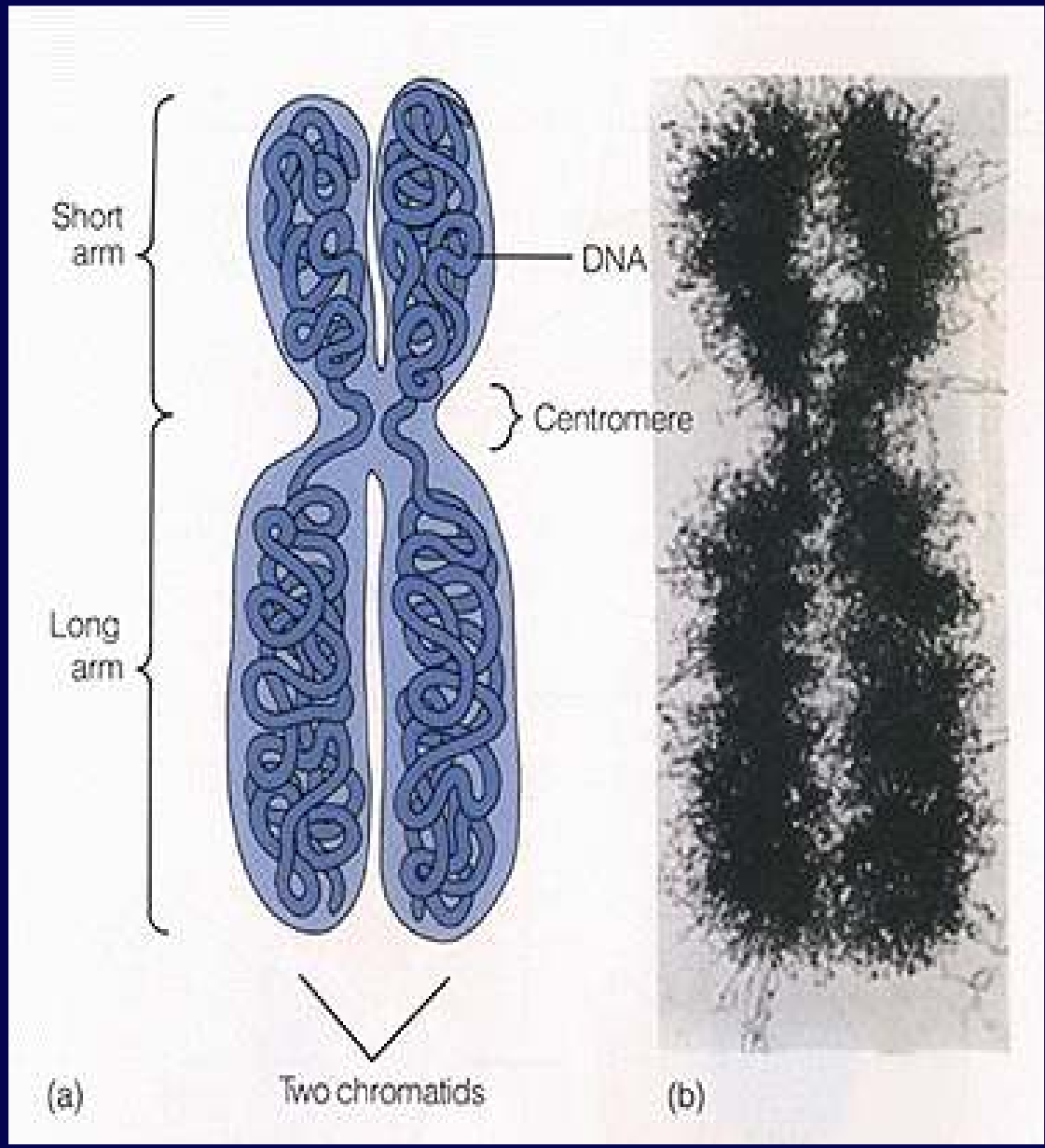
# Eukaryotic Chromosomes

- 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

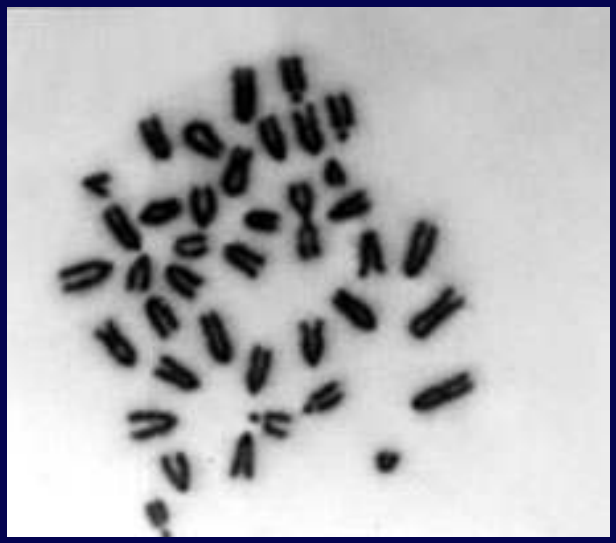
- Duplicated chromosomes are called **chromatids** & are held together by the **centromere**



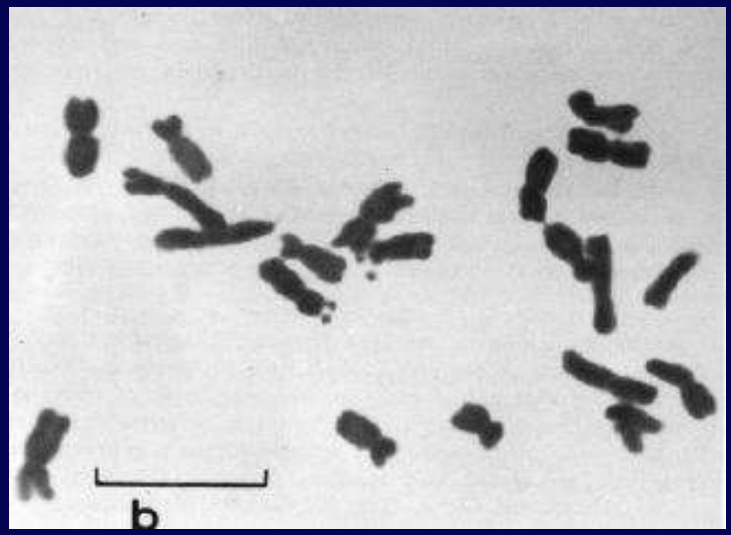

Called Sister Chromatids

# 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



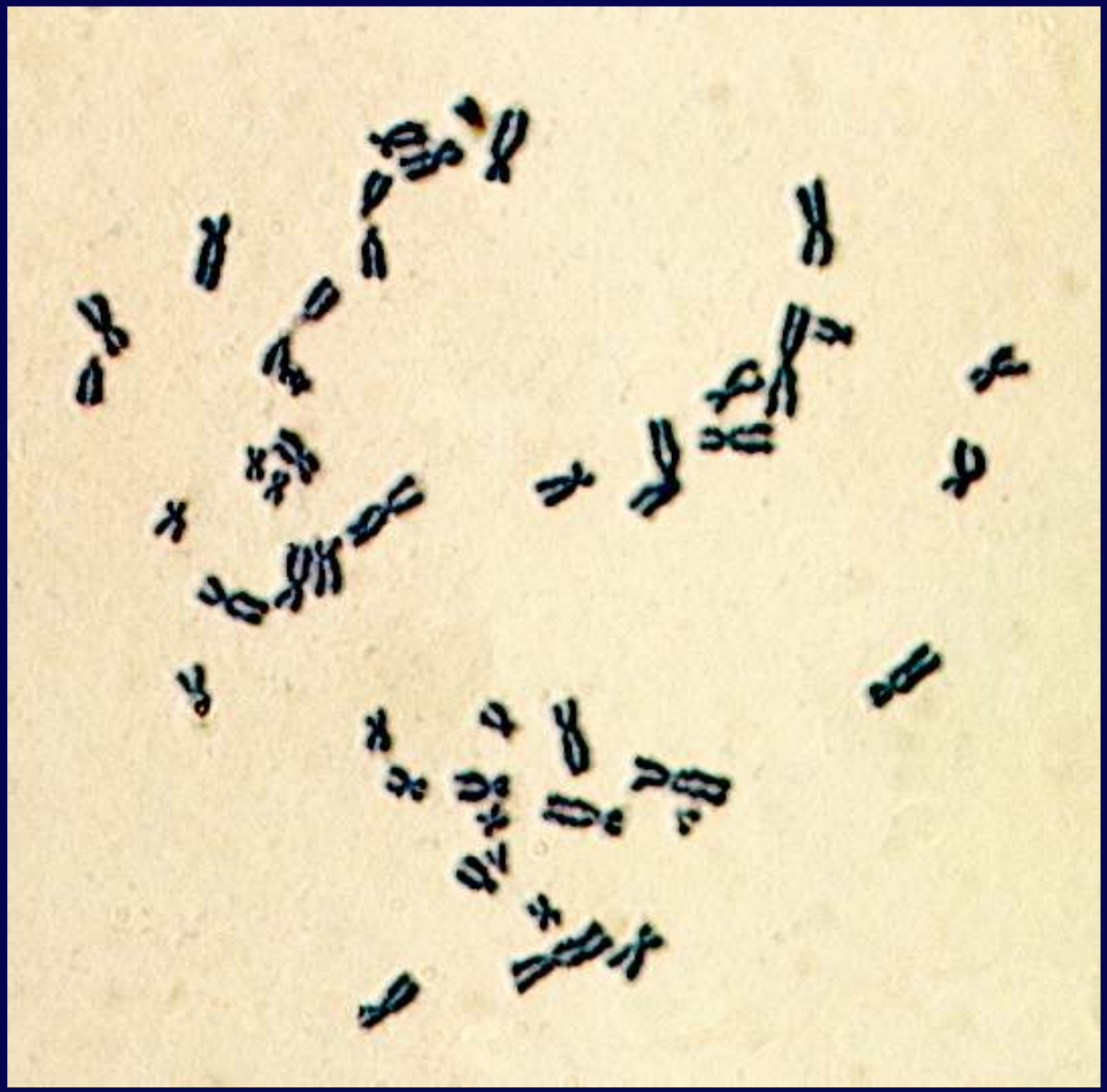
Mouse




Maize

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

# Human chromosomes

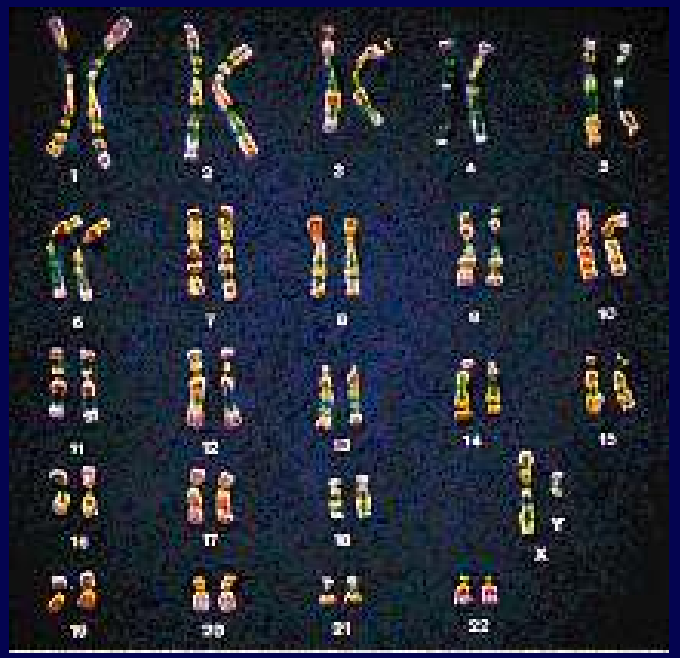


# Identifying chromosomes

Chromosomes can be identified by:

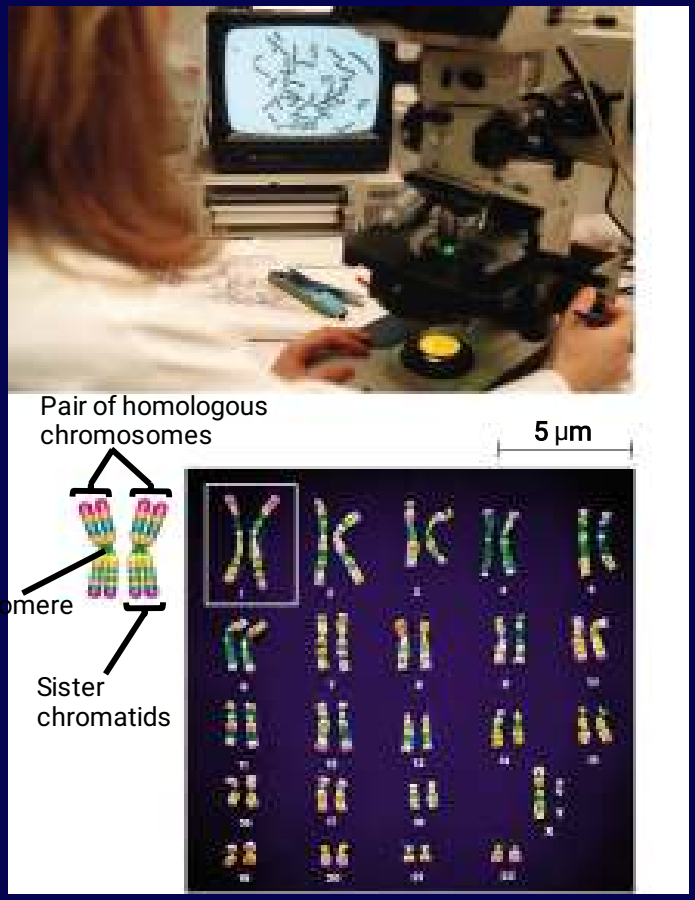
- Their size
- Their shape (the position of the centromere)
  NB Chromosomes are flexible
- Banding patterns produced by specific stains (Giemsa)

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



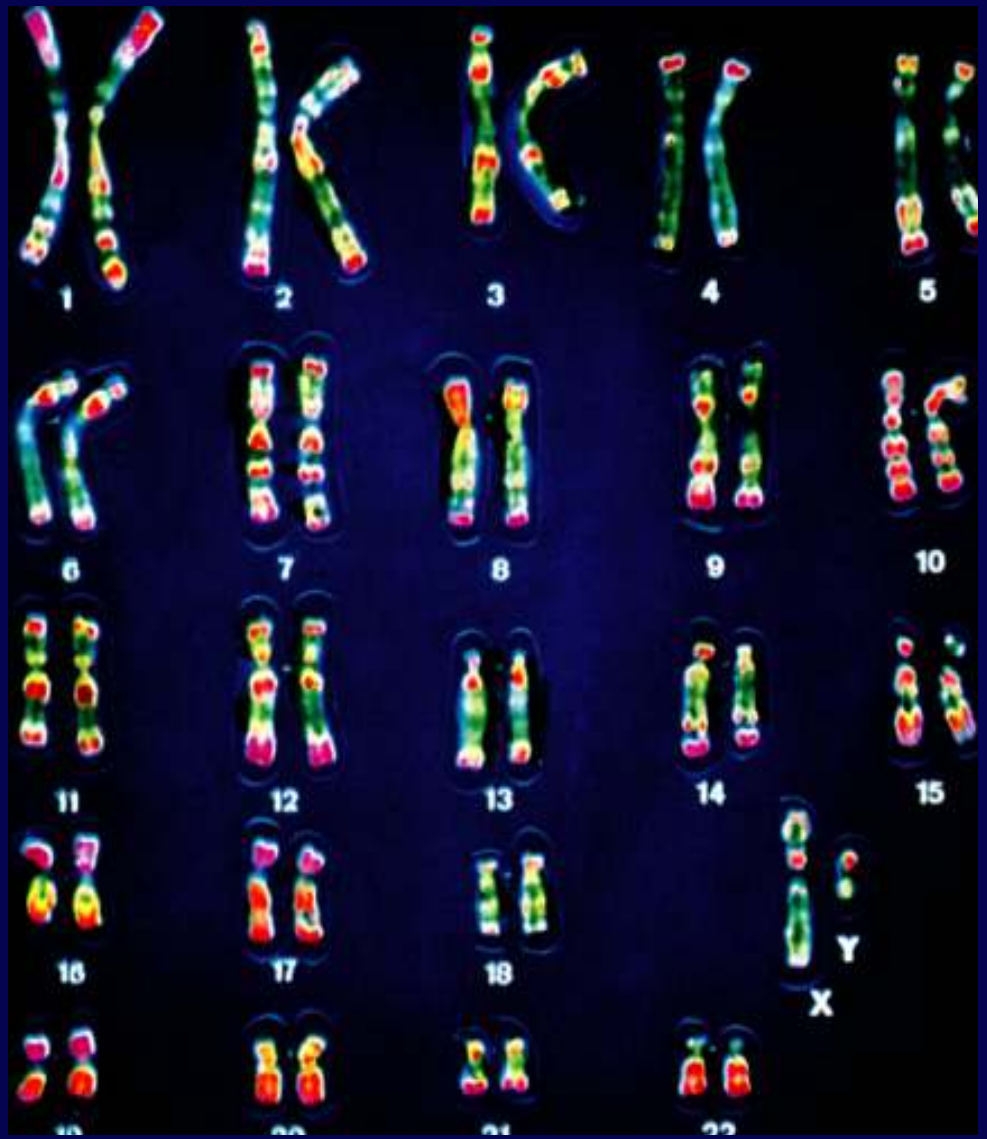
# Karyotype

- 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

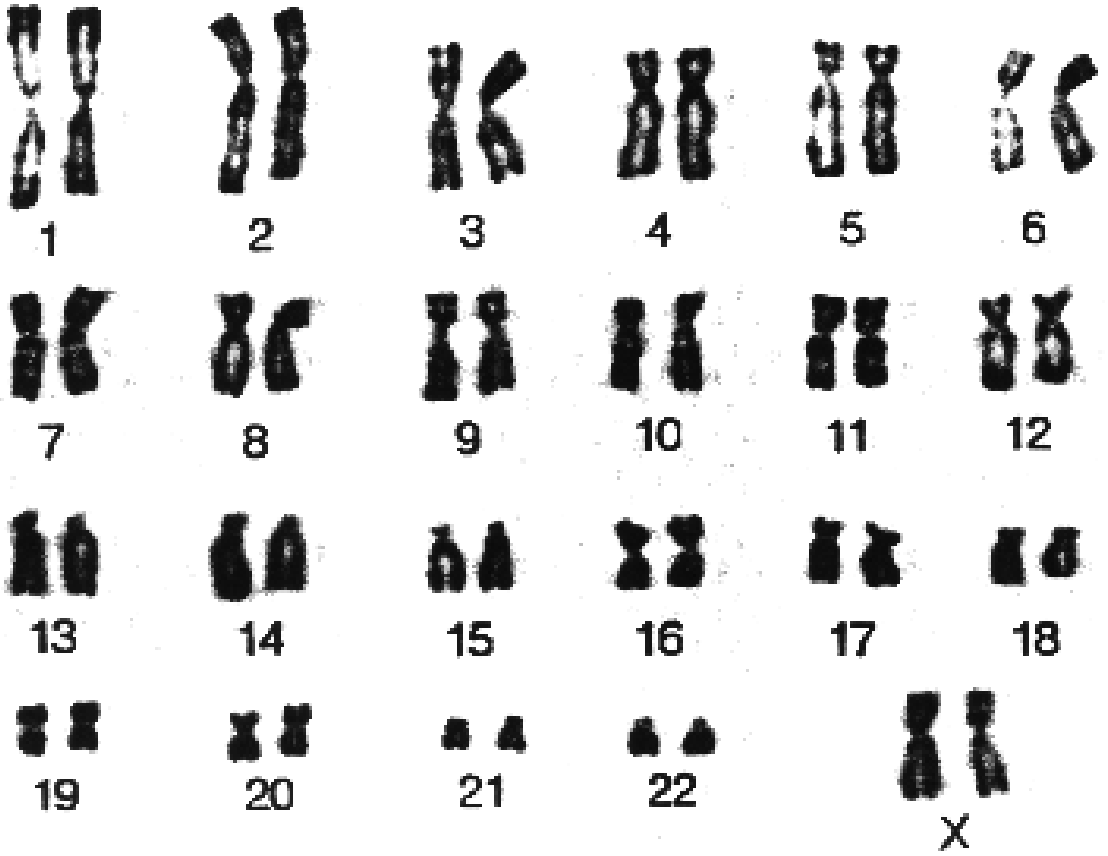


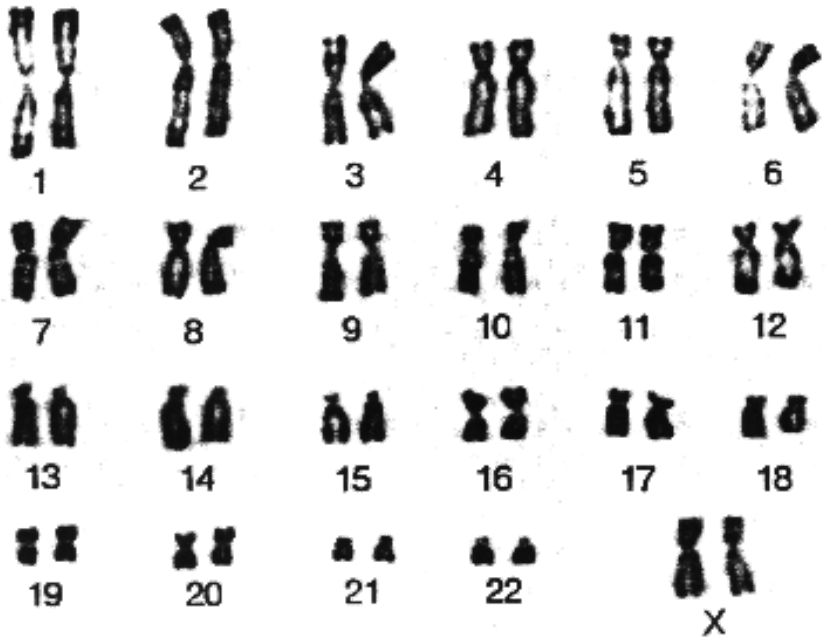
# Karyotype

- 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

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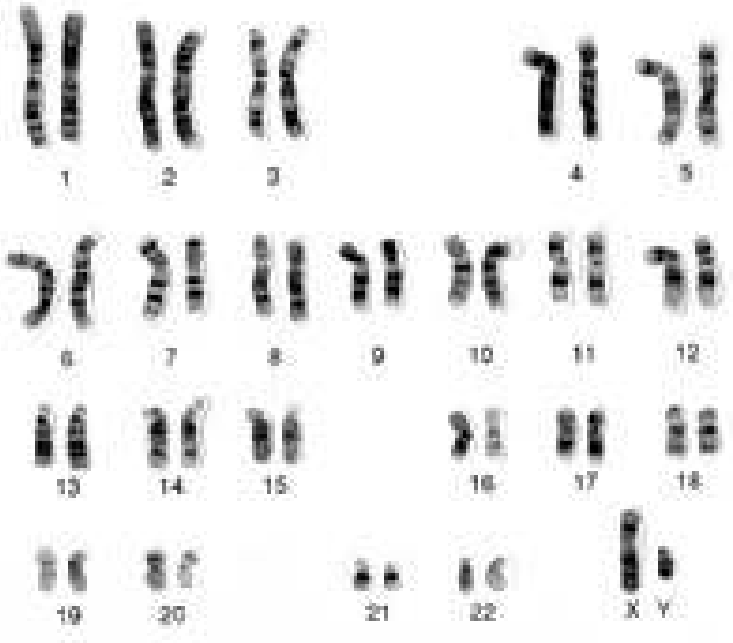
Female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Male

# DNA And Chromosomes

- An average eukaryotic cell has about 1,000 times more DNA then 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

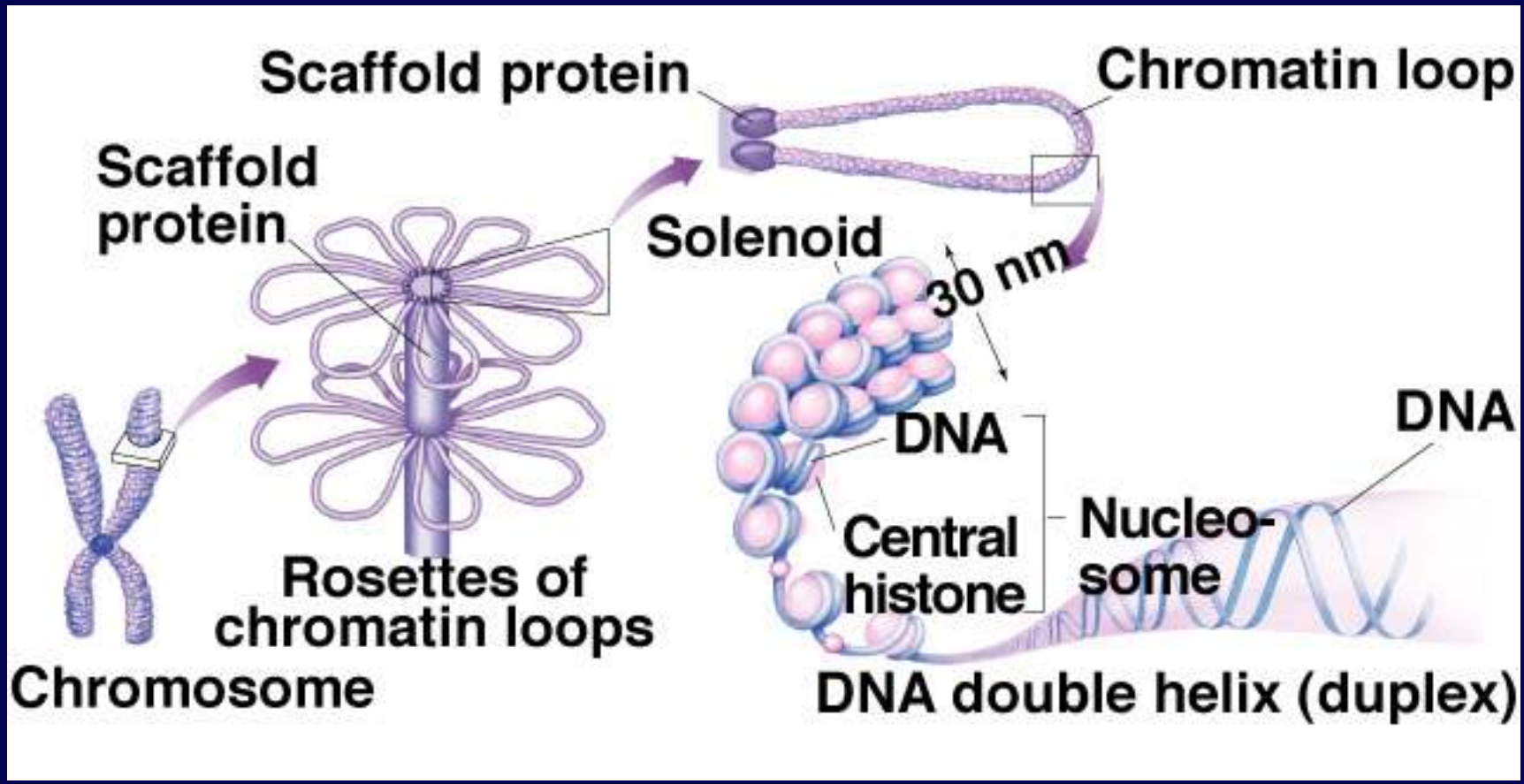
- All eukaryotic cells store genetic information in chromosomes.
  - Most eukaryotes have between 10 and 50 chromosomes in their body cells.
  - Human cells have 46 chromosomes.
  - 23 nearly-identical pairs

# 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

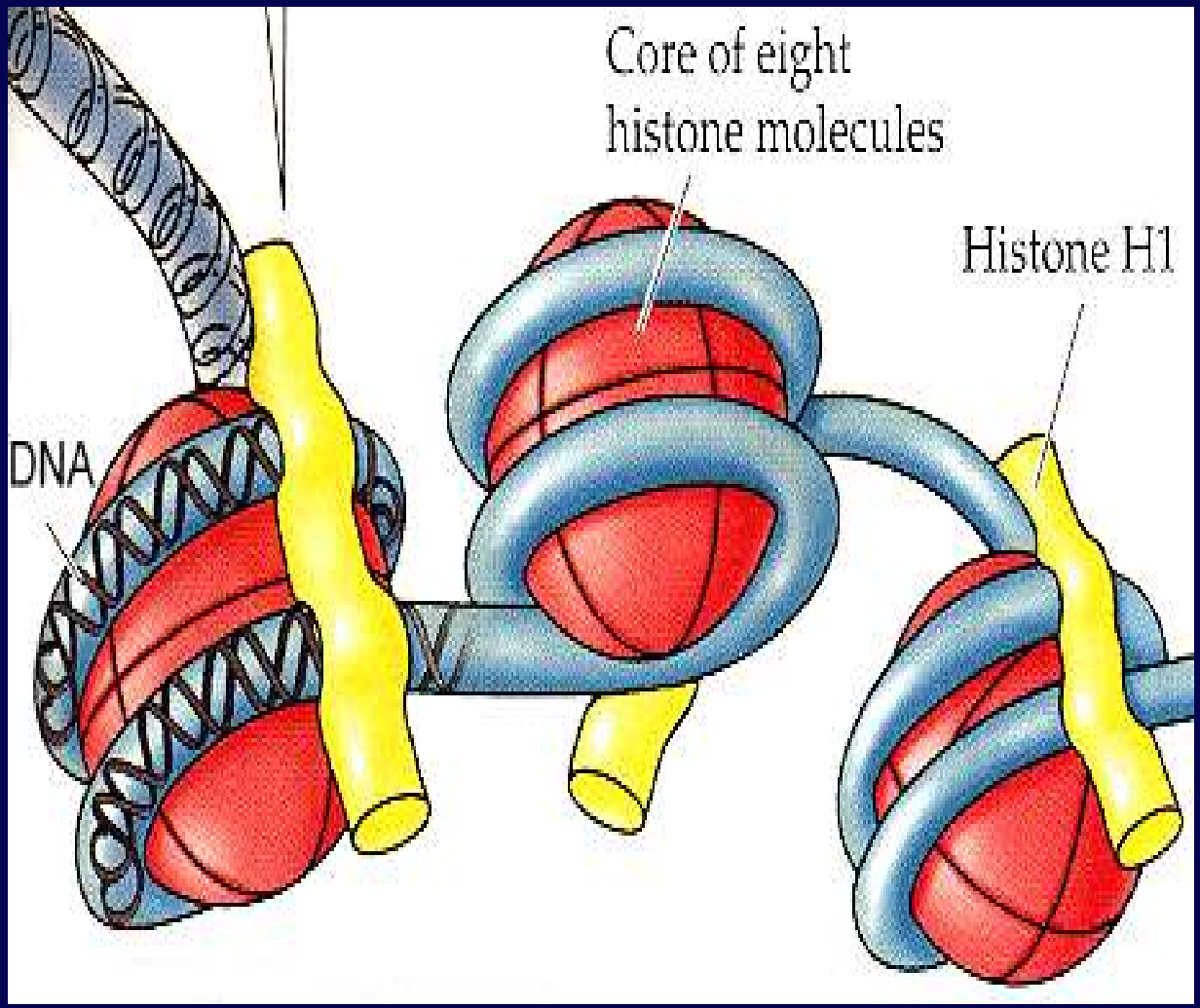
# Structure of Chromosomes

- 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

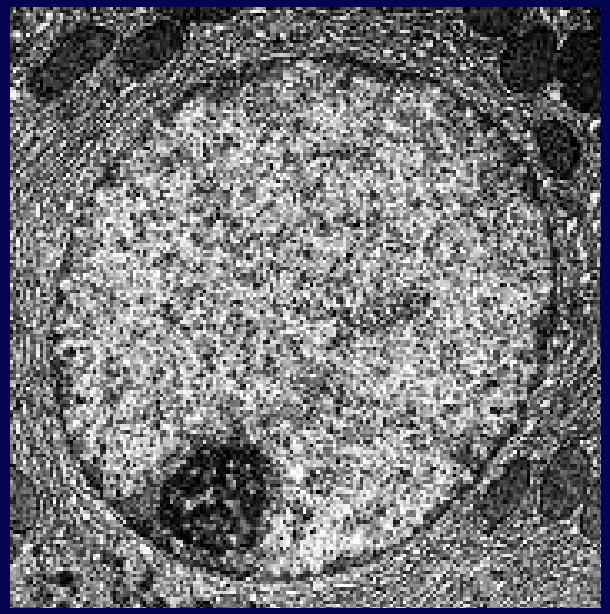


# Structure of Chromosomes

- 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:

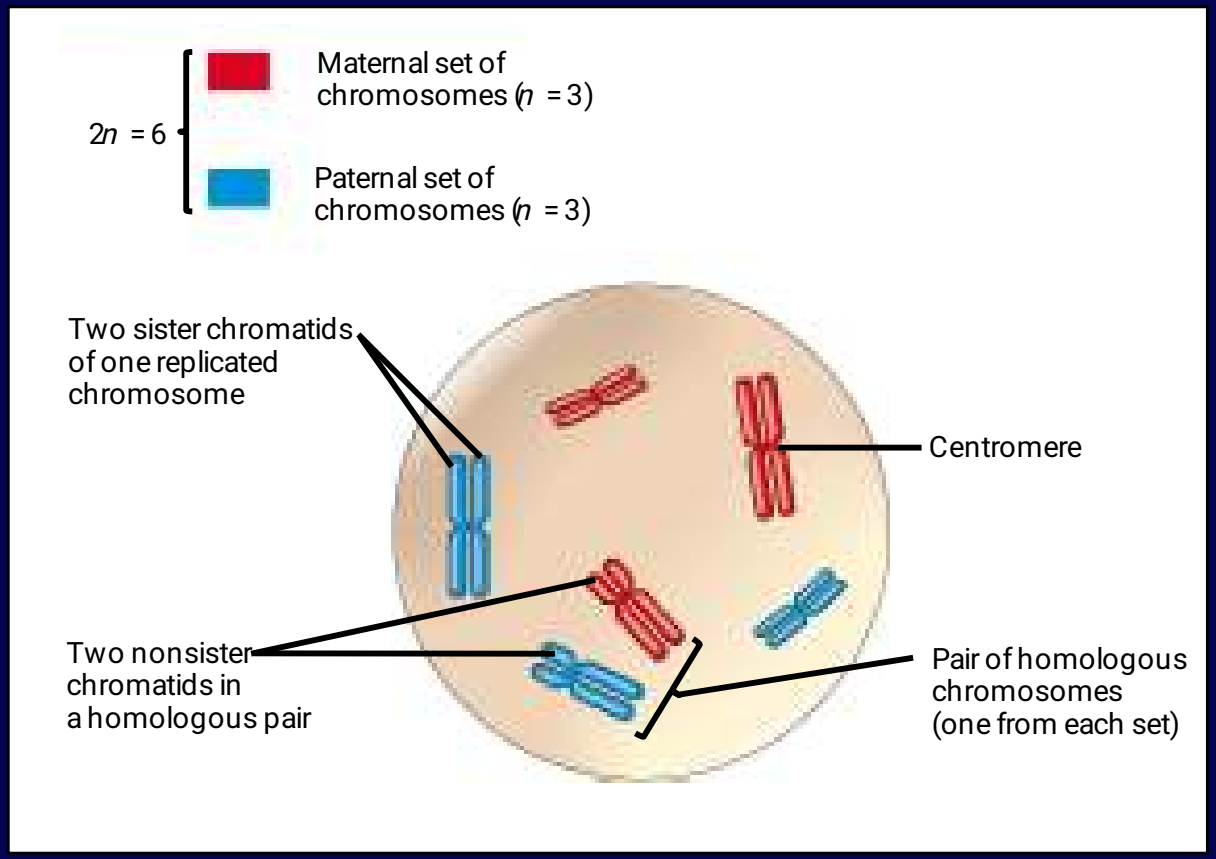


# Chromosomes

- 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.

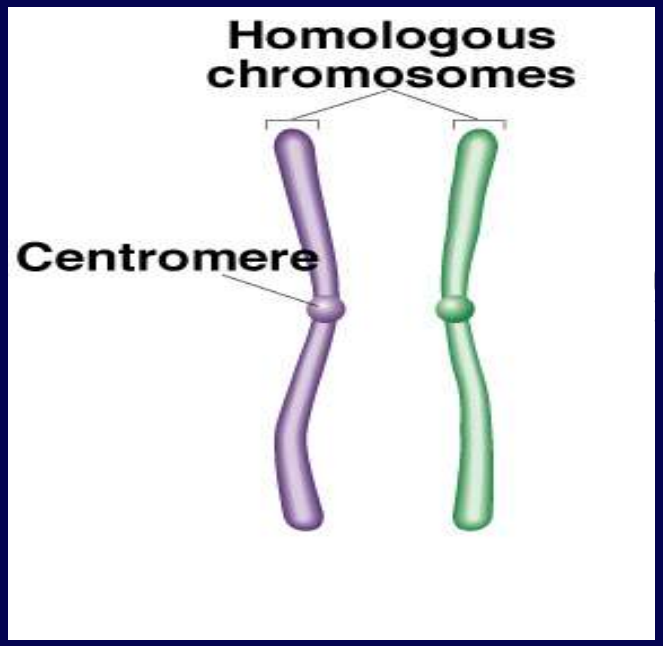
# Chromosomes

- 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

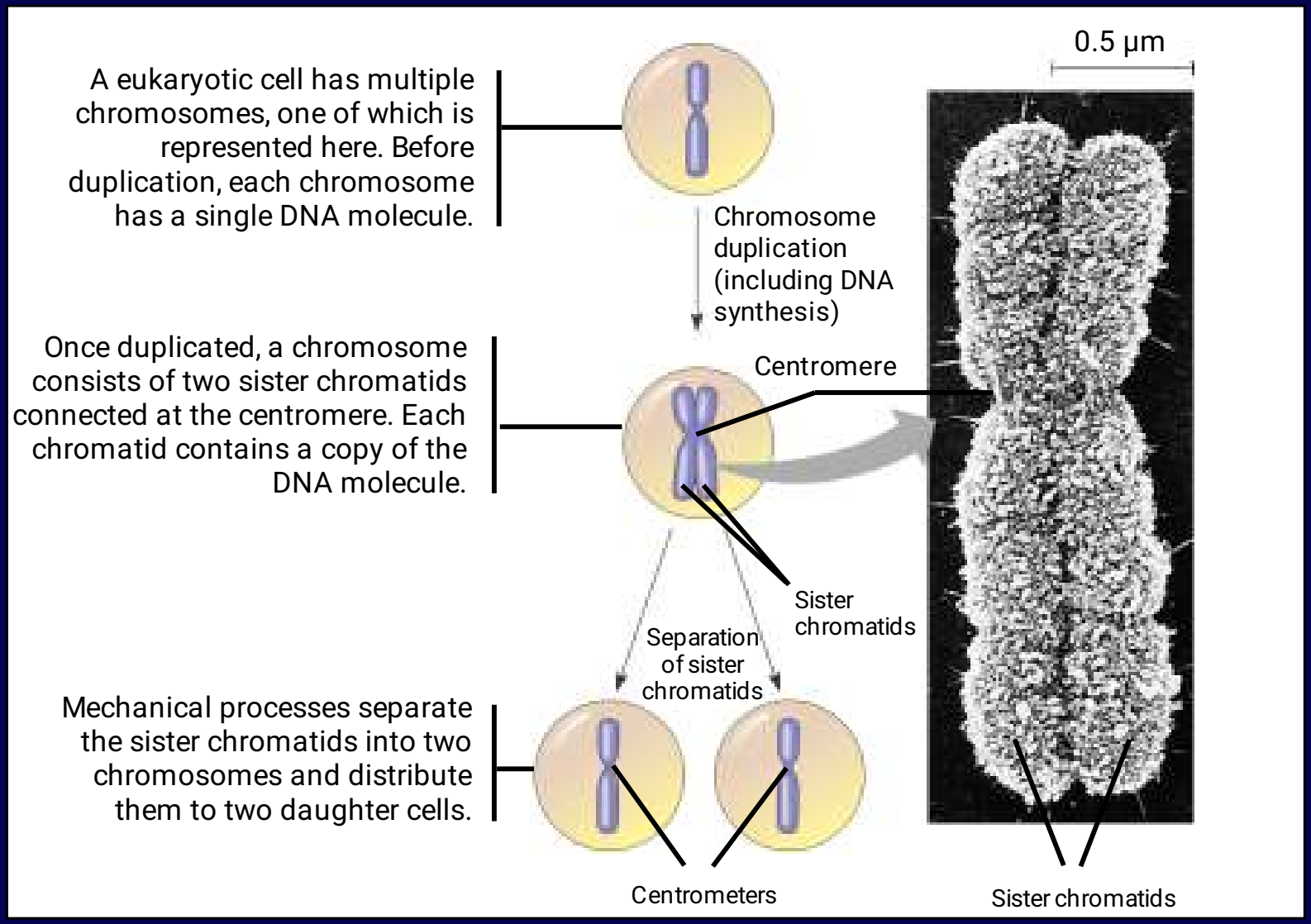
- Homologous chromosomes:
  - Look the same
  - Control the same traits
  - May code for different forms of each trait
  - Independent origin - each one was inherited from a different parent





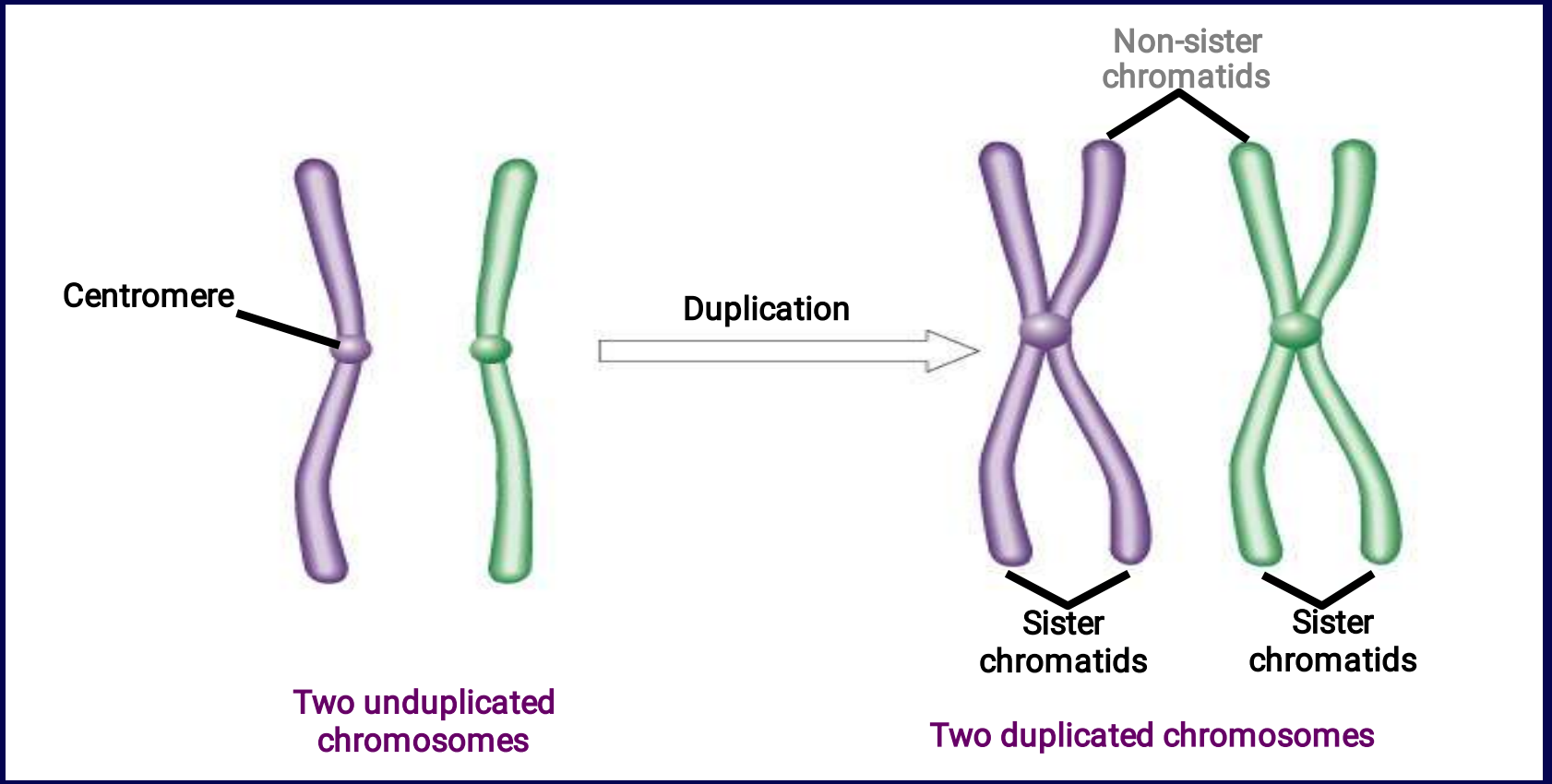
# Chromosome Duplication

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



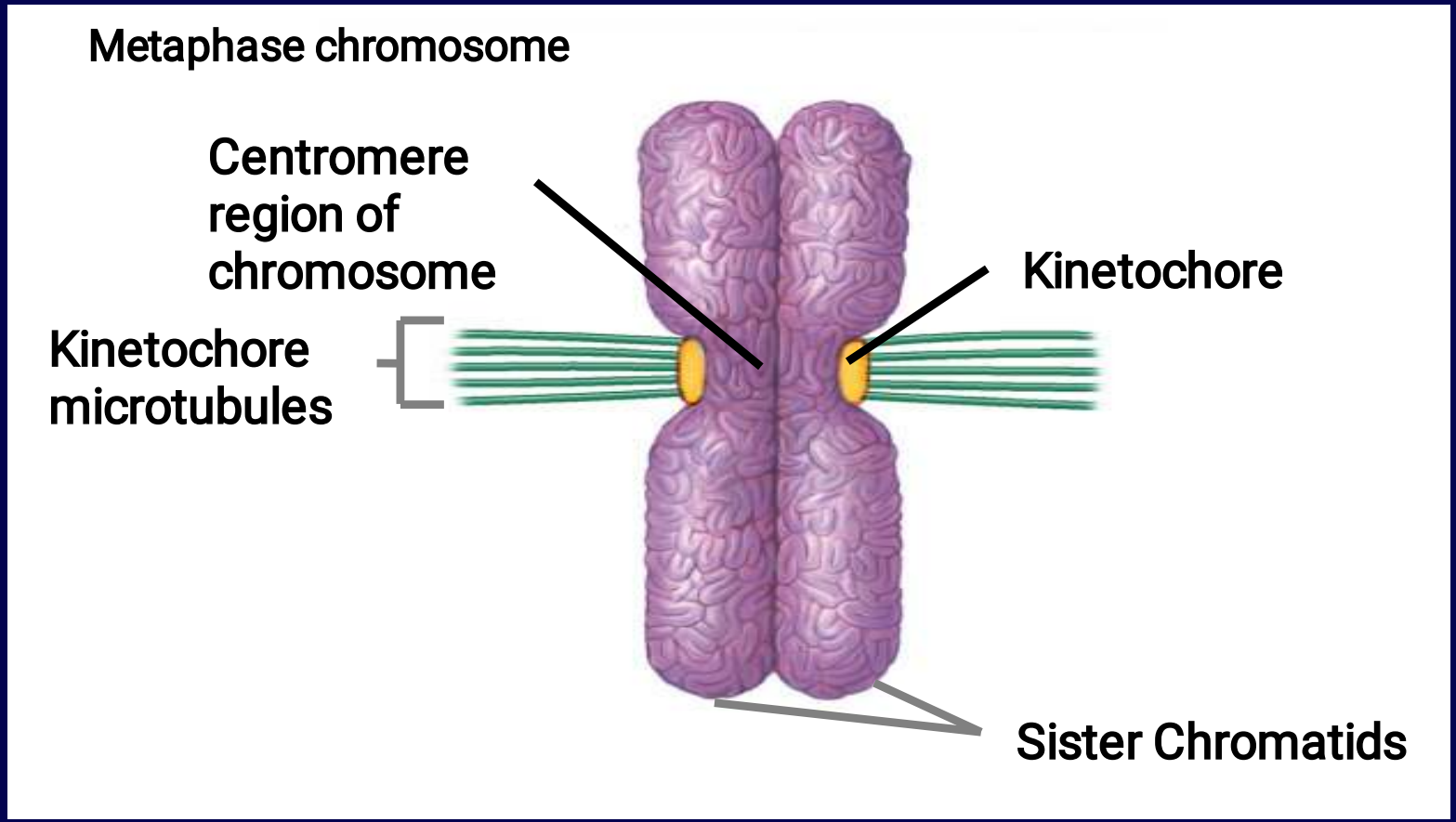
# Chromosome Duplication

- 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).