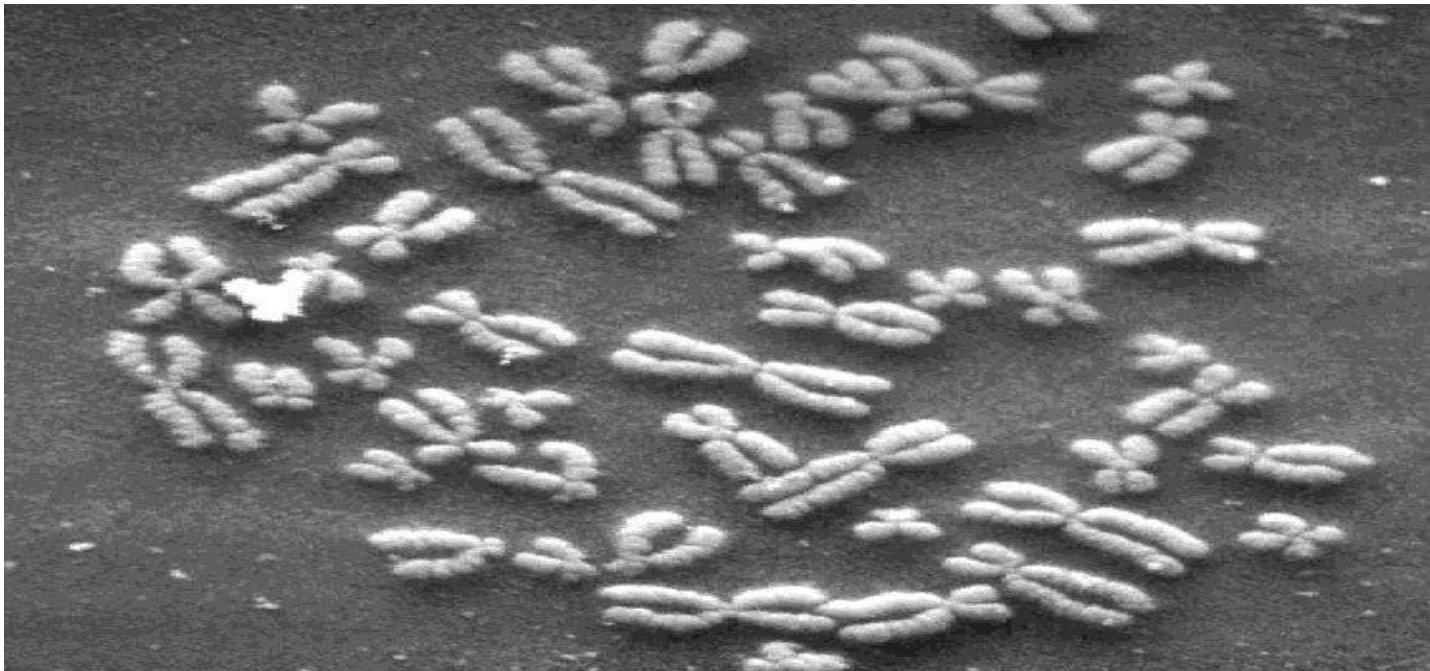


CHROMOSOMES



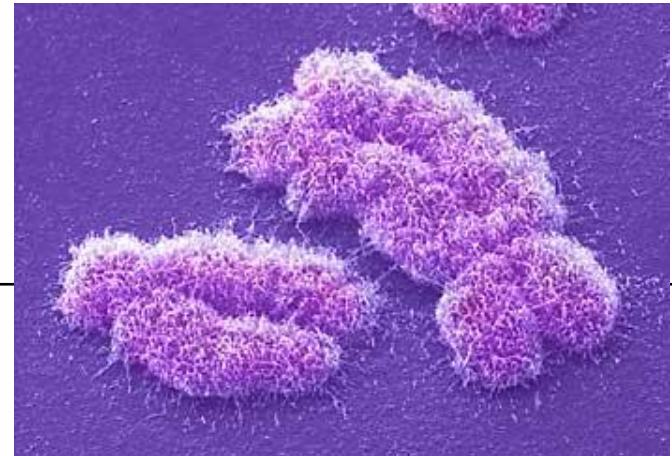
professor Dr. Mushtak T. S. Al-Ouqaili

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 |

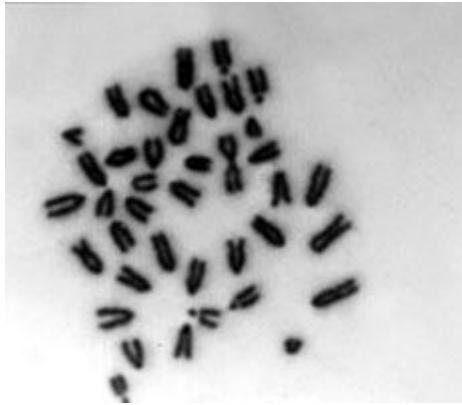
Chromosomes in eukaryotes

- 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

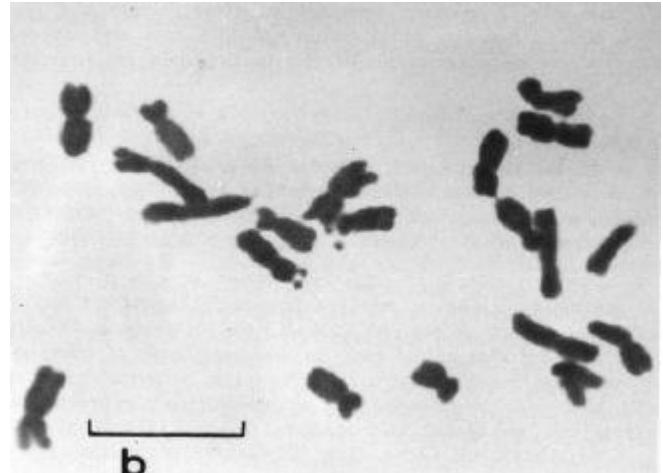


Numbers of chromosomes

- 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

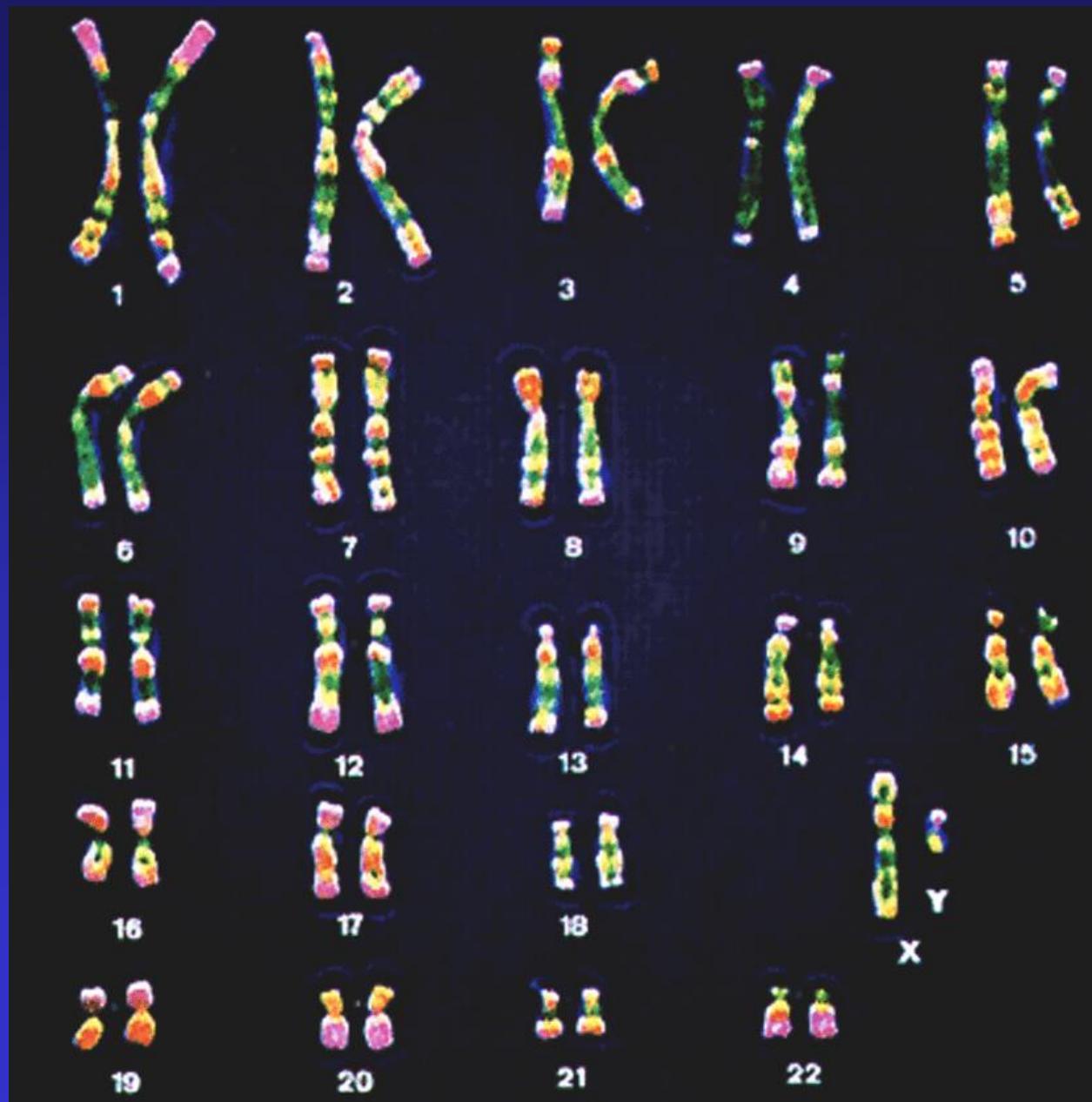


Maize

Image believed to be in the Public Domain

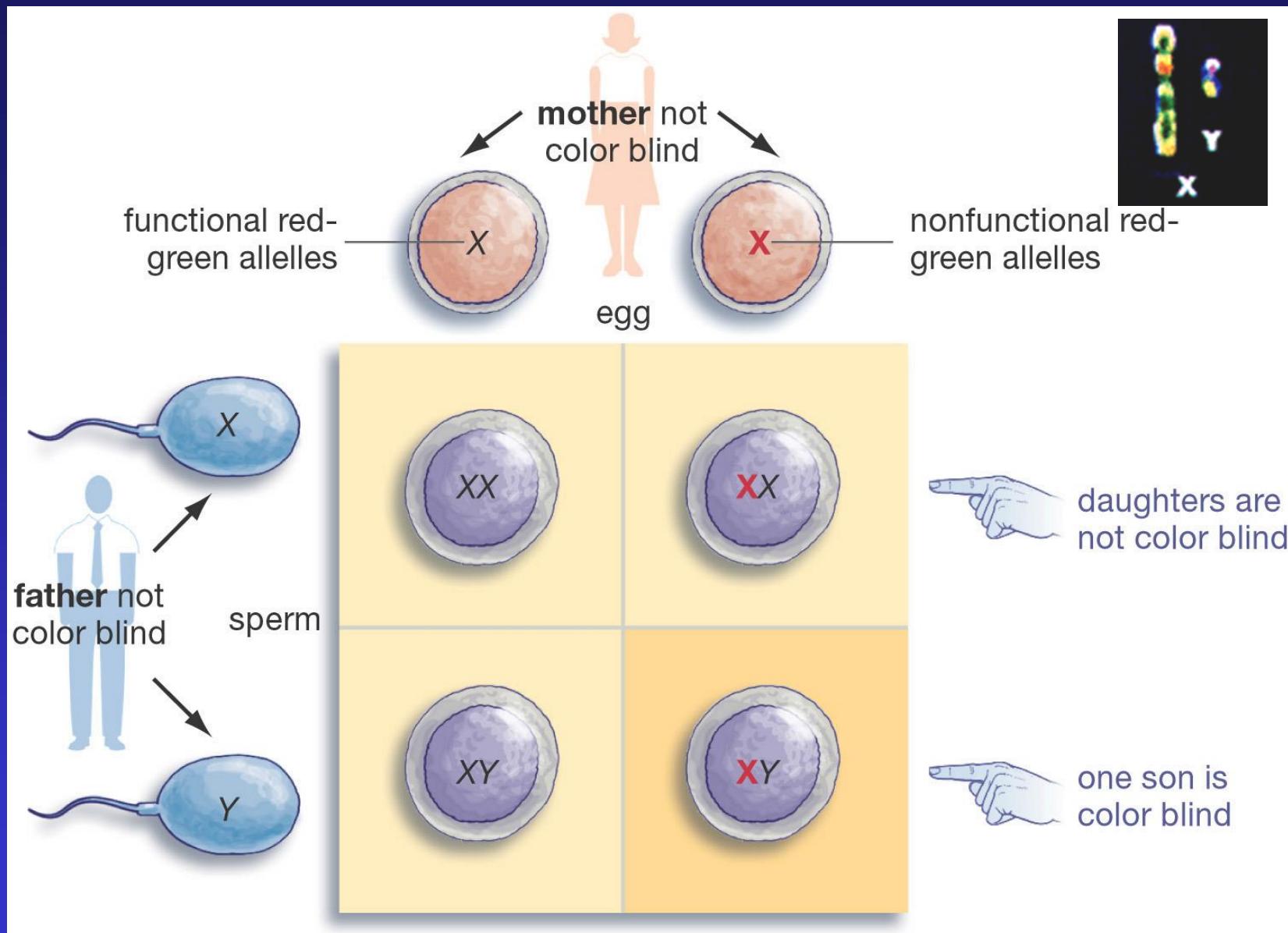
Chromosomes and Inheritance

Since genes are carried on chromosomes, knowledge of chromosome number and structure has far-reaching implications for basic genetics, human health, and evolution.



A normal human male karyotype.

X-linked Inheritance



There are many X-linked recessive traits.

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

Human chromosomes

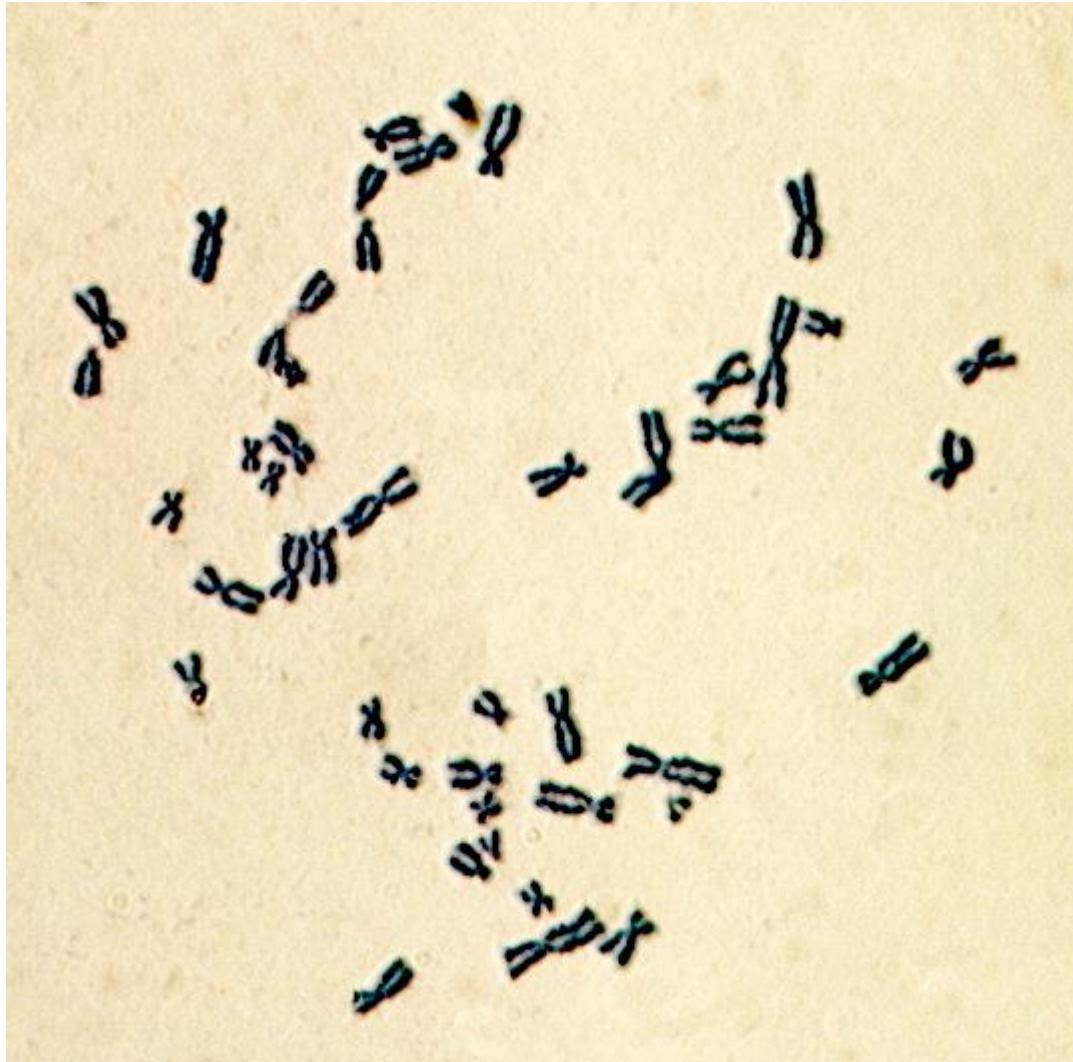
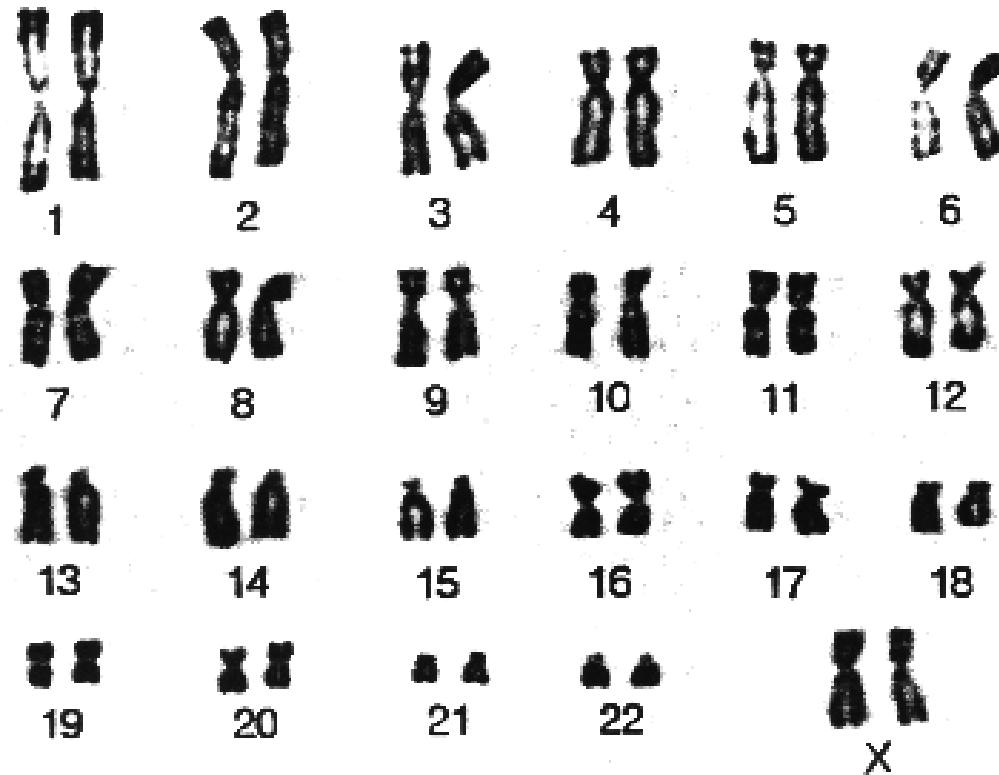


Image believed to be in the Public Domain

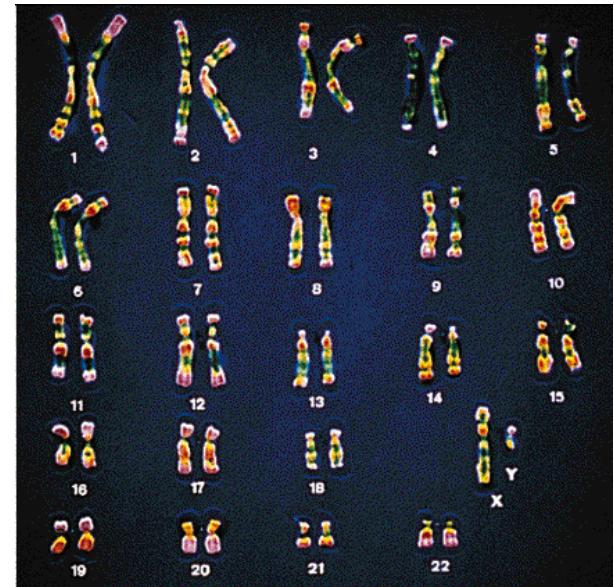
The chromosomes of a human female



Identifying chromosomes

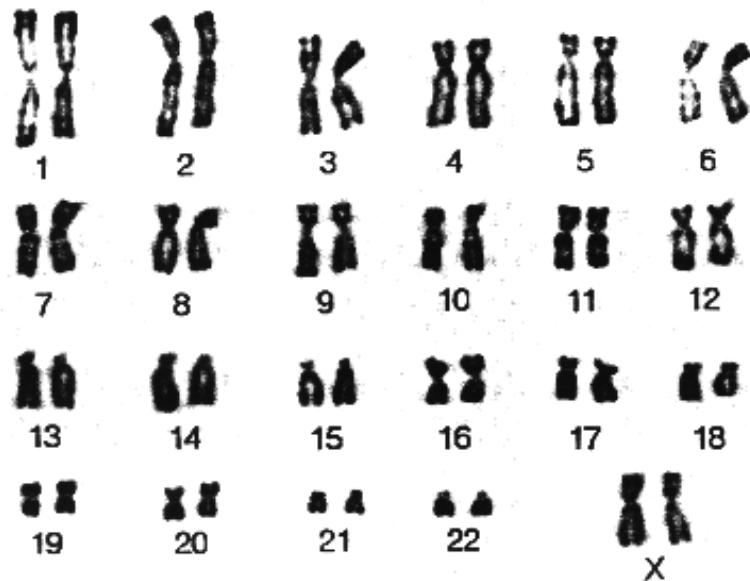
Chromosomes can be identified by:

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

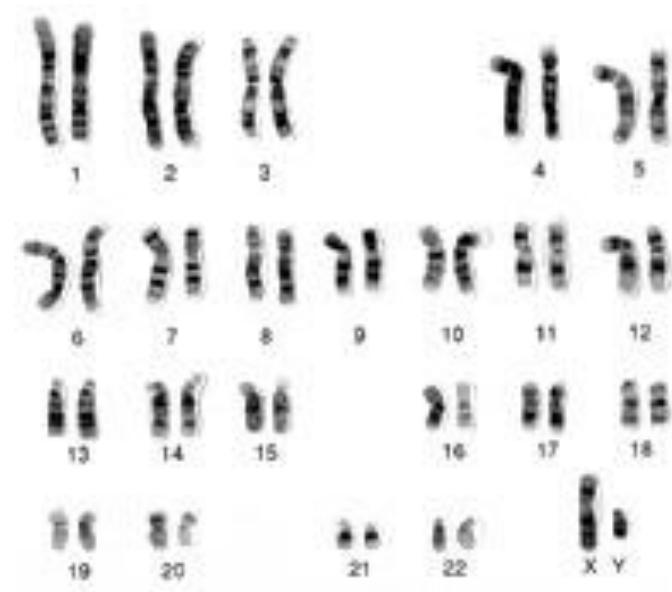


© Biologyreference.com

Chromosomes are analysed by organising them into a
KARYOTYPE



Female



Male

Down's syndrome

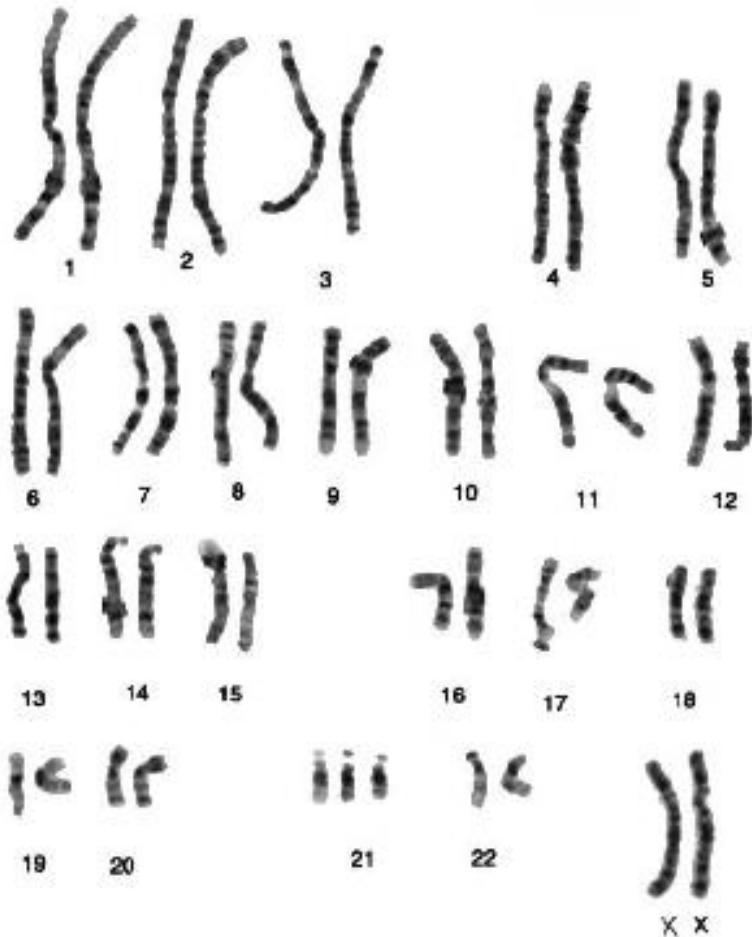


Image believed to be in the Public Domain

Changes in Chromosome Number and Structure

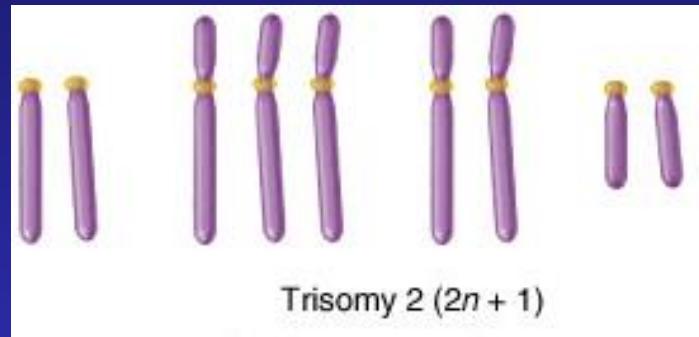
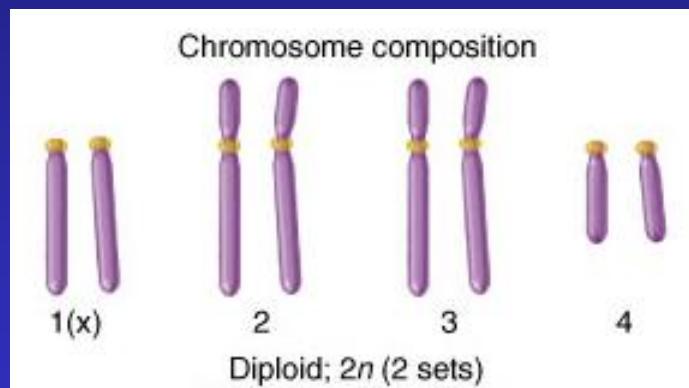
Changes in chromosome number and structure are important for health and evolution.



Down syndrome is caused by a change in chromosome number.

Aneuploidy

Aneuploidy occurs when one of the chromosomes is present in an abnormal number of copies.



Trisomy and monosomy are two forms of aneuploidy.

Down Syndrome is Caused by Trisomy for Chromosome 21

Aneuploidy is remarkably common, causing termination of at least 25% of human conceptions.

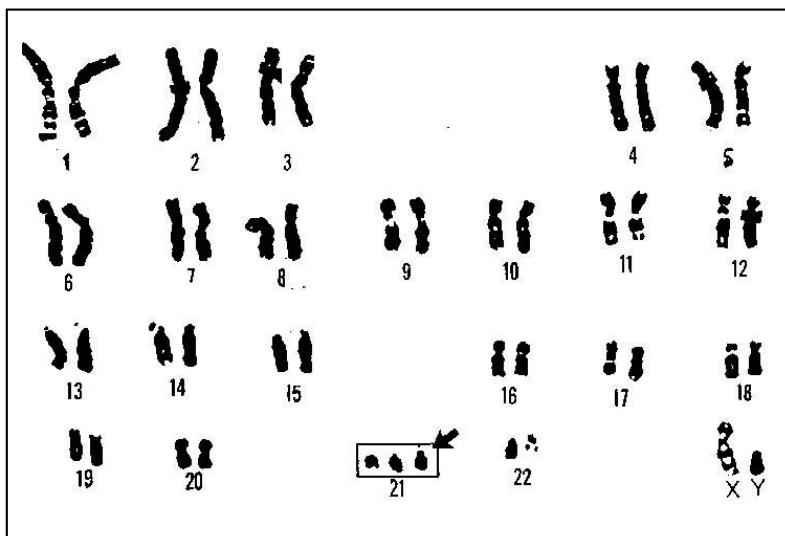
Aneuploidy is also a driving force in cancer progression (virtually all cancer cells are aneuploid).



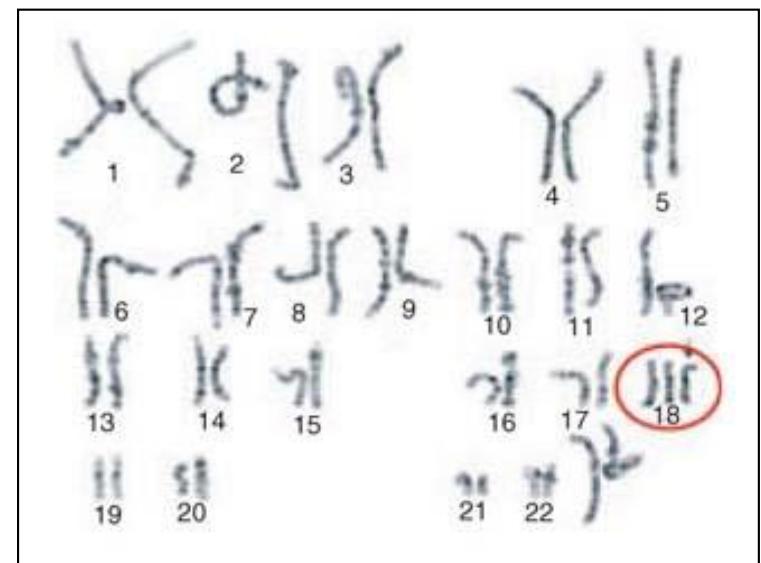
Development and chromosomes

- Differences in chromosomes are associated with difference in the way we grow.
- The karyotypes of males and females are not the same
Females have two large X chromosomes
Males have a large X and a small Y chromosome
The X and the Y chromosomes are called **sex chromosomes**
The sex chromosomes are placed at the end of the karyotype
- Unusual growth can be associated with **chromosome abnormalities**
e.g. People who develop Down's syndrome have trisomy 21

Chromosomal abnormalities

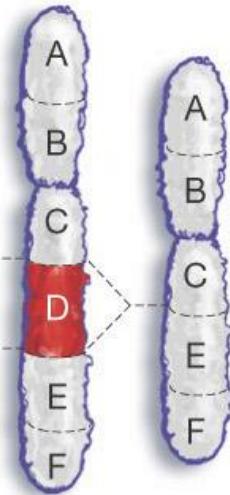


Trisomy-21 → Down's syndrome

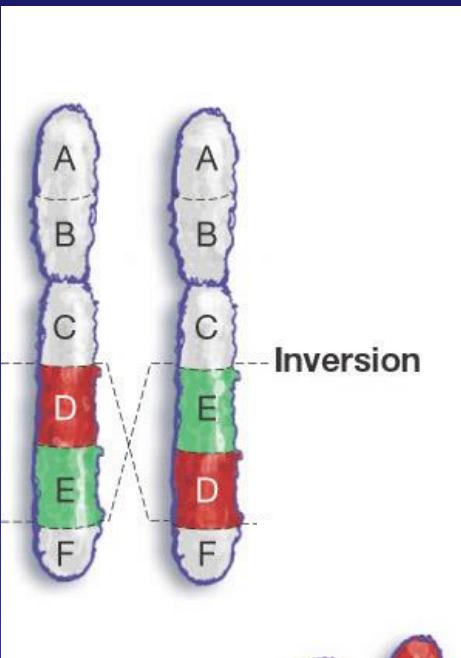


Trisomy-18 → Edward's syndrome

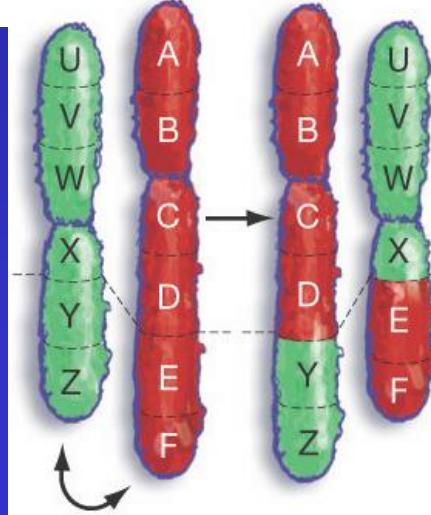
Chromosome Structural Changes



Deletion

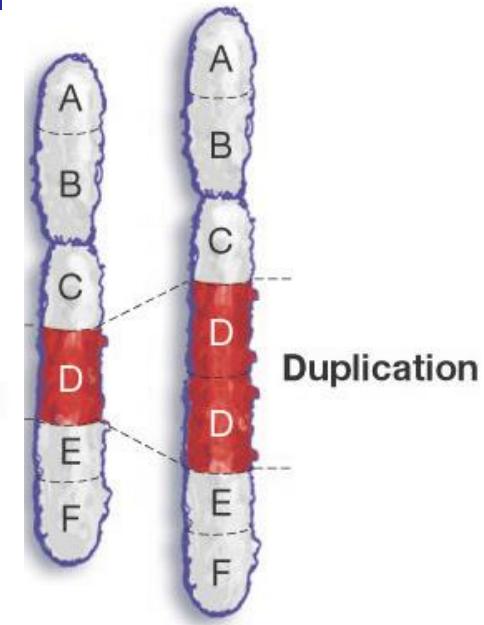


Inversion



Translocation

There are 4 types of chromosome structural change – all of them associated with human disorders



Duplication

Therefore genetic information is found on our chromosomes

Chromosomes and cell division

- Multicellular organisms **copy** their chromosomes before cell division.
- They must **grow** to a mature size.
- The nucleus divides, distributing the chromosomes into two equal groups (**mitosis**).
- The cytoplasm then divides (**cytokinesis**) each part taking a nucleus.

Interphase

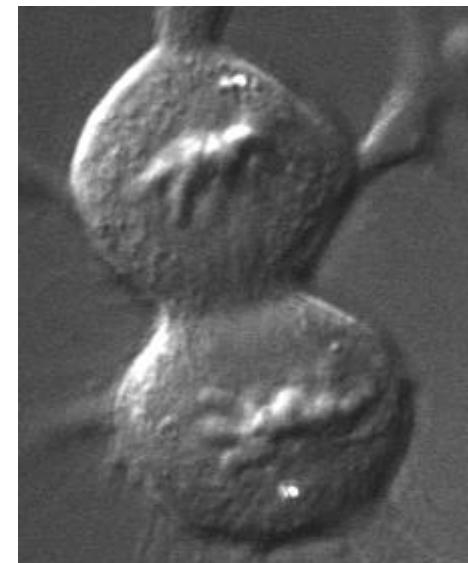
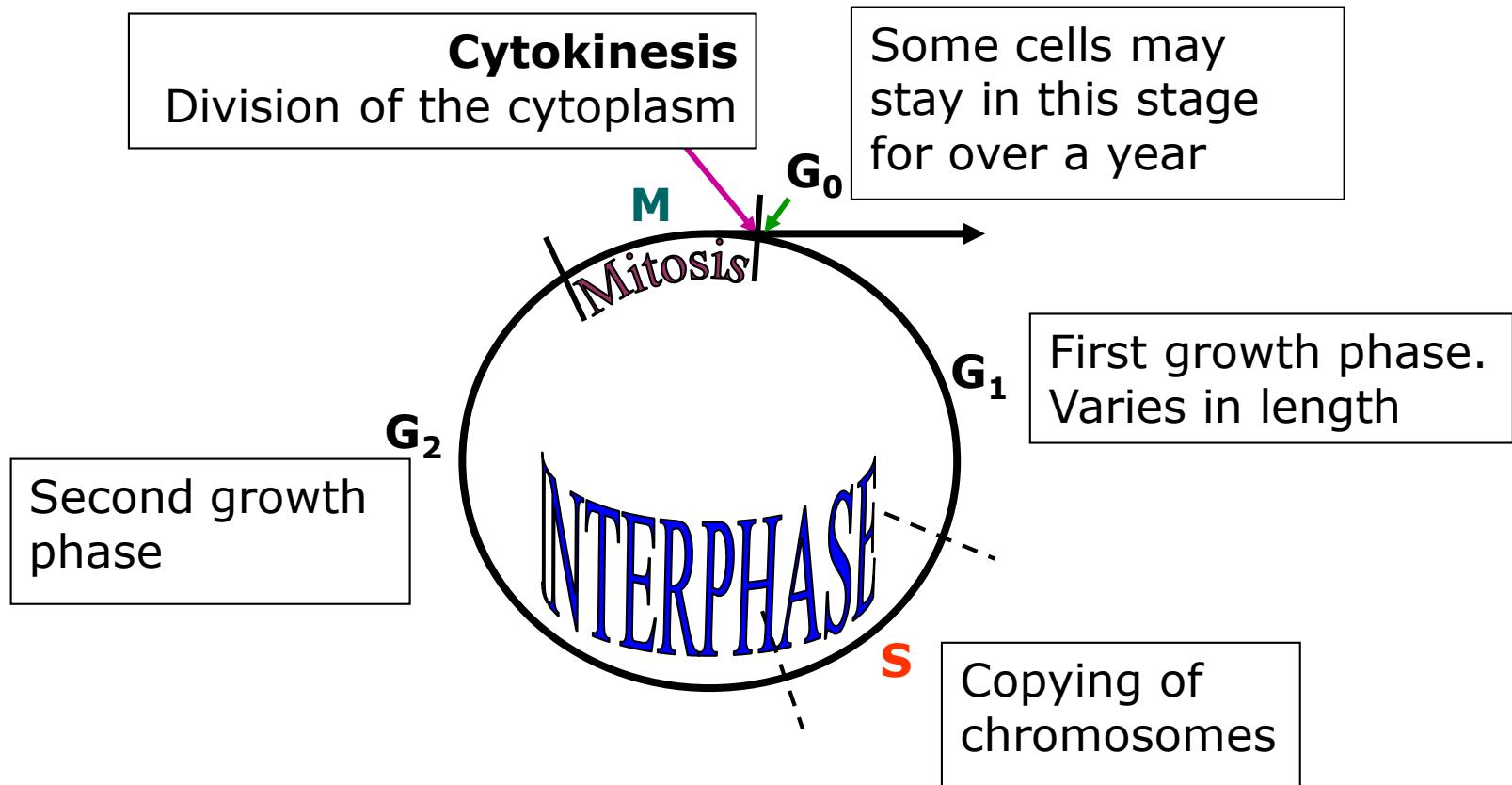


Image believed to be in the Public Domain

The cell cycle



$$\mathbf{G_1 + S + G_2 = INTERPHASE}$$

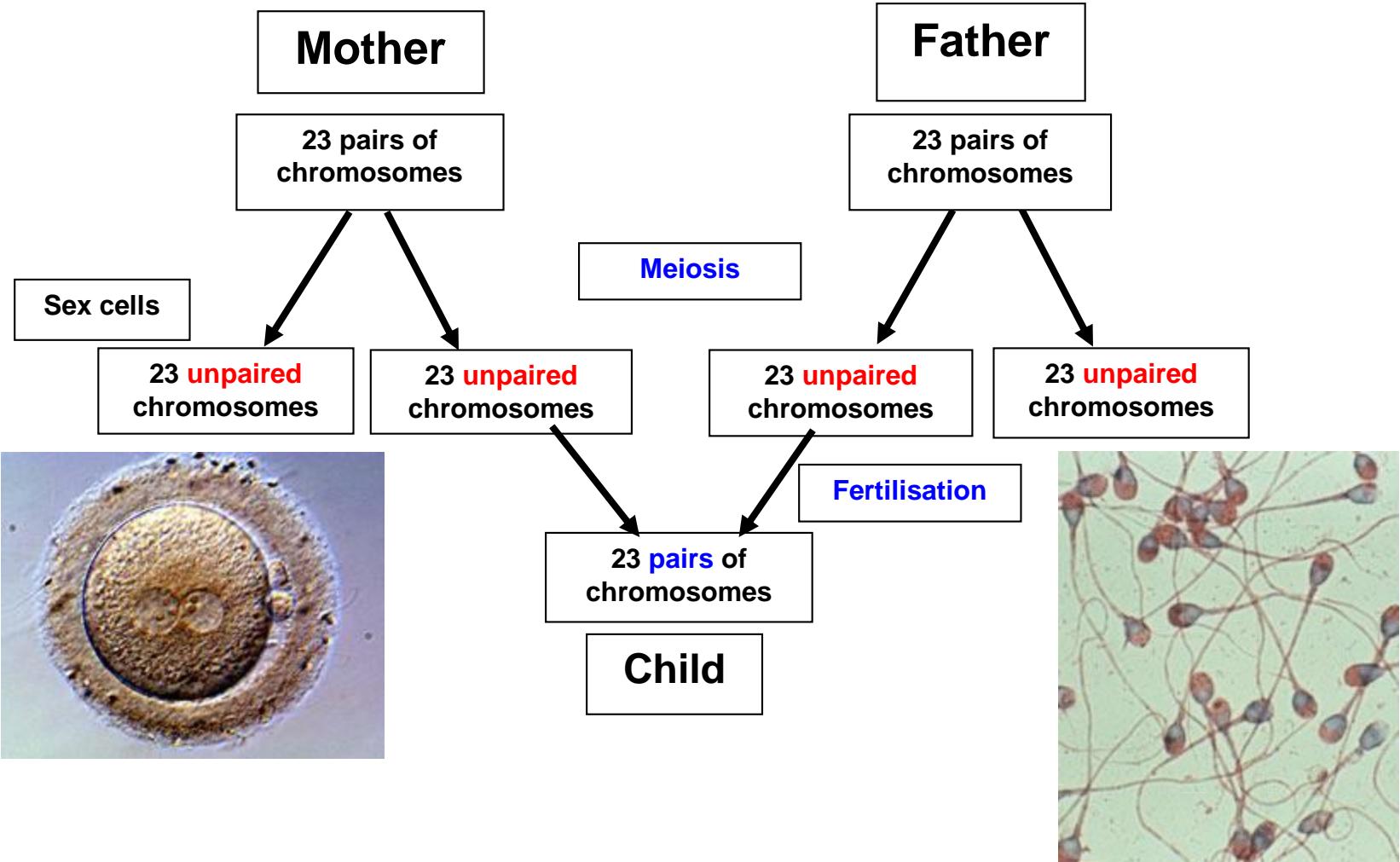
The cell cycles in different cells

| Cell type | Cell cycle / hours |
|----------------------------------|---------------------------|
| Bean root tip | 19.3 |
| Mouse fibroblast | 22 |
| Chinese hamster fibroblast | 11 |
| Mouse small intestine epithelium | 17 |
| Mouse oesophagus epithelium | 181 |

Chromosomes and reproduction

- Chromosomes come in pairs
One of the pair is maternal the other is paternal
- When parents make sex cells the number of chromosomes must be halved
One of each type of chromosome is taken

Meiosis and fertilisation



Meiosis

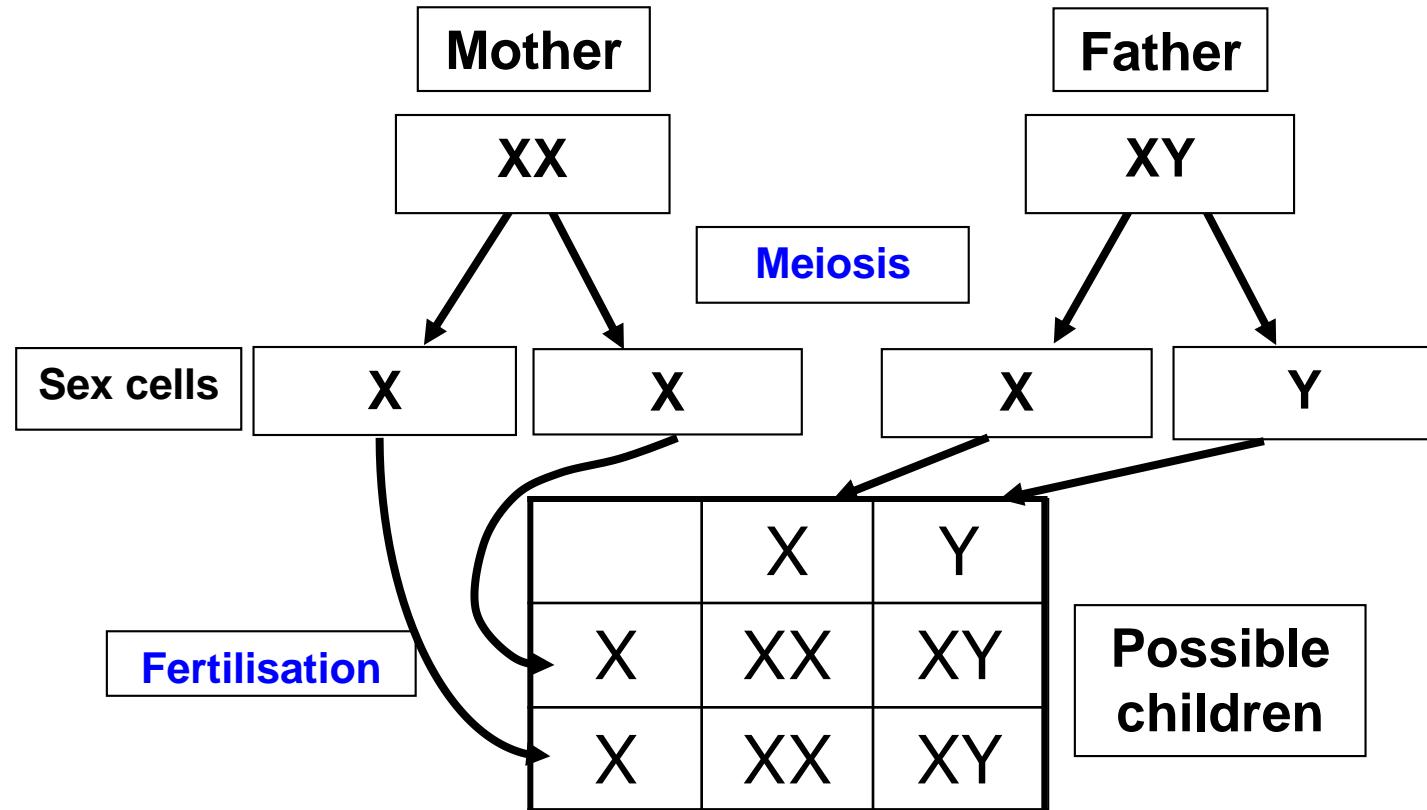
- A special type of cell division
- Used to make **sex cells**
- Meiosis **halves** the numbers of chromosomes
- Meiosis picks one chromosome from each pair at random and places them in a sex cell. This results in enormous variation amongst the sex cells.

The inheritance of gender

Is it going to be a boy or a girl?



The inheritance of gender



Chance of a girl 50%
Chance of a boy 50%

Sex chromosomes

- The sex of many animals is determined by genes on chromosomes called **sex chromosomes**
- The other chromosomes are called **autosomes**
- One sex is homogametic
- The other sex is heterogametic

Sex determination in different animals

| HOMOGAMETIC SEX | HETEROGAMETIC SEX | SEX DETERMINATION |
|------------------|-------------------|--|
| Female XX | Male XY | Presence of Y-chromosome = maleness (mammals and fish) Presence of second X-chromosome = femaleness (Drosophila, the fruit fly) |
| Male ZZ | Female ZW | Birds, amphibians, reptiles, butterflies, moths. |
| Female XX | Male Xo | Grasshoppers |