The Somatic Cell Cycle

Diploid Zygote

MITOSIS

Diploid organism

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Diploid organism
The Mitotic cell cycle is essential to cell division and growth of an organism.

Gene Expression and Cell Division conflict:

- Gene expression requires

- Cell division requires

Gene Expression and Cell Division are separated into different stages
The Somatic Cell Cycle

Stages of the cell cycle:

- **M** Mitosis = period of cell division
- **G₁** Gap₁ = period during cellular interphase from the end of one telophase to the beginning of DNA replication
- **S** Synthesis = period of pre-mitotic interphase when DNA is replicated
- **G₂** Gap₂ = period during interphase after completion of DNA replication and before beginning of prophase

**G₁** and **G₂** are called gaps in the cell cycle when no DNA synthesis occurs.

Cytological observations of the cell cycle are divided into two parts, interphase and mitosis.
Interphase

G₁

1. Period of gene expression
2. Daughter cells retain the diploid set of chromosomes and DNA content is 2c
3. More variable in length than S, G₂ or M
4. Some event during G₁ is the focus of regulation of cell reproduction in tissues
5. Differentiated cells that cease to reproduce usually contain G₁ amount of DNA (2c) whether cessation is reversible or irreversible (G₀)
6. In cells that continue to reproduce, the reproductive rate is governed by the average length of time that cells are retained in the G\textsubscript{1}.

7. Measurement of DNA content in dormant plant embryos indicate cells are arrested in G\textsubscript{1}.

8. G\textsubscript{1} may be absent in rapidly proliferating cells or higher organisms, particularly during embryogenesis.

9. Once cells progress from G\textsubscript{1} to S, they are committed to proceed through mitosis.
1. Period of DNA synthesis (DNA content goes from 2c to 4c)

2. Autoradiography shows that DNA synthesis is confined to a relatively short period

3. DNA replication is initiated by factors in the cytoplasm

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   a) when two or more nuclei share the same cytoplasm, they are nearly always synchronized
Interphase

S

4. DNA replication is initiated by factors in the cytoplasm

b) Gurdon (1973) observed that DNA synthesis was initiated when nuclei from various tissue of *Xenopus* were implanted into an unfertilized egg

c) Nuclei from adult liver, brain, and blood cells injected into mature eggs of *Xenopus* initiated DNA synthesis within 90 minutes of injection

d) Inhibition of protein synthesis in G₁ will inhibit or delay on set of the S phase
Interphase

G₂

1. The nucleus contains two diploid sets of chromatids (DNA content is 4c)

2. Period required for cells to synthesize elements necessary for chromosome condensation and the construction and operation of the mitotic apparatus

3. Protein synthesis is necessary for cells to complete most of the G₂ period, but protein synthesis required for mitosis is completed prior to prophase

4. G₂ lasts until mitosis begins
5. The fusion of a mitotic HeLa cell with an interphase cell results in condensation of interphase chromosomes (Rao and Johnson, 1970)

a) Chromosomes do not have to be replicated to respond to the condensation signal

b) The condensation factor is effective across phylogenetic lines (Bull sperm, chicken erythrocytes, and mosquito were condensed by the HeLa factor)
Life cycle of a sexually reproducing organism correlated with the amount of DNA per cell

- **G** = Gamete
- **Z** = Zygote
- **S** = Period of DNA synthesis
- **A** = Mitotic Anaphase
- **A1** = First meiotic anaphase
- **A2** = Second meiotic anaphase

Sequence of stages:
- Fertilization
- Mitotic divisions
- Meiotic divisions

Amount of DNA/cell C values:
- 0
- 1
- 2
- 3
- 4
Stages of Mitosis

- **Interphase:**
  - Chromosomes are fine diffuse strands and are difficult to see with light microscopy
  - Chromosomes are duplicated
  - The nuclear envelope is intact

- **Prometaphase**
  - Further chromosome condensation
  - Nuclear envelope disintegrates
  - Chromosomes become associated with spindle apparatus
  - Sister chromatids remain attached at the centromere, but begin to separate at other regions
Stages of Mitosis

➤ **Metaphase**

✔ Sister chromatid pairs are aligned near the spindle with centromeres still associated
✔ The centromeres orient toward opposite pools and are lined up on the metaphase plate

➤ **Anaphase**

✔ Sister chromatid pairs separate with one member of each pair moving toward the poles

➤ **Telophase**

✔ Chromatids reach opposite poles and poleward movement ceases
✔ New nuclear envelope is formed around each diploid chromosome set
✔ Chromosomes begin to decondense
Stages of Mitosis

Cytokinesis

- During mitosis doubling of all the cytoplasmic organelles also occurs, they are distributed to daughter cells during this stage
- Central ring of myosin and actin fibers contract to separate the daughter cells
- In plants the cell plate is laid down in preparation for the rigid cell wall
Control of Mitotic Cell Division

Molecular clock

G2 Phase

signal for G2 to mitosis transition

G1 Phase

start signal

S Phase

M Phase
Buildup of Cyclin B

Phosphorylation of Cyclin B

G_1

G_2

S

Inactive

P

Dephosphorylation

Breakdown of Cyclin B

MPF or maturation-promoting factor or mitosis promoting factor

P34^{cdc2}
Mitotic Index = \frac{\# \text{ of mitotic cells}}{\text{Total \# of cells}}

Mitotic cells = cells in stages from prophase to telophase
Glossary of terms

**The Somatic Cell Cycle** = Events that occur from one cell division to the next

**2C** = DNA content of nucleus in the somatic cells of an organism

**Chromatid** = A single chromosomal strand; a metaphase chromosome is composed of two “sister” chromatids

**Centromere** = A region of chromosome from which kinetochore microtubules radiate during mitosis or meiosis

**Kinetochore** = A specialized region on the centromere that links each sister chromatid to the mitotic spindle

**Heterochromatin** = non-transcribed eukaryotic chromatin that is so highly compacted that it is visible with a light microscope during interphase

**Euchromatin** = The more open, unraveled form of eukaryotic chromatin, which is available for transcription