3.3 Meiosis

19/04/16

Essential Idea: Alleles segregate during meiosis allowing new combinations to be formed by the fusion of gametes.

3.3 Meiosis

Nature of science:

Making careful observations—meiosis was discovered by microscope examination of dividing germ-line cells. (1.8)

Understandings:

- One diploid nucleus divides by meiosis to produce four haploid nuclei.
- The halving of the chromosome number allows a sexual life cycle with fusion of gametes.
- DNA is replicated before meiosis so that all chromosomes consist of two sister chromatids.
- The early stages of meiosis involve pairing of homologous chromosomes and crossing over followed by condensation.
- Orientation of pairs of homologous chromosomes prior to separation is random.
- Separation of pairs of homologous chromosomes in the first division of meiosis halves the chromosome number.
- Crossing over and random orientation promotes genetic variation.
- Fusion of gametes from different parents promotes genetic variation.

Applications and skills:

- Application: Non-disjunction can cause Down syndrome and other chromosome abnormalities.
- Application: Studies showing age of parents influences chances of non-disjunction.

Theory of knowledge:

- In 1922 the number of chromosomes counted in a human cell was 48. This remained the established number for 30 years, even though a review of photographic evidence from the time clearly showed that there were 46. For what reasons do existing beliefs carry a certain inertia?

Utilization:

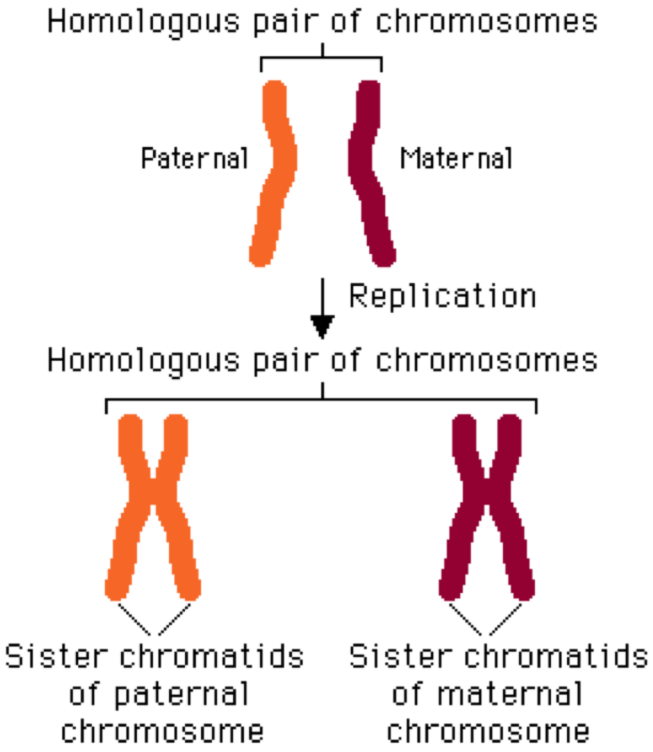
- An understanding of karyotypes has allowed diagnoses to be made for the purposes of genetic counselling.

Syllabus and cross-curricular links:
Biology
Topic 1.6 Cell division
Topic 10.1 Meiosis
Topic 11.4 Sexual reproduction

Aims:

- **Aim 8:** Pre-natal screening for chromosome abnormalities gives an indication of the sex of the fetus and raises ethical issues over selective abortion of female fetuses in some countries.

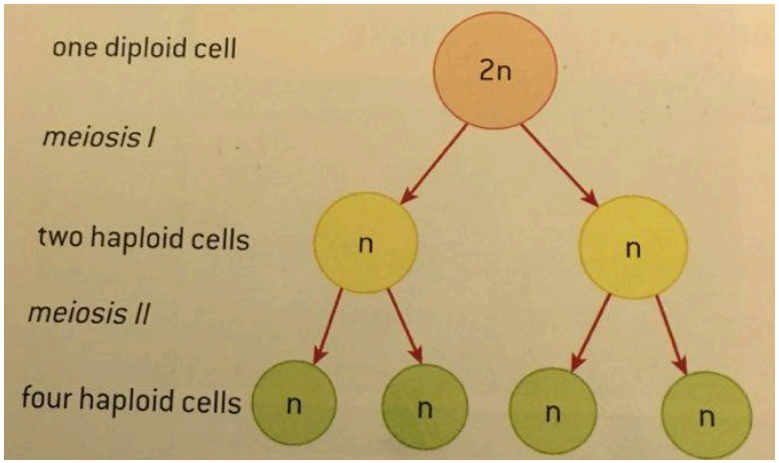
3.3 Meiosis	
• Application: Description of methods used to obtain cells for karyotype analysis e.g. chorionic villus sampling and amniocentesis and the associated risks. • Skill: Drawing diagrams to show the stages of meiosis resulting in the formation of four haploid cells. **Guidance:** • Preparation of microscope slides showing meiosis is challenging and permanent slides should be available in case no cells in meiosis are visible in temporary mounts. • Drawings of the stages of meiosis do not need to include chiasmata. • The process of chiasmata formation need not be explained.	

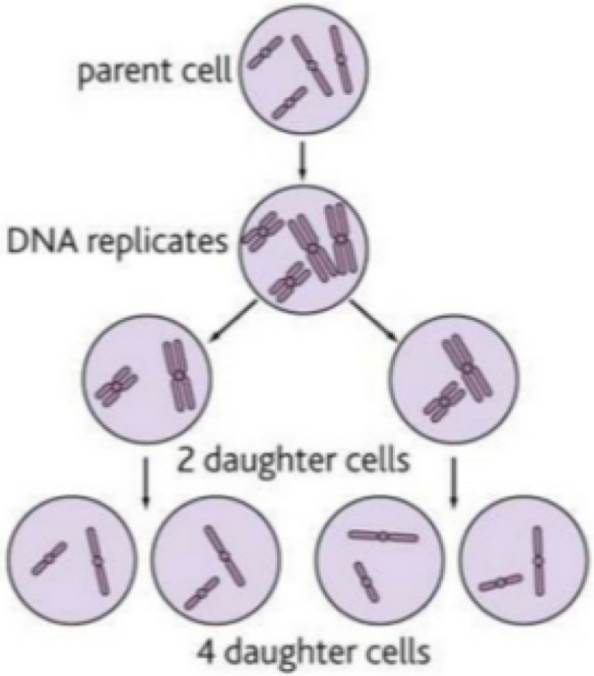


A homologous pair: is a pair of matching chromosomes that carry the same genes but not necessarily the same alleles of those genes.

One diploid nucleus divides by meiosis to produce four haploid nucleus

- Meiosis happens in the eukaryotic cell and divides twice, rather than once in mitosis.



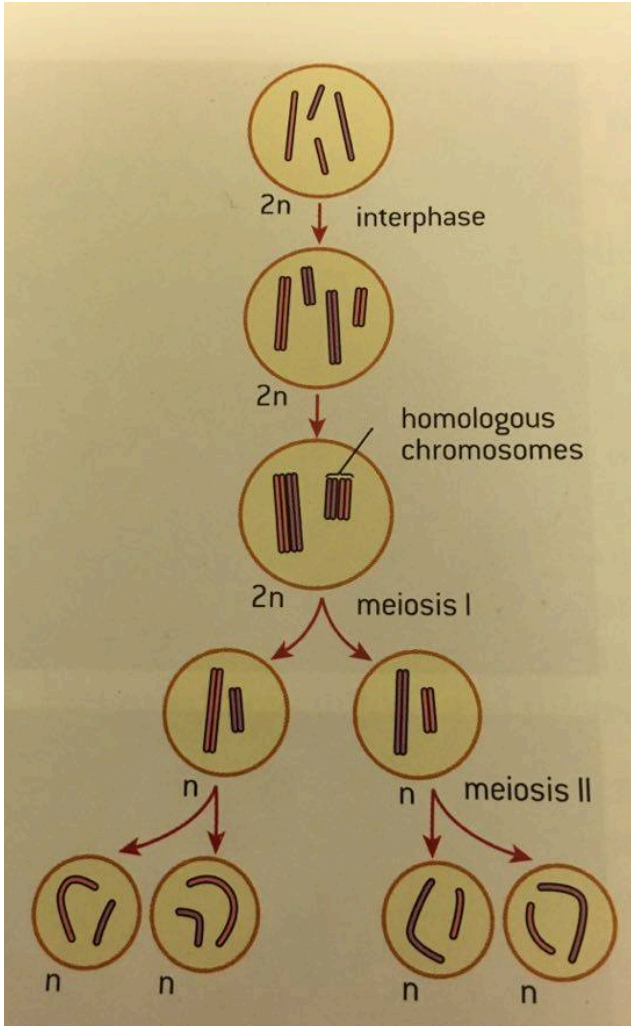


The halving of the chromosome number allows a sexual life cycle with fusion of gametes

- Life cycles of living organisms can be sexual or asexual.
- Asexual life cycle- offspring have the same number of chromosomes as the parent, so are genetically identical.
- Sexual life cycle- differences between chromosomes of offspring and the parents, genetic diversity.
- In eukaryotic organisms, sexual reproduction involves fertilisation.
- Fertilization- union of sex cells, or gametes, usually from two different parents. It doubles the number of chromosomes each time it occurs, so halving of chromosome number happens during meiosis.
- Meiosis happens during process of creating gametes.

DNA is replicated before meiosis so that all chromosomes consist of two sister chromatids.

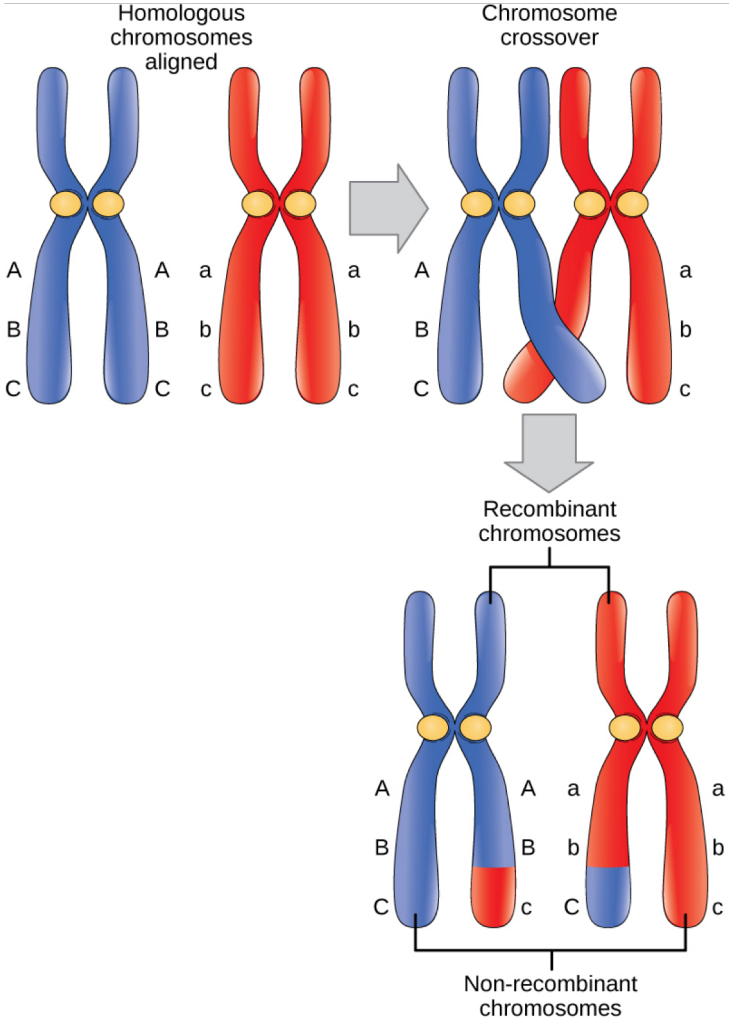
- Before meiosis,
- Supercoiling of chromosomes.
- Replication happens, so each chromosome from paternal and maternal has been replicated and now consists of two sister chromatids, genetically identical.
- One diploid nucleus, each containing two chromatids, divides twice to produce four haploid nuclei, each chromosome consists of one chromatid.



Early stages of meiosis involve pairing of homologous chromosomes and crossing over followed by condensation.

Meiosis I,

- DNA replication already occurred, two chromatids in each chromosome and four DNA molecules. Homologous chromosomes pair up with each other- process sometimes called synapsis.
- After synapsis, crossing over takes place. Junction created, one chromatid in each of the homologous chromosomes breaks and rejoins with the other chromatid, occurs at random positions.
- There is a mutual exchange of genes between the chromatids. Chromatids with new combinations of alleles produced.



Orientation of pairs of homologous chromosomes prior to separation is random.

- Pairs of homologous chromosomes condensing in early stages of meiosis, spindle microtubules are growing from poles of the cell.
- After nuclear membrane broken down, spindle microtubules attach to centromeres of chromosomes.

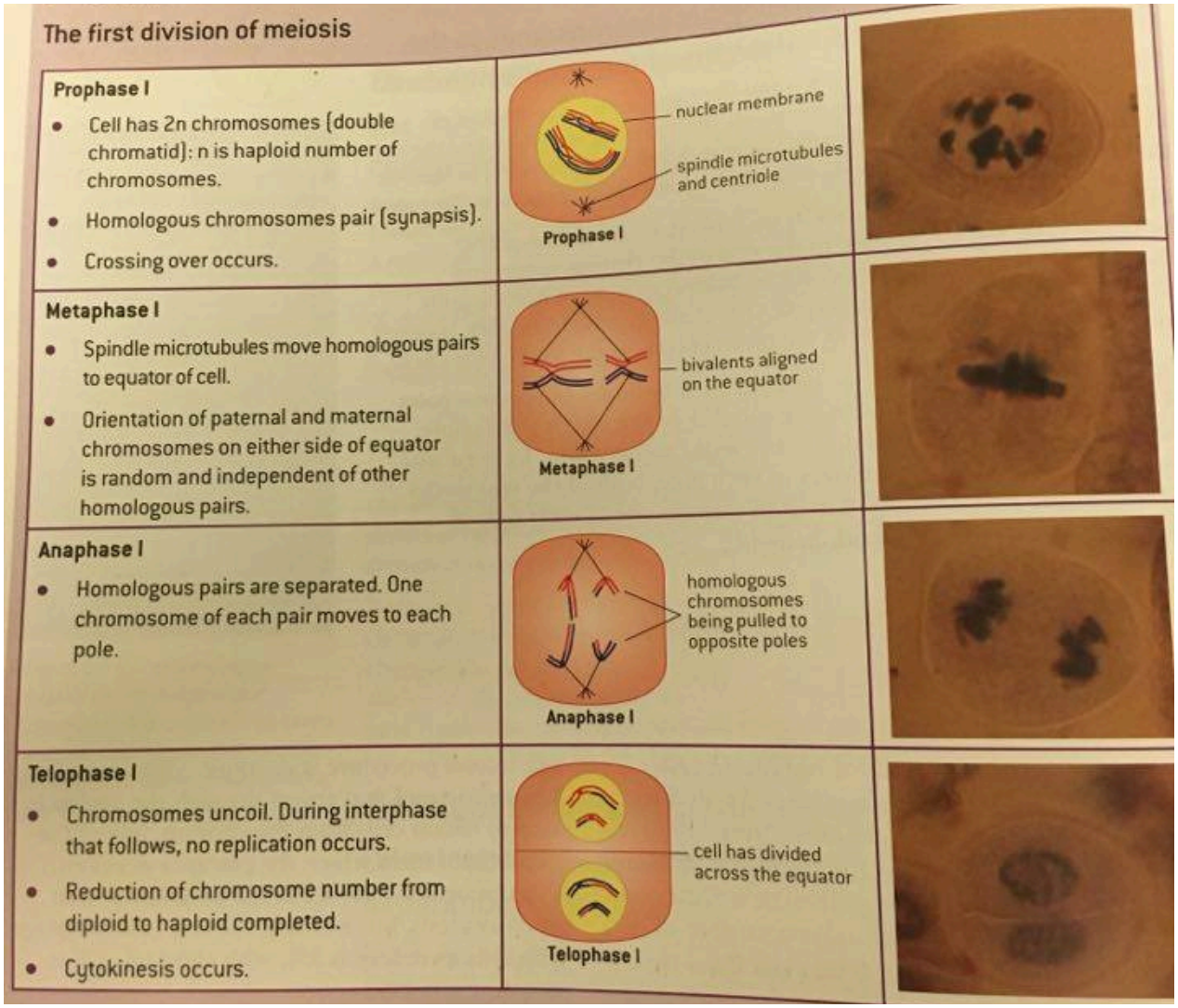
Attachment principles different to mitosis:

- Each chromosome attached to one pole only
- Two homologous chromosomes in a bivalent are attached to different poles.
- Pole to which each chromosome attached depends on which way pair of chromosomes facing- orientation
- Orientation of bivalents is random, equal chance of attaching to one pole.
- Orientation of one bivalent doesn’t affect other bivalents.

Separation of pairs of homologous chromosomes in the first division of meiosis halves the chromosome number.

- Initially, two chromosomes in each bivalent held together by chiasmata, slide to end of chromosomes and they separate. Separation of homologous chromosomes- disjunction. One chromosome from each bivalent goes to opp poles.
- The separation of pairs of homologous chromosomes to opposite poles of the cell halves the chromosome number. One chromosome of each type move to each pole and nucli formed in first division of meiosis contain one of each type of chromosome, so both are haploid.

Drawing diagrams to show the stages of meiosis resulting in the formation of four haploid cells.



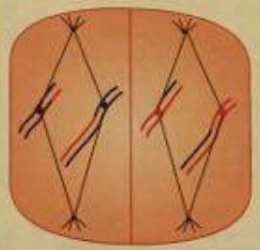
The second division of meiosis

Prophase II

- Chromosomes, which still consist of two chromatids, condense and become visible.

Prophase II

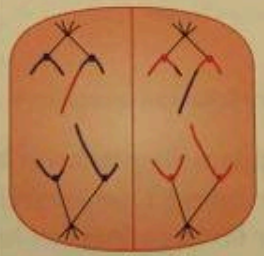
Metaphase II



Metaphase II

Anaphase II

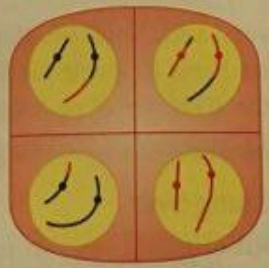
- Centromeres separate and chromatids are moved to opposite poles.



Anaphase II

Telophase II

- Chromatids reach opposite poles.
- Nuclear envelope forms.
- Cytokinesis occurs.



Telophase II

Crossing over and random orientation promotes genetic variation.

Random orientation of bivalents:

- Metaphase 1, orientation of bivalents is random and doesn't affect other bivalents. This produces genetic variation among genes that are on different chromosome types. Possible chromosome combinations : For a haploid number of =n, 2^n and with haploid number of 23, this amounts to $2^{23.}$

Crossing over:

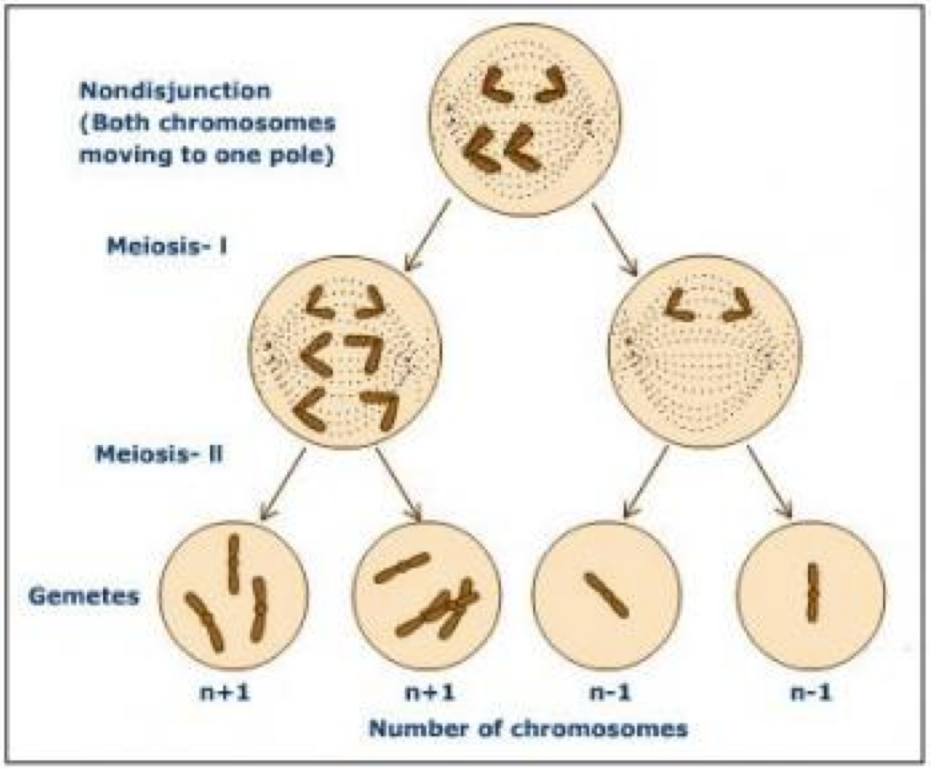
- It allows allele combinations to be reshuffled and produces new combinations.

Fusion of gametes from different parents promotes genetic variation.

- Allows alleles from two different individual to be combined in one new individual.
- Combination of alleles unlikely to have existed before.
- Promotes genetic variation in species.
- Essential for evolution.

App: Non-disjunction can cause Down syndrome and other chromosome abnormalities.

- Example of meiosis error:
- When homologous chromosomes fail to separate at anaphase- non-disjunction.
- Both of chromosomes move to one pole and neither to other pole. Gamete has extra chromosome and one has a deficient chromosome.
- Abnormal number of chromosomes leads to syndrome. E.g. Down syndrome: triosmy 21, three of chromosome number 21 instead of two.



Methods used to obtain cells for karyotype analysis e.g. chronionic villus sampling and amniocentesis and the associated risks.

- Obtaining cells containing fetal chromosomes need for producing karyotype.

1. Amniocentesis: passing needle through mother's abdomen wall, guided by ultrasound. Needle withdraws a sample of amniotic fluid containing fetal cells from amniotic sac.
2. Chorionic villus sampling: enters through vagina used to obtain cells from the chorion, membranes from which placenta develops.