

Mitotic index and Duration of the cell cycle

Objectives:

Upon completion of this lab, the students should be able to:

1. Understand the meaning of mitotic index and duration of stages (phases)
2. Calculate the mitotic indexes
3. Calculate the duration of stages (phases) of different organisms
4. Comment on any experimental results

Mitotic Index

It is defined as the ratio of cells undergoing mitosis (as seen in the region of most mitotic activity) to the total number of observed cells

On the basis of the equation mainly

$$\text{Mitotic index} = \frac{\text{Number of dividing cells}}{\text{Total number of counted cells}}$$

$$\% \text{ cells in mitosis} = \frac{\text{Total number of cells undergoing mitosis}}{\text{Total number of cells}} \times 100$$

Mitotic index is used to quantify the differences in cell division when environmental parameters are changed.

N.B. Mitotic activity (and MI in turn) decreases with increasing distance from the zone of meristematic cells in the root tip.

Duration of the Cell Cycle:

The division cycle of eukaryotic cells is divided into four discrete phases: G₁, S, G₂ and M. The M phase (mitosis) is usually followed by cytokinesis. The duration of these cell cycle phases varies considerably in different kinds of cells.

The duration of any stage (or phase) in the cell cycle (minutes) =

$$\frac{\text{Number of cells in the stage (or phase)} \times \text{Cell Cycle duration of the organism}}{\text{Total number of cells}}$$

Where the cycle duration of higher plants = **1440** min (divide every 24 hr).

Where the cycle duration of yeast cells = **120** min (divide every 2 hr).

Dissolved Problem:

Cells of *Saccharomyces cerevisiae* (yeast) were treated with the fungicide 'Chlorothalonil'. The following data show the effect of the treatment on the various mitotic stages as compared with control cells.

Phases of cell cycle	Number of cells in the phase	
	Control	Treatment
Interphase	180	187
Prophase	9	5
Metaphase	7	6
Anaphase	2	1
Telophase	2	1
Total	200	200

- Calculate the mitotic indices in both cases.
- Calculate the time spent in each phase (in **min.**) of both cases.
- Comment on the calculated data.

Calculation of MI:

$$\text{MI} = \frac{\text{Number of dividing cells}}{\text{Total number of counted cells}}$$

$$\% \text{ cells in mitosis} = \frac{\text{Total number of cells undergoing mitosis}}{\text{Total number of cells}} \times 100$$

$$\% \text{ cells in mitosis (control)} = (20 / 200) \times 100 = 10$$

$$\% \text{ cells in mitosis (treatment)} = (13 / 200) \times 100 = 6.5$$

Comment on MI:

- **Since MI control > MI treatment**, so the treatment decreases the no. of cells undergoing mitosis, as compared to control.
- This reveals the cytotoxic effect of the applied fungicide on the test organism.

Calculation of Phases Duration:

$$\text{The duration of any stage (or phase) in the cell cycle (minutes)} = \frac{\text{Number of cells in the stage (or phase)}}{\text{Total number of cells}} \times \text{Cell Cycle duration of the organism}$$

$$\text{The cycle duration of yeast cell} = 2 \text{ hour/cell cycle} = 120 \text{ min}$$

The duration of different phases in the cell cycle in minutes is calculated in the following table:

	Control	Treatment
Interphase	$(180/200) \times 120 = \mathbf{108}$ min	$(187/200) \times 120 = \mathbf{112.2}$ min
Prophase	$(9/200) \times 120 = \mathbf{5.4}$ min	$(5/200) \times 120 = \mathbf{3}$ min
Metaphase	$(7/200) \times 120 = \mathbf{4.2}$ min	$(6/200) \times 120 = \mathbf{3.6}$ min
Anaphase	$(2/200) \times 120 = \mathbf{1.2}$ min	$(1/200) \times 120 = \mathbf{0.6}$ min
Telophase	$(2/200) \times 120 = \mathbf{1.2}$ min	$(1/200) \times 120 = \mathbf{0.6}$ min

Comment on Duration:

The **duration** of these cell cycle phases varies considerably in different kinds of cells.

- Longer duration of interphase in treated cells than that of control cells indicates that MI of treated cells is lower than that of control cells.
- This is accompanied by a general decline in the duration of different dividing stages of the treated cells.

Student name:**Code number:**

STUDENT'S ASSIGNMENT
Give it to your laboratory instructor

Problem:

Vicia faba roots were treated with a nano-fungicide 'Trifloxystrobin'. The following data show the effect of the treatment on the various mitotic stages as compared with control plants.

phases of cell cycle	Number of cells in the phase	
	Control	Treatment
Interphase	176	189
Prophase	11	4
Metaphase	8	5
Anaphase	3	1
Telophase	2	1

- Calculate the mitotic indices in both cases.
- Calculate the time spent in each phase (in **min.**) of both cases.
- Comment on the calculated data.

N.B. equations must be written