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 (MI)

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

On the basis of the equation namely

$$MI = \frac{\text{Total number of dividing cells}}{\text{Total number of counted cells}} \times 100$$

Mitotic index is used to quantify the differences in cell division when environmental parameters are changed. Thus, the cytotoxic level of a chemical compound on a test organism can be determined on the basis of its harmful effect on MI.

N.B.

* Note that 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:

On the basis of nuclear events, cell cycle is usually divided into a short mitosis (M) phase followed by a much longer interphase. The duration of cell cycle phases varies considerably in different kinds of organisms, whereas

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

- Cycle duration of some higher plants =**1440** min (divide every 24 hr).
- Cycle duration of yeast cells = **120** min (divide every 2 hr).

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

$$\frac{\text{Number of phase cells}}{\text{Total number of cells}} \times \text{Cell cycle duration of the organism (in min.)}$$

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

a. **Calculate** the mitotic indices in both cases.
b. **Calculate** the time spent in each phase (in **min.**) of both cases.
c. **Comment** on both **(a)** and **(b)** data.

Calculation of MI

$$MI = \frac{\text{Number of dividing cells}}{\text{Total number of counted cells}} \times 100$$

MI (control) = (20 / 200) x 100 = **10**

MI (treatment) = (13 / 200) x 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:

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

$$\frac{\text{Number of phase cells}}{\text{Total number of cells}} \times \text{Cell cycle duration of the organism (in min.)}$$

The cycle duration of yeast cell = 2 hour/cell cycle = **120** min

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

	Control	**Treatment**
Interphase	(180/200) x 120 = **108** min	(187/200) x 120 = **112.2** min
Prophase	(9/200) x 120 = **5.4** min	(5/200) x 120 = **3** min
Metaphase	(7/200) x 120 = **4.2** min	(6/200) x 120 = **3.6** min
Anaphase	(2/200) x 120 = **1.2** min	(1/200) x 120 = **0.6** min
Telophase	(2/200) x 120 = **1.2** min	(1/200) x 120 = **0.6** min

Comment on Phases Duration

- Longer duration of interphase in treated cells than that of control cells confirms 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

a. **Calculate** the mitotic indices in both cases.

b. **Calculate** the time spent in each phase (in **min.**) of both cases.

c. **Comment** on both **(a)** and **(b)** data.

N.B.

equations must be written

A problem on mitotic index and cell cycle

Saccharomyces cerevisiae (yeast) were treated with 2 fungicides (**A** and **B**). The following data show the effect of the treatments on the various mitotic stages as compared with control yeast cells.

Phases of cell cycle	**Number of cells in the phase**		
	Control	**Fungicide A**	**Fungicide B**
Interphase	180	185	189
Prophase	11	8	4
Metaphase	6	5	5
Anaphase	1	1	1
Telophase	2	1	1

I. **Calculate** the time spent in interphase (**in min.**) in all treatments

II. **Calculate** the mitotic indices in all treatments.

III. **Comment on** your results. **Define** which fungicide (A or B) is better (**Why**?).

N.B.

Equations must be written