# 9.1 Karyotype, mitosis and meiosis

## The Human Karyotype

- See figure (to be supplied)
- 46 chromosomes (23 pairs) are present in all nucleated cells.
- The autosomes are in pairs, numbered 1-22.
- Females have two X, sex chromosomes, (46,XX) and men have one X and one Y, sex chromosomes (46,XY).
- Chromosomes have a short arm (p) and long arm (q).
- Euchromatin contains the active genes.
- All chromosomes show normal variation in DNA content.

## Lyonisation

- Lyonisation is inactivation of one of X chromosomes in every female cell.
- Inactivation only occurs in somatic cells.
- Random process whether paternal or maternal X is inactivated, but is subsequently fixed for all descendants of that cell.
- X inactivation affects most but not all genes on the X chromosome.
- Exceptions are those genes which have homologues on the Y chromosomes, in the pseudo-autosomal region.
- Inactive X remains condensed during most of interphase and can be seen as Barr body or X chromatin.
- If cell has more than two X chromosomes then the extra X's are also inactivated.
- The randomness of X inactivation accounts for some females being affected with X-linked recessive disorders.

## Mitosis

- Occurs in somatic cells.
- One cell produces two identical daughter cells (see figure).

### Interphase

- Includes gap 1 (G1), S and gap 2 (G2) phases.
- Replication of DNA occurs during S phase.

### Prophase

- Each chromosome consists of a pair (sister chromatids), held together at the centromere.
- Centriole divides and migrates to opposite poles of the cell.

### Metaphase

- Chromosomes move to the equatorial plate and attach to spindle fibre by centromere.

### Anaphase

- Chromatids pulled toward opposite cell poles.

### Telophase

- Cytoplasm divides.
- Nuclear membrane reforms.

## Meiosis

- Occurs in gonads.
- Two successive divisions.
- DNA replicates only once, before the first division (S phase).
- Somatic diploid chromosomal complement halved to a haploid number (see figure).

### First meiotic division (reduction division)

*Prophase*

- Leptotene (pair of sister chromatids formed)
- Zygotene (pairing of homologous chromosomes, as bivalents)
- Pachytene (cross-over occurs)
- Diplotene (bivalents start separating)
- Diakinesis (chromosome thickening, spindle fibres form)

*Metaphase*

- Chromosomes move to equatorial plate.

*Anaphase*

- Bivalents separate, one going to each pole.
- Cytoplasm divides.
- Each cell now has 23 chromosomes, each of which is a chromatid pair.
- Chromatids differ only as a result of crossing-over.

### Second meiotic division (resembles mitosis)

- Second meiotic division follows 1st meiotic division with no interphase
- Centromeres now divide.
- Sister chromatids pass to opposite poles.

## Non-disjunction

- Failure of sister chromatids to disjoin at anaphase in either mitosis or meiosis.
- Causes aneuploidy with two cells produced, one with extra copy (trisomy) and one with missing copy (monosomy) of a chromosome.
- Related to increasing maternal age.
- For example, Down syndrome (Trisomy 21), Edward Syndrome (Trisomy 18), Patau syndrome (Trisomy 13).

## Spermatogenesis

- Occurs from time of sexual maturity onwards.
- In seminiferous tubules.
- Primary spermatocyte undergoes 1st meiotic division to produce 2 secondary spermatocytes, each with 23 chromosomes.
- Following the 2nd meiotic division, two spermatids are formed.
- Spermatogenesis produces 4 sperm per meiotic division.
- Production of a mature sperm takes 61 days.
- Numerous replications increase chances for mutation, particularly in older men.

## Oogenesis

- Mostly complete by birth.
- Primary oocytes form by the end of 1st trimester and remain in suspended prophase (dictyotene) until sexual maturity.
- Oocyte released into fallopian tube after first meiotic division.
- Completion of 1st meiotic division may take over 40 years.
- First meiotic division results in formation of the 1st polar body.
- Second meiotic division completed after fertilisation in fallopian tube, resulting in mature ovum and 2nd polar body.
- Oogenesis produces only one ovum.
- Long resting phase during the 1st meiotic division may be factor in increased risk of homologous chromosomes separation failure during meiosis (non-disjunction) in older mothers.

## Chromosomal Rearrangements

- Balanced rearrangements are common, 1 in 500.
- Unbalanced rearrangements have additional/missing genetic material, causing fetal loss or physical/mental handicap.

Figures to supply

Normal karyotype
Abnormal karyotype
Cell division
Gametogenesis