Chapter 11: The Continuity of Life: Cellular Reproduction

What is Cellular Reproduction?
Answer: The division of a parent cell into two daughter cells

Requirements of Each Daughter Cell:
1) Necessary genomic information (DNA)
2) A complete assortment of cytoplasmic materials

Cell Types Differ in Reproductive Process:
- Prokaryotes = Binary Fission
- Eukaryotes = Mitosis or Meiosis

Binary Fission - “splitting in two”
- Prokaryote DNA:
  - Single circular chromosome
  - Attached to cell wall

Steps in Binary Fission:
1) Chromosome replicates
2) Cell elongates (membrane production)
   - Chromosomes pulled apart
3) Membrane pinches in middle
4) Daughter cells formed

(Figure 11.1)

What is Cellular Reproduction?
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Cell Types Differ in Reproductive Process:
- Prokaryotes = Binary Fission
- Eukaryotes:
  1) Mitosis: Daughter cells genetically identical to parent cells
  2) Meiosis: Daughter cells genetically different from parent cells

Functions:
- Growth (We all start as a single cell...)
- Maintenance (Skin flakes off...)
- Repair (Wounds heal...)
- Asexual reproduction (produces clone of parent)

Mitosis:
Cell Cycle: The cell activity from one cell division to the next

Interphase (majority of time):
1) G₁ Phase (growth phase 1)
   - Acquire materials
   - Grow
2) S Phase (synthesis phase)
   - Replicate DNA
3) G₂ Phase (growth phase 2)
   - Synthesize material for cell division
Mitosis:
Cell Cycle: The cell activity from one cell division to the next

Interphase (majority of time):
During G₁ phase, cell is sensitive to signals:

GO → S Phase

STOP → G₀ Phase
  • Metabolically active
  • No division
Cancer = Signal Failure

Mitotic Cell Division:
One copy of DNA and half of cytoplasm distributed to two (2) identical daughter cells
1) Mitosis
   • Division of DNA
2) Cytokinesis
   • Division of cytoplasm

How is DNA in Eukaryotes Organized?
Answer: DNA is packaged into chromosomes

• Chromosomes contain:
  1) Linear DNA strand
  2) Histones: Packaging proteins
• Chromosome condensed during cell division and extended other times (chromatin)
• When condensed, DNA has already replicated
  • Identical copies = same alleles.
  • Sister chromatids connected at centromere

DNA Organization:
• Chromosomes often occur in pairs called homologues
  • Both members are same length and contain same genes in same order

Diploid: Cells with pairs of homologous chromosomes (2n)
  • Found in most cells of human body
Haploid: Cells with only one of each type of chromosome (n = Haploid number)
  • Found in sex cells (e.g., sperm / egg)
Karyotype: Entire set of chromosomes from a single cell

Human Karyotype:
Haploid Number:
\( n = 23 \)

Diploid Number:
\( 2n = 46 \)
(23 pairs)

Sex Chromosomes:
X and Y
Female = XX
Male = XY
### Haploid Number and Diploid Number

<table>
<thead>
<tr>
<th>Organism</th>
<th>Haploid Number (n)</th>
<th>Diploid Number (2n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human</td>
<td>23</td>
<td>46</td>
</tr>
<tr>
<td>Chimpanzee</td>
<td>24</td>
<td>48</td>
</tr>
<tr>
<td>Gorilla</td>
<td>24</td>
<td>48</td>
</tr>
<tr>
<td>Dog</td>
<td>39</td>
<td>78</td>
</tr>
<tr>
<td>Cat</td>
<td>19</td>
<td>38</td>
</tr>
<tr>
<td>Shrimp</td>
<td>127</td>
<td>254</td>
</tr>
<tr>
<td>Fruitfly</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Potato</td>
<td>24</td>
<td>48</td>
</tr>
</tbody>
</table>

### Cell Cycle: The cell activity from one cell division to the next

#### Mitotic Cell Division:
- One copy of DNA and half of cytoplasm distributed to two (2) daughter cells
  1. **Mitosis**
     - Division of DNA
  2. **Cytokinesis**
     - Division of cytoplasm

### What are the Phases of Mitosis?

**Answer:**
1. **Prophase**
2. **Metaphase**
3. **Anaphase**
4. **Telophase**

#### For the Exam (Figure 11.10):
1. Understand what spindle fibers, centrioles, and kinetochores are, where they are found during each stage of mitosis, and what is their function.
2. Be familiar with the appearance of a cell at each stage of mitosis = pictures of mitosis phases will be on the exam.
Cell Cycle: The cell activity from one cell division to the next

Mitotic Cell Division:
One copy of DNA and half of cytoplasm distributed to two (2) daughter cells
1) Mitosis
   • Division of DNA
2) Cytokinesis
   • Division of cytoplasm

Cytokinesis in Animal Cells:
• Microfilaments form ring around cell equator and contract to pinch cytoplasm into two parts

(Figure 11.11)

The microfilaments act like a belt that tightens until the cell is split into two daughter cells.
Cytokinesis in Plant Cells - Is it the same? NO

• Cell wall makes cell too stiff to constrict at middle:
  1) Carbohydrate-filled vesicles line up on cell equator
  2) Cells fuse, producing cell plate
  3) Fusion continues until new cell wall divides cell

(Figure 11.13)

What is Cellular Reproduction?
Answer: The division of a parent cell into two daughter cells

Cell Types Differ in Reproductive Process:
• Prokaryotes = Binary Fission
• Eukaryotes:
  1) Mitosis: Daughter cells genetically identical to parent cells
  2) Meiosis: Daughter cells contain 1/2 the genetic information of parental cell
    • Sexual reproduction (produces gametes)

B. Behavior of chromosome sets in the human life cycle
All sexual life cycles include 2 events:

Meiosis
2n → 1n

Fertilization
1n + 1n → 2n

What is the Advantage to Sexual Reproduction?
Answer: Allows for reshuffling of genes to produce genetically unique offspring better suited to environment...

Mutations in DNA are source of genetic variability:
• Allele = Alternate forms of a given gene (e.g. eye color)

• Almost all genes have two or more alleles

Zygote = fertilized egg (1-cell embryo)
Reshuffling Genes (Alleles) to Benefit Organism - Example:

- **Motionless Allele**
  - Freezes when predator approaches

- **Bright Allele**
  - Coloration stands out

- **Motion Allele**
  - Moves when predator approaches

- **Camouflage Allele**
  - Coloration blends in

Sexual Reproduction

- **Motionless Allele**
  - Freezes when predator approaches

- **Camouflage Allele**
  - Coloration blends in

Asexual Reproduction

- **Dinner**

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When gene shuffling is good...

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Meiosis ("To Diminish"):

- **Begin with:** Parent diploid cell (2n = 46)
- **Finish with:** Four daughter haploid cells (n = 23)

Similar to Mitosis except cell goes through **two** nuclear divisions:

- **Meiosis I:** Homologous chromosomes pair up and separate from one another (2n → n)
- **Meiosis II:** Sister chromatids separate (Mitosis revisited...)

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Chiasmata

How many chiasmata can you find?

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Meiosis I:

1) **Prophase I** - Homologous chromosomes pair up
   - Maternal chromosome & paternal chromosome
   - Chiasma = Region where paired chromosomes joined
2) **Metaphase I** - Homologous pairs line up at cell center
3) **Anaphase I** - Homologous pairs pulled to opposite poles
4) **Telophase I** - Formation of two daughter cells (haploid)

(Figure 11.21)

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Meiosis II:

- **Repeat of mitosis...**

(Figure 11.21)
Differences between meiosis I and mitosis

<table>
<thead>
<tr>
<th>Meiosis-I</th>
<th>Mitosis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Prophase I:</strong></td>
<td><strong>Prophase:</strong></td>
</tr>
<tr>
<td>Homologs pair up.</td>
<td>Homologs do not pair.</td>
</tr>
<tr>
<td>Crossing over between homologous chromosomes.</td>
<td>No crossing over between homologous chromatids</td>
</tr>
<tr>
<td><strong>Anaphase I:</strong></td>
<td><strong>Anaphase:</strong></td>
</tr>
<tr>
<td>Homologs separate</td>
<td>Sister chromatids separate.</td>
</tr>
</tbody>
</table>

How Meiosis Produces Genetic Variability:

1) Shuffling of Homologous Chromosomes creates Novel Combinations of Chromosomes:

During metaphase I:

\[ 2^n = 6 \]

Potential Results of Meiosis I:

\[ 2^3 = 2 \times 2 \times 2 = 8 \]

2) Crossing over creates Chromosomes with Novel Combinations of Genes:

3) Fusion of Gametes adds further Variability:

Sperm = 8 million unique gametes

Egg = 8 million unique gametes

Fusion = 6 trillion possibilities

Cloning:

1. Cells from the interior or dermal layer of a Blashke's cloned sheep is removed and placed in a test tube. 
2. A Blashke’s cloned sheep is removed and placed in a test tube. 
3. The egg cell without a nucleus and the sperm cell without a nucleus is removed. 
4. The egg cell without a nucleus and the sperm cell without a nucleus is removed. 
5. The embryo is implanted into the uterus of a second Blashke’s sheep. 
6. The embryo is implanted into the uterus of a second Blashke’s sheep.

Fusion is sperm and egg Blashke’s sheep. 

Fusion is sperm and egg Blashke’s sheep.