Chapter 11:
Meiosis

I. Meiosis Overview
II. More on Chromosomes
III. Meiosis
IV. Problems with Meiosis

I. Meiosis Overview

Two types of cell division:

1. Mitotic Cell Division
   - Daughter cells identical to parental cell
   - Growth, repair & asexual reproduction

2. Meiotic Cell division
   - Daughter cells have \( \frac{1}{2} \) genetic info of parent cell
   - Sexual reproduction (Egg & sperm production)
Why might a cell use **Meiosis** instead of **Mitosis**?

**Sexual reproduction!!!**

1 sex precursor cell (2n) undergoes meiotic division →

It produces four (1n) gametes

Gametes have half the DNA of a parental cell

Gametes combine (during fertilization) to form 2n zygote

**ADVANTAGE?**

Alleles in zygote could be from either parent…

Potential for **recombination** → new genetic individuals

Potential for ADAPTATIONS!

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**Why is Sexual Reproduction Important?**

- Reshuffling genes between parents can combine alleles in new, beneficial ways
III. Meiosis

Meiosis I
- Prophase I
- Metaphase I
- Anaphase I
- Telophase I

Meiosis II
- Prophase II
- Metaphase II
- Anaphase II
- Telophase II

Meiosis I ≠ Mitosis
Meiosis II ~ Mitosis
Meiosis I - Prophase

1. Chromosomes finish condensing
2. Nuclear envelope dissolves
3. Centrioles have replicated & moved apart (Interphase)
4. Spindle apparatus forms
5. Synapsis - Homologous chromosomes pair up

Meiosis I: Prophase: Synapsis and Crossover

- Synapsis: Chromatids exchange parts with chromatids from the other homologous chromosome
- Crossover: Homologous Chromosomes after crossover

= Recombination
Creates new combinations of alleles on a chromosome!!!
Meiosis I - Metaphase

1. Homologous chromosomes align on an equatorial plane

Meiosis I - Anaphase

1. Homologous chromosomes separate

2. *Reduction division* of chromosomes where

\[ 2N \rightarrow 1N \]
Meiosis I - Telophase

1. Chromosomes decondense
2. Nuclear membrane forms
3. Spindle apparatus disappears
4. Cytokinesis – Two haploid daughter cells form

Haploid Daughter Cells

Meiosis I: Summary

MEIOSIS I: Homologous chromosomes separate

INTERPHASE PROPHASE I METAPHASE I ANAPHASE I

Centrioles Crossing over Spindle Sister chromatids

Chromatin Sister chromatids Homologous chromosomes separate
Meiosis II

MEIOSIS II: Chromatids separate

<table>
<thead>
<tr>
<th>MELOPHASE I AND CYTOKINESIS</th>
<th>PROPHASE II</th>
<th>METAPHASE II</th>
<th>ANAPHASE II</th>
<th>TELOPHASE II AND CYTOKINESIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cleavage furrow</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sister chromatids separate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Haploid daughter cells form – Gametes!!</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Huge point of understanding →
There is no DNA replication between Meiosis I & Meiosis II!

Meiosis - Summary

55
MEIOSIS and Sexual Reproduction create diversity

Mechanisms:

- Shuffling of homologues in Metaphase 1
- Crossing over → New combinations of alleles on chromosomes (different from both parents)
- Fusion of gametes → produces variety
IV. Problems with Meiosis & DNA Replication

Nondisjunction in Meiosis I

All of the gametes are abnormal
Nondisjunction in Meiosis II

Half of the gametes are abnormal

Fertilization after Nondisjunction in the mother
Autosome Nondisjunction

1. Most common birth defect
2. 1 in 750
3. Physical features
   - Round face
   - Flattened nose bridge
   - Short stature
   - Heart defects
4. Susceptibility to infections

Trisomy 21 or Down Syndrome

Maternal age and incidence of Down syndrome
In human females, oocytes enter but arrest in prophase of meiosis I during fetal development.

Each oocyte remains arrested in prophase of meiosis I until that individual oocyte is ovulated, as much as 50 years later!

Asymmetrical cell division (cytokinesis)

An oocyte proceeds through meiosis II only after (and if) it is fertilized.

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Nondisjunction of Sex Chromosomes

- Female XX
- Male XY

Eggs XX

- XXX Female (triple X)
- X0 Female (Turner syndrome)
- XXY Male (Klinefelter syndrome)
- OY Nonviable
Abnormalities of sex chromosome number in humans

**TABLE 8.22 ABNORMALITIES OF SEX CHROMOSOME NUMBER IN HUMANS**

<table>
<thead>
<tr>
<th>Sex Chromosomes</th>
<th>Syndrome</th>
<th>Origin of Nondisjunction</th>
<th>Frequency in Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>XXY</td>
<td>Klinefelter syndrome (males). Male secondary sex characteristics poorly developed</td>
<td>Meiosis in egg or sperm formation</td>
<td>1/2,000</td>
</tr>
<tr>
<td>XY</td>
<td>Males may be normal or... delayed mental maturation &amp; speech.</td>
<td>Meiosis in sperm formation</td>
<td>1/2,000</td>
</tr>
<tr>
<td>XXX</td>
<td>Females – May be normal .... or Tall stature, delayed puberty</td>
<td>Meiosis in egg or sperm formation</td>
<td>1/1,000</td>
</tr>
<tr>
<td>XOX</td>
<td>Turner syndrome (females) Developmental abnormalities</td>
<td>Meiosis in egg or sperm formation</td>
<td>1/5,000</td>
</tr>
</tbody>
</table>

Klinefelter syndrome (XXY)

- Poor beard growth
- Breast Development
- Under-developed testes

→ Sterile male
→ Many female characteristics
→ May have diminished mental capacity
Web of skin
Constriction of aorta
Poor breast development
Underdeveloped ovaries

A woman with Turner syndrome (XO)

- Sexually underdeveloped
- Short stature
- Folds of skin on the back of the neck
- Wide-spaced nipples
- Narrow aorta
- Pigmented moles
- 99% die before birth
- Infertile
- Low to normal intelligence

Alterations of chromosome structure involving one chromosome or a homologous pair

Deletion

Duplication

Inversion

Cri du chat
- Chromosome 5 deletion
- 1 in 25,000-50,000
- Can be detected by amniocentesis
- Mental retardation
- May live normal life span
Spontaneous abortions

~50% of human pregnancies \(\rightarrow\) spontaneous abortion or miscarriage

50% of spontaneously aborted embryos and fetuses have chromosomal abnormalities

nearly all during first trimester of pregnancy, with many during the first month, when pregnancy is recognized only by hormonal assays

Therefore, 25% of all human embryos have chromosomal abnormalities that result in embryo loss.
Genetic Versatility in Plants: Polyploidy

1. Plants are much more tolerant of polyploidy than animals; often results in speciation
2. Polyploidy can happen as the result of a failure during meiosis
3. Or, polyploidy can happen as the result of hybridization between two different species

631 pairs of chromosomes or 1262 chromosomes per cell

Mustard Greens

Black Mustard

Yellow Mustard: Turnips

Kale; Rutabaga

Cabbage

B. juncea
2n = 36
AABB

B. carinata
2n = 34
BBCC

B. campestris
2n = 20
AA

B. napus
2n = 38
AACC

Brassica nigra
2n = 16
BB

B. oleracea
2n = 18
CC