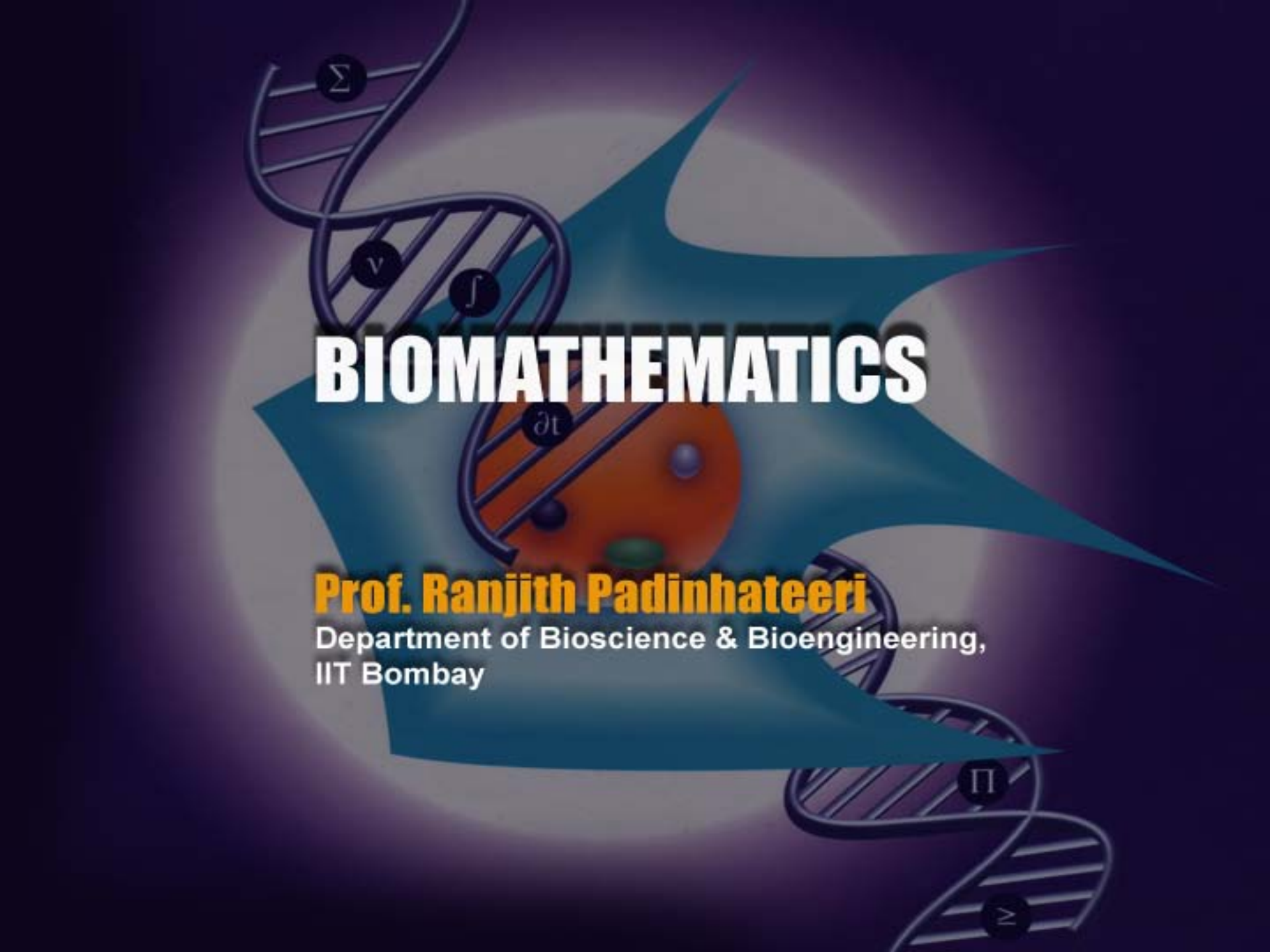

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Mathematical methods for the life sciences

Introduction

Why Mathematics?

- Mathematics is like a language
- Using mathematics we can describe many natural phenomena
- Mathematical equations are like precise statements

Mathematics as a language

In plain English we would say:

- Bacterial colony is ***growing slow***
- Bacterial colony is ***growing fast/very fast***

But these are qualitative statements

Mathematically, we can make a quantitative statement :

$$N = 2^{kt}$$

N : Number of bacteria at time t

k : growth rate

In this course, we will learn how to use mathematical equations to make precise statements

Experimental results : quantification

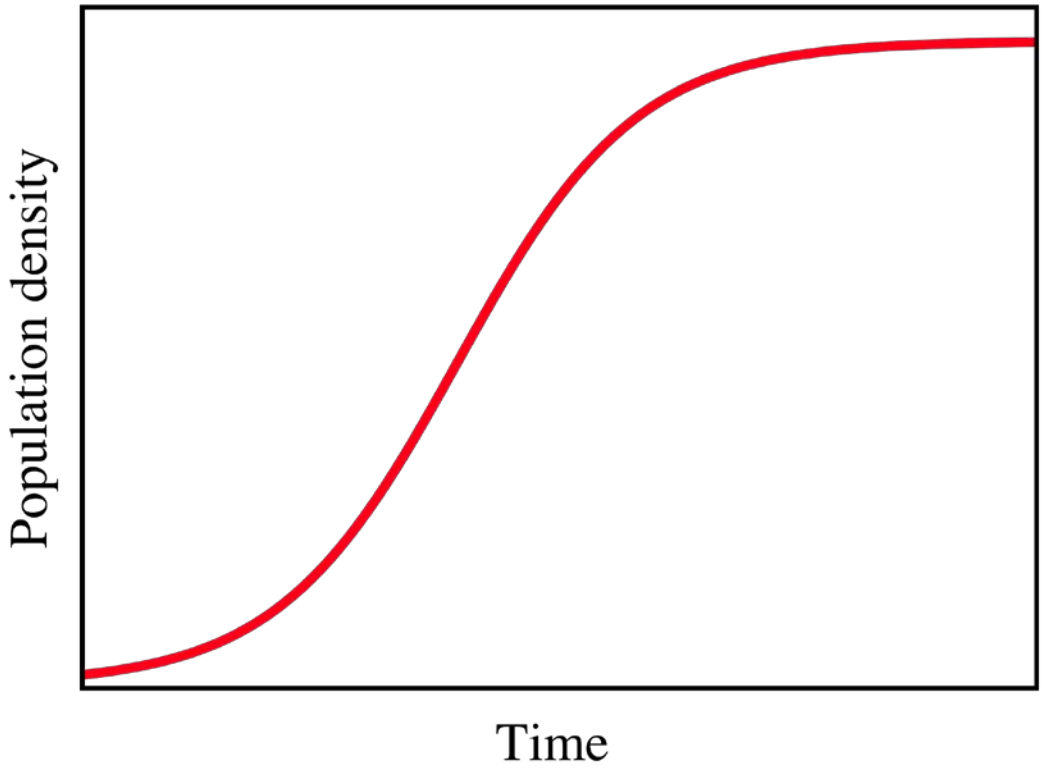
- Experimental results are typically presented as a graph -- not as a set of statements.
- A graph conveys much more information than a set of statements
- It is more quantitative.

Graphical representation

- A graph, in principle, can be represented by a mathematical equation.
- Understanding that equation, we can learn more about the experimental data/biological system.

Using mathematics, how do we extract more information from the experimental data ?

Growth of fish population

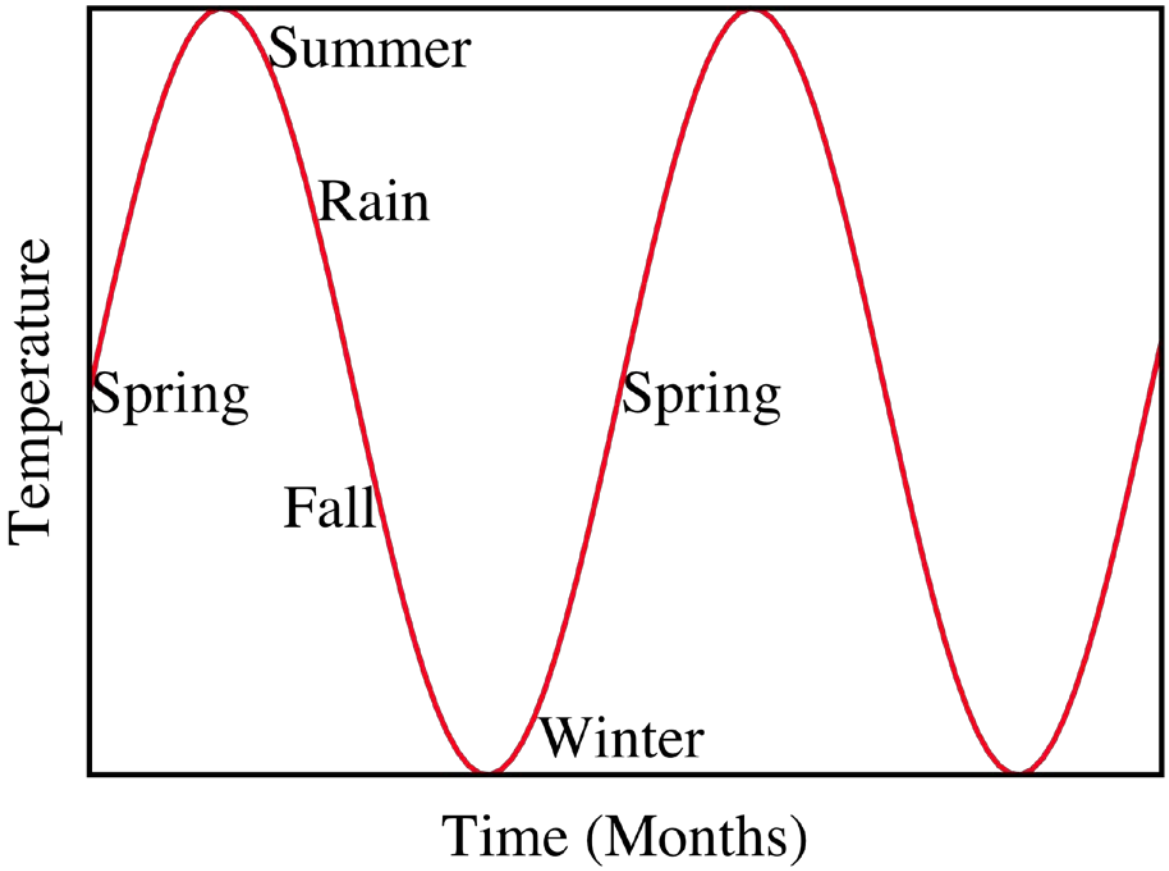


At what population density, we will get maximum yield ?

To answer this question, one should know the idea of “derivative” in mathematics

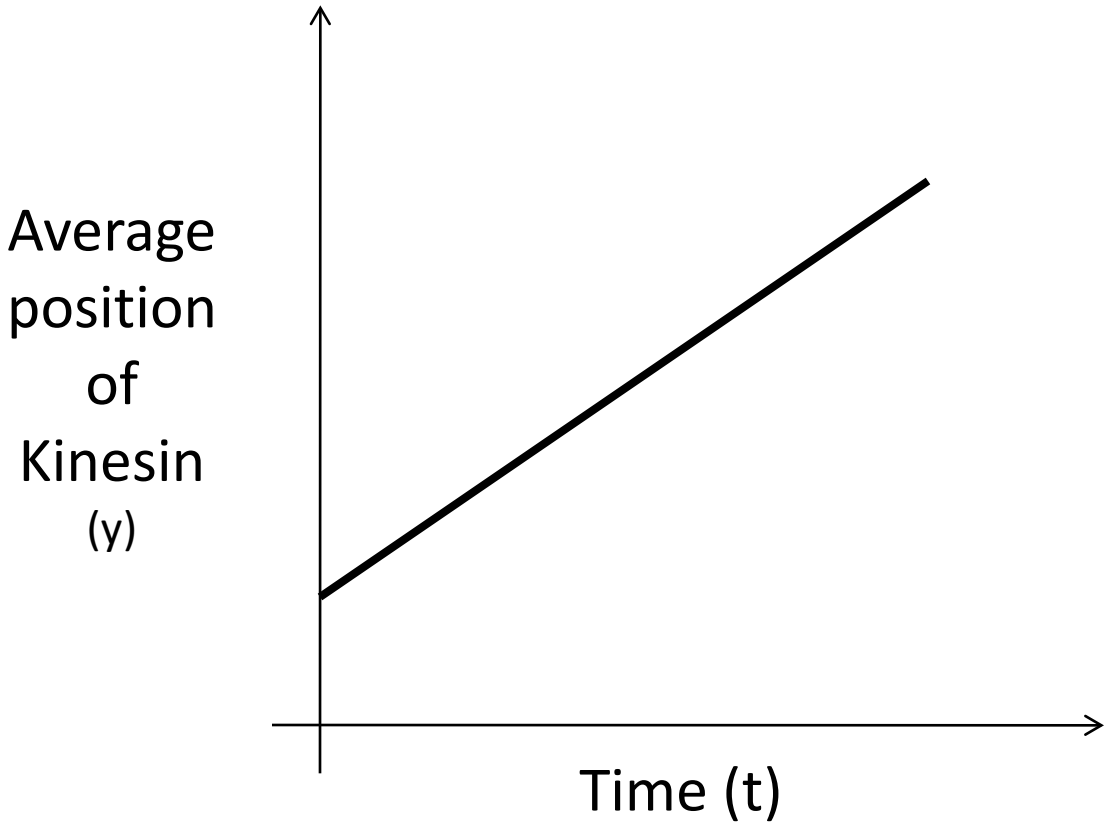
Let us see how certain ideas/phenomena can be represented using graphs

Seasons

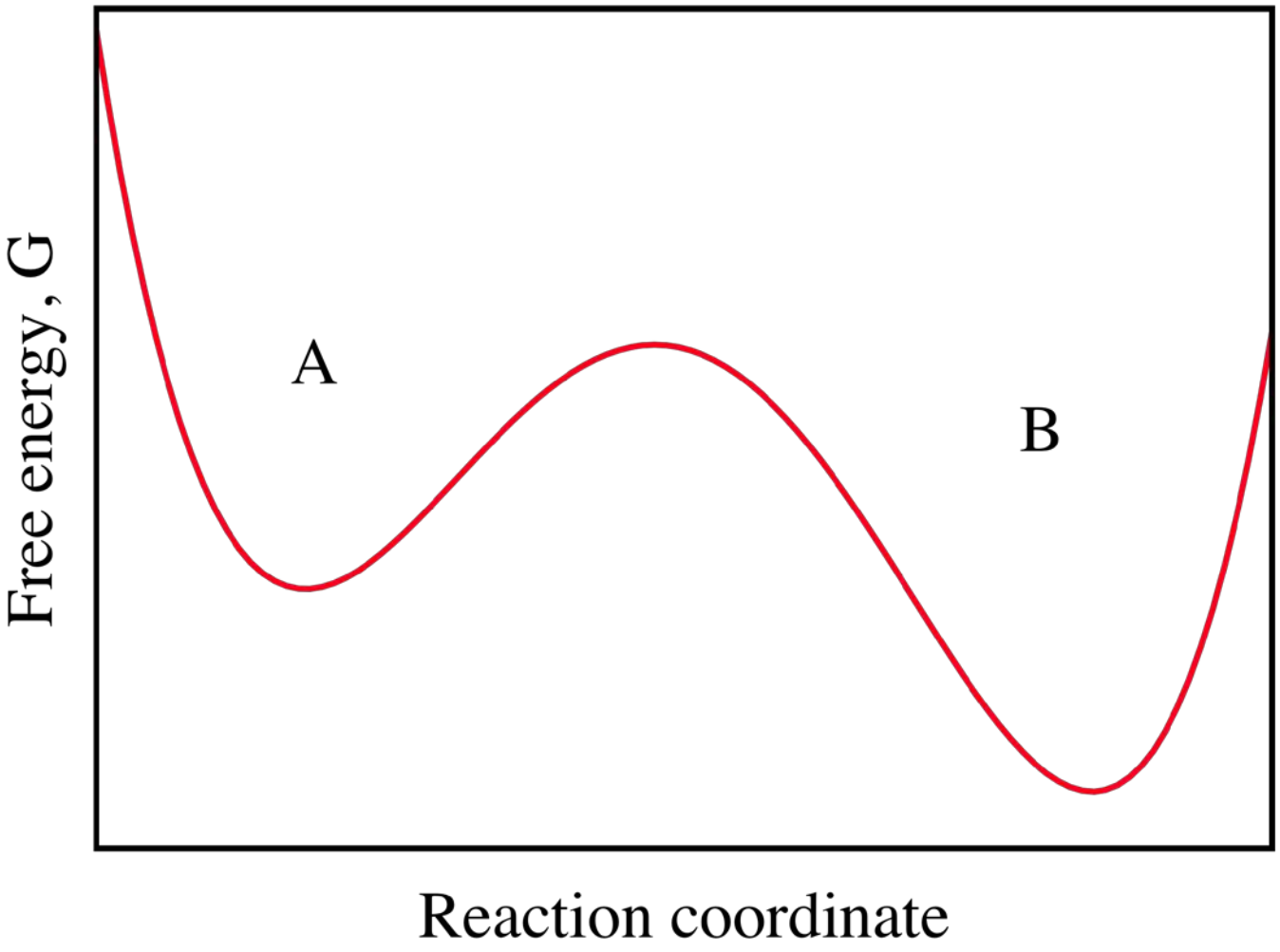


Periodic in nature

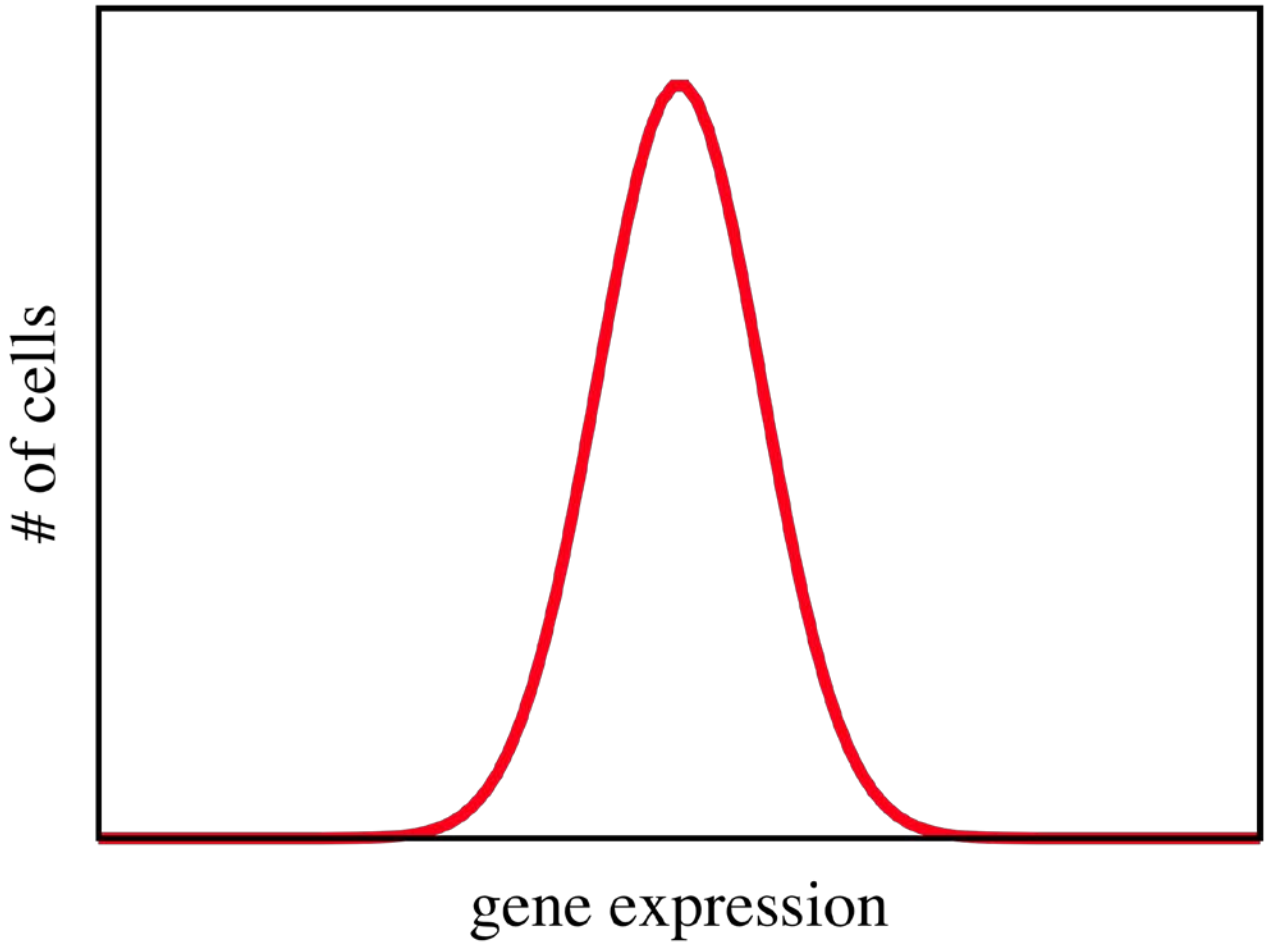
Molecular motor walking along microtubule



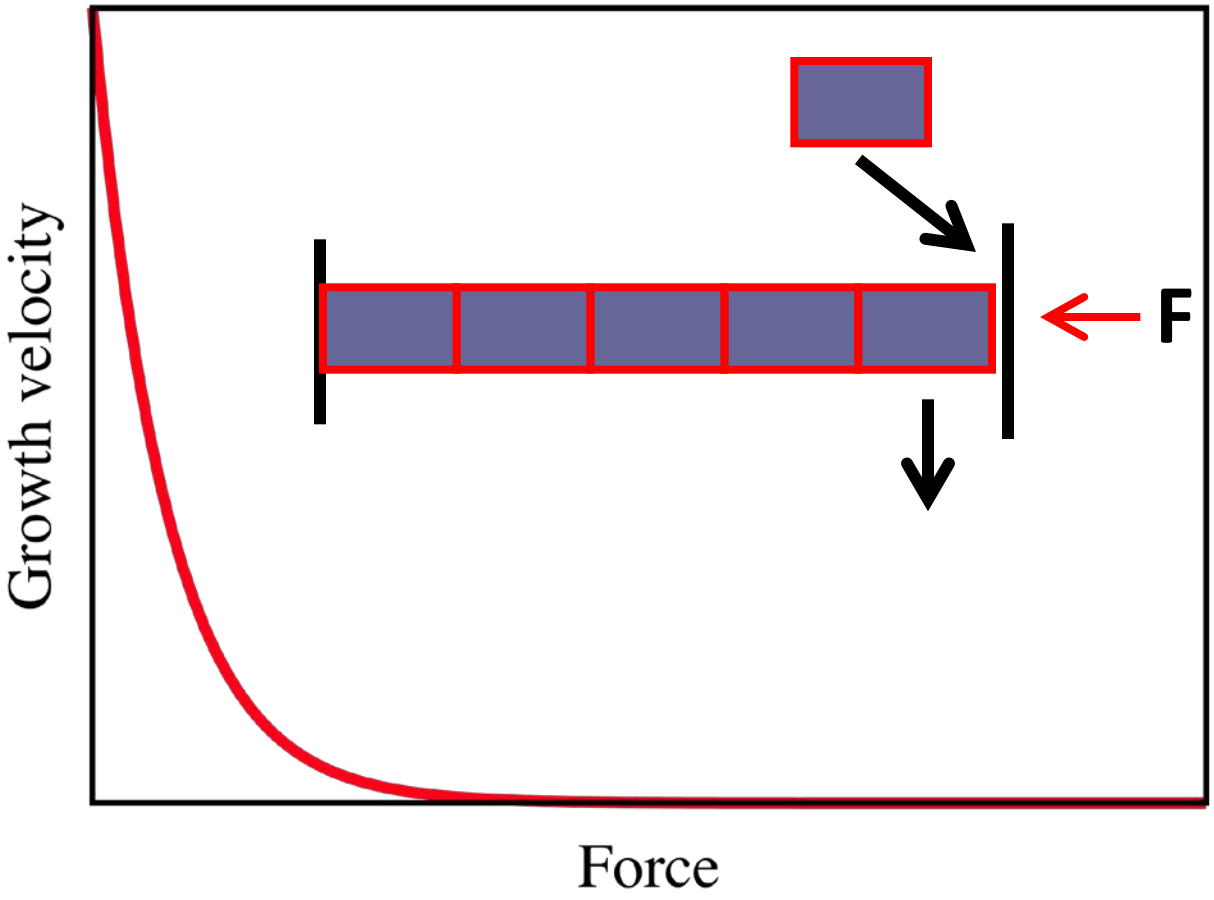
Free energy (G)



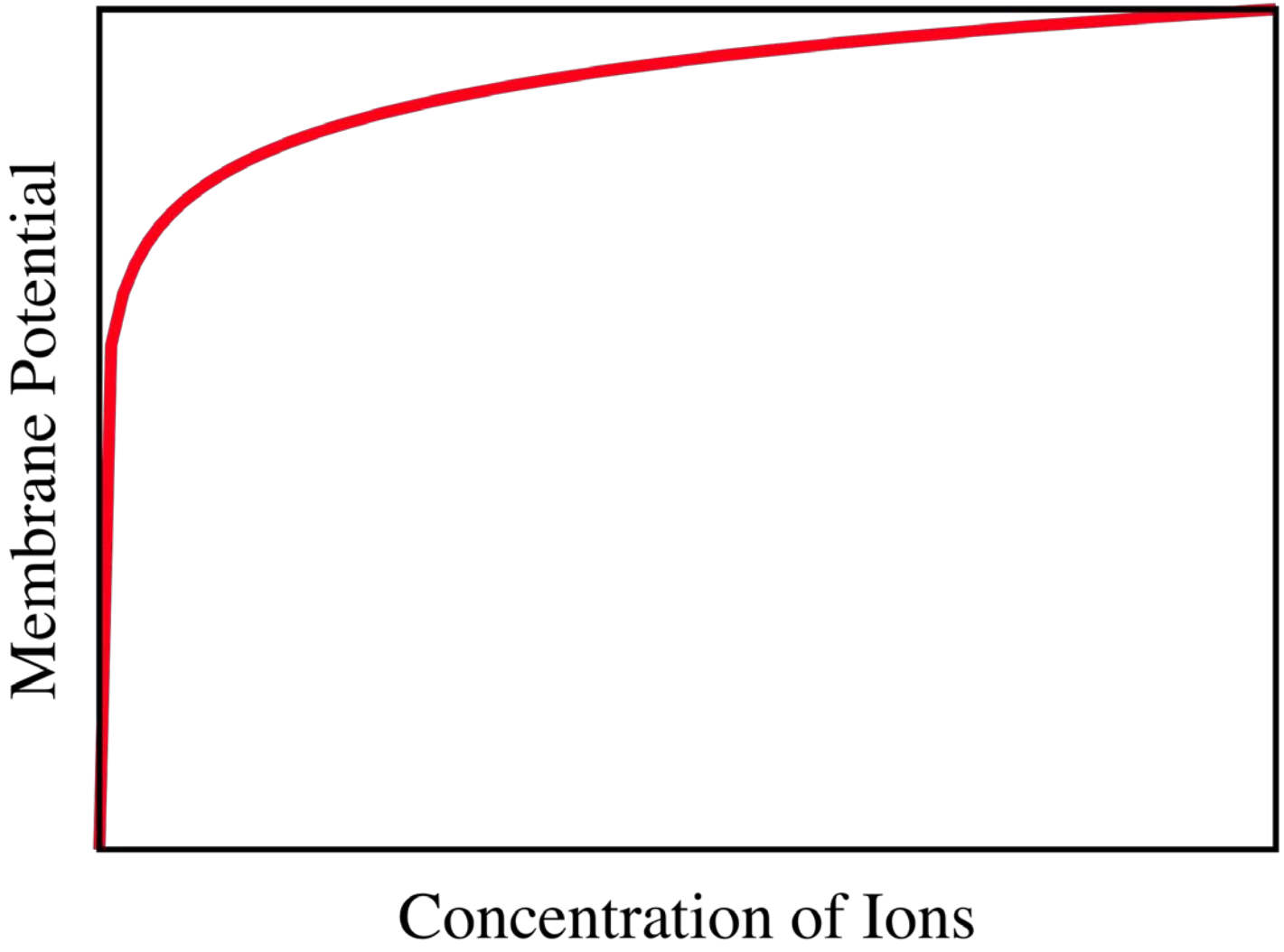
Gene expression



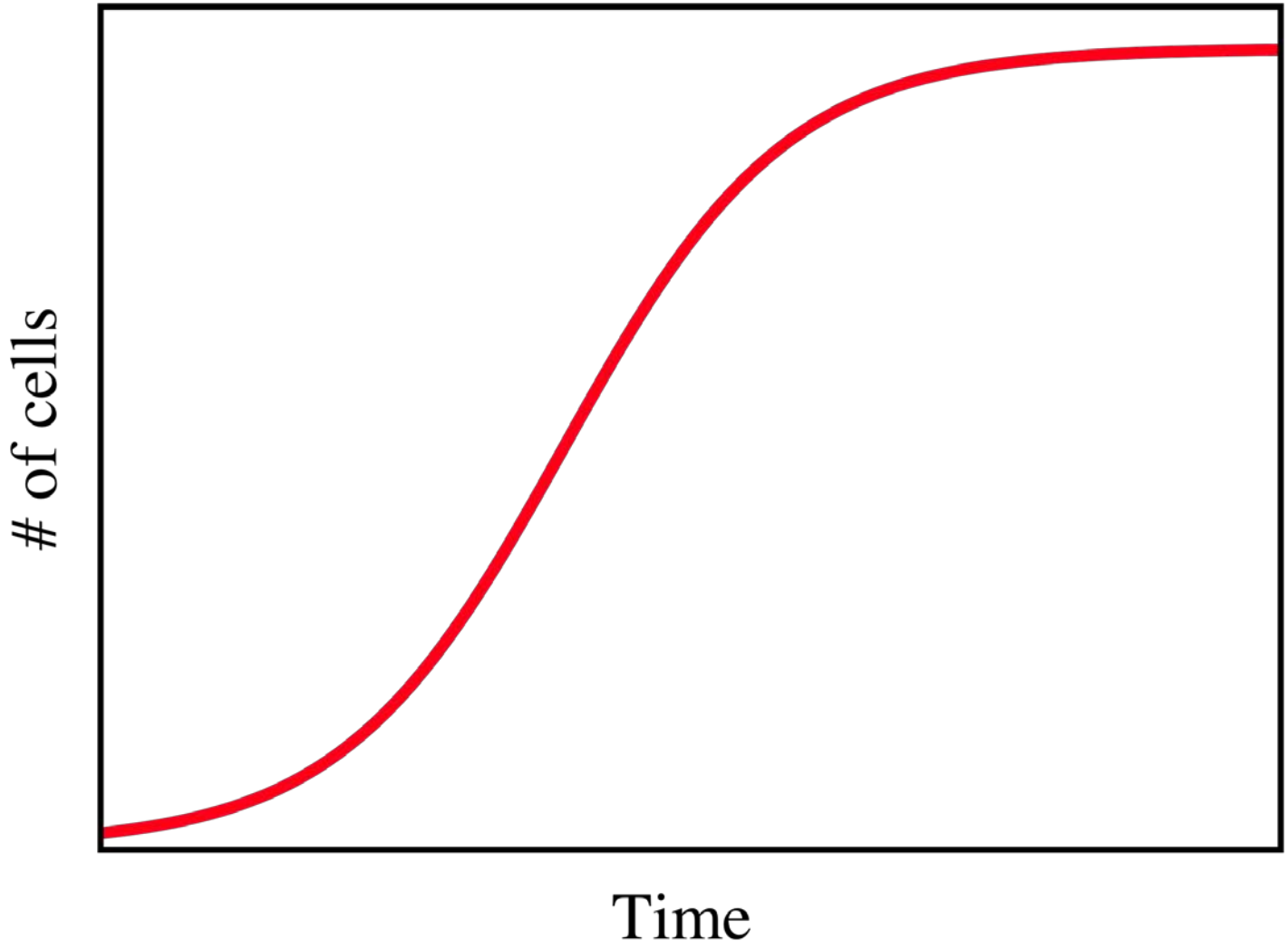
Actin/Microtubule : Force-velocity



Membrane Potential



Growth curve

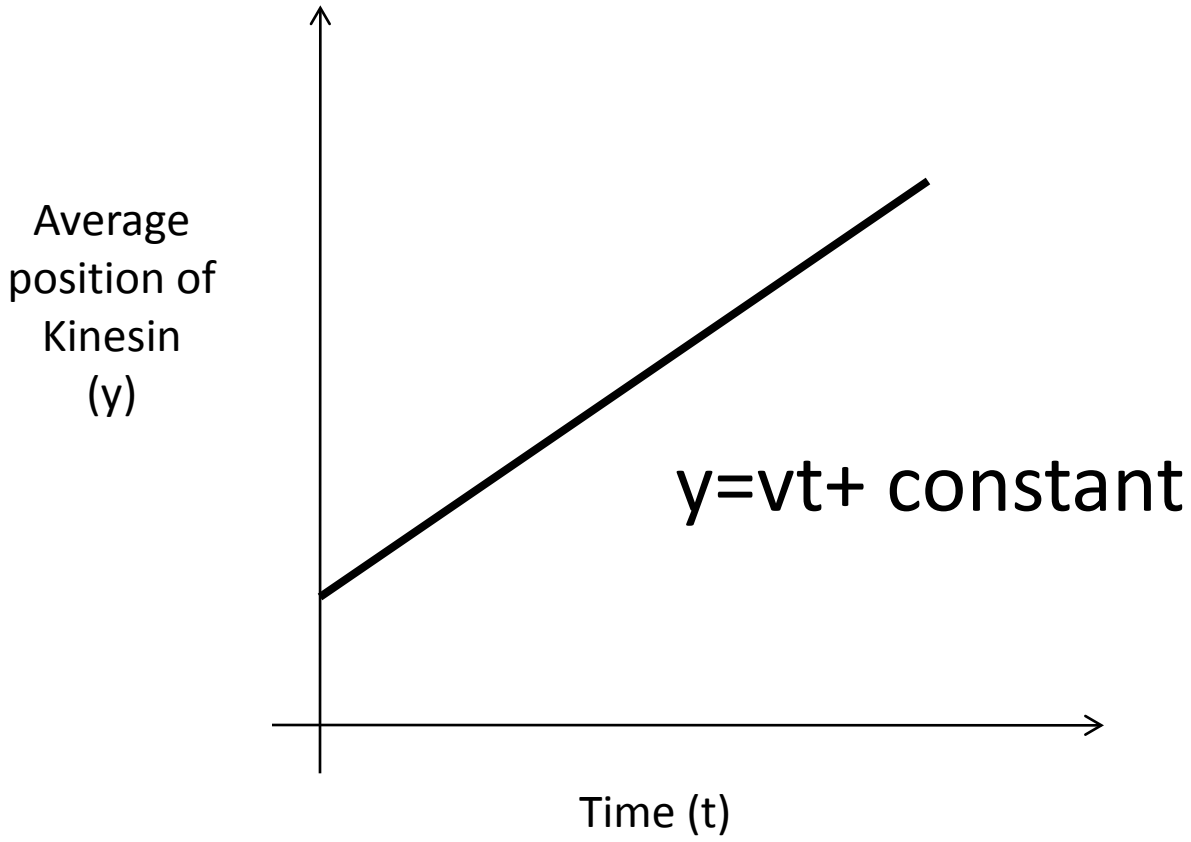


Function

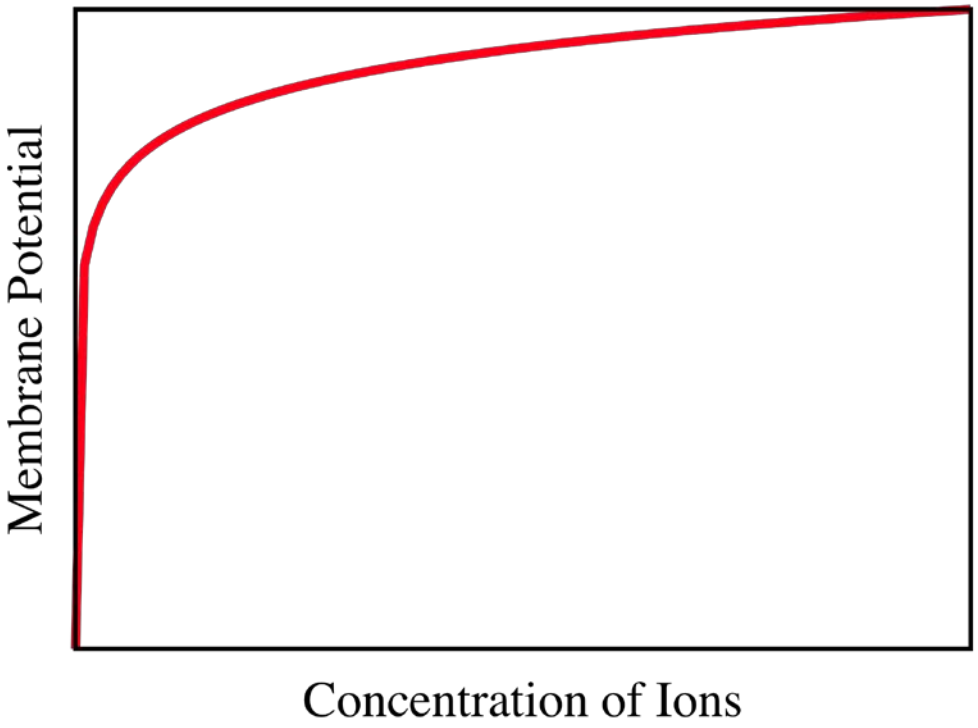
- Each of the curves can be represented by a mathematical equation
- y = mx + constant : a relation between y and x
- V = A log (C)
- N(t) = A-exp(-kt)

"Function" is a relation between quantities that we plot in X and Y axis

Molecular motor walking along microtubule



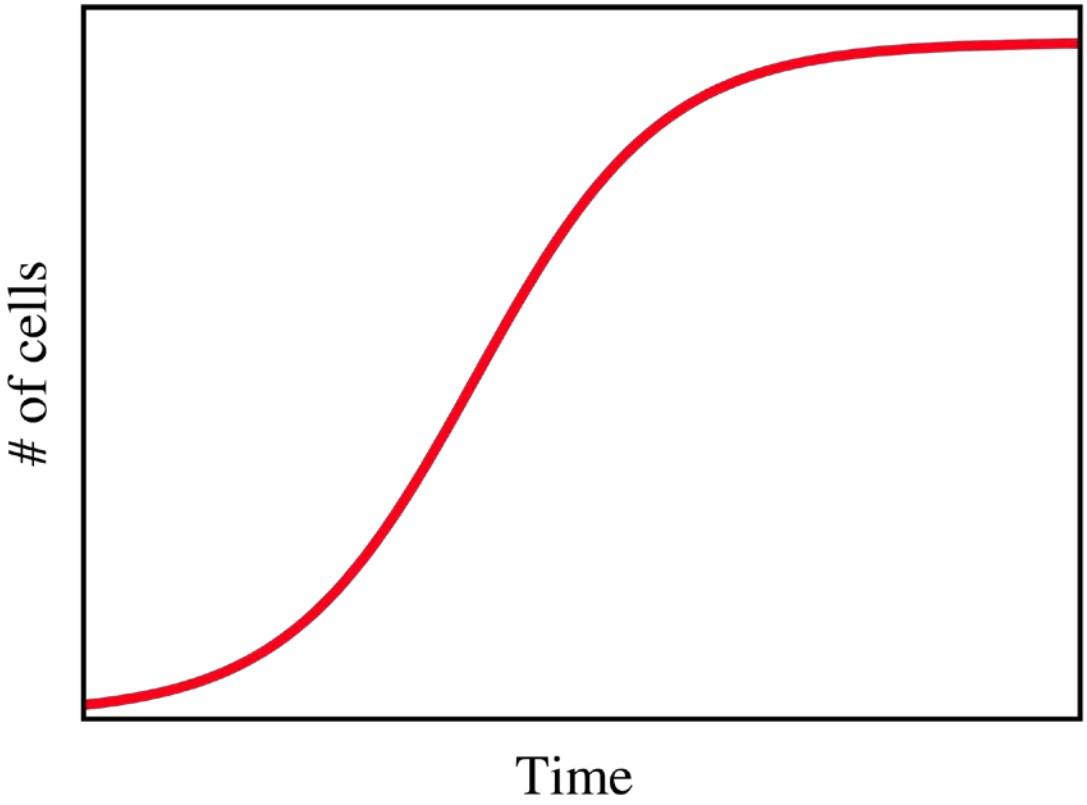
Membrane Potential



How potential across Membrane varies with concentration of ions

We can say : Membrane potential is a function of ion concentration

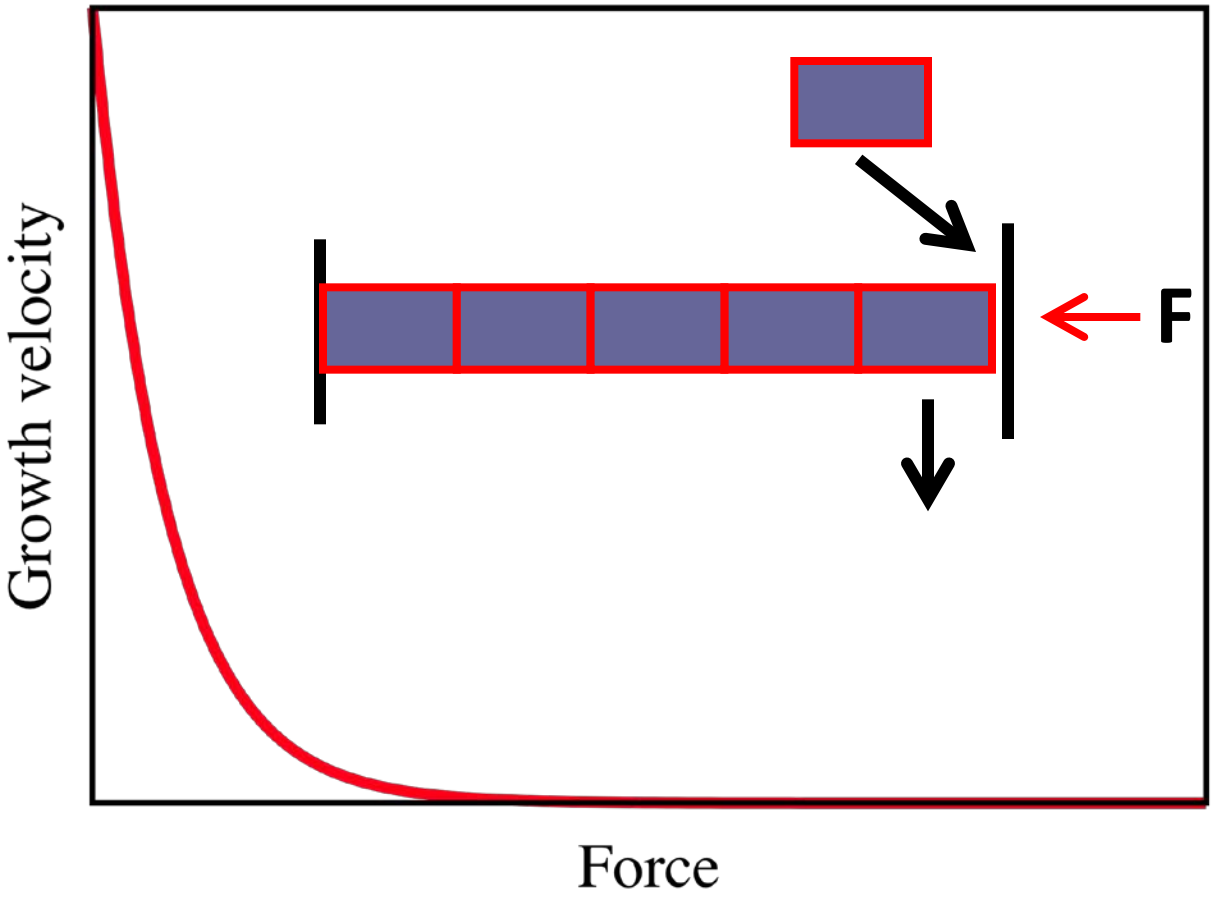
Growth curve



How number of cells increases with time

We can say : Number of cells is a function of time

Actin/Microtubule : Force-velocity

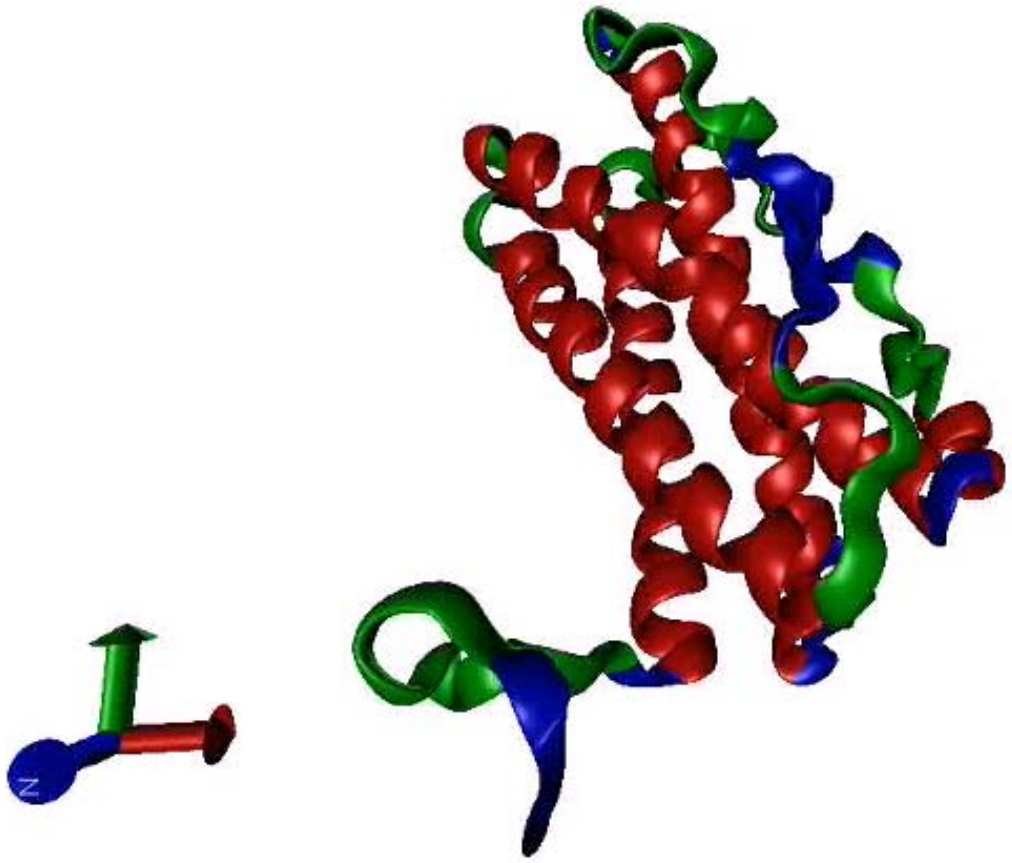


Summary: Idea of a “function”

- A graph represents a mathematical “function”
- A function is a relation between two quantities

Why mathematics ? : Structure of bio molecules

3-dimensional configuration of proteins

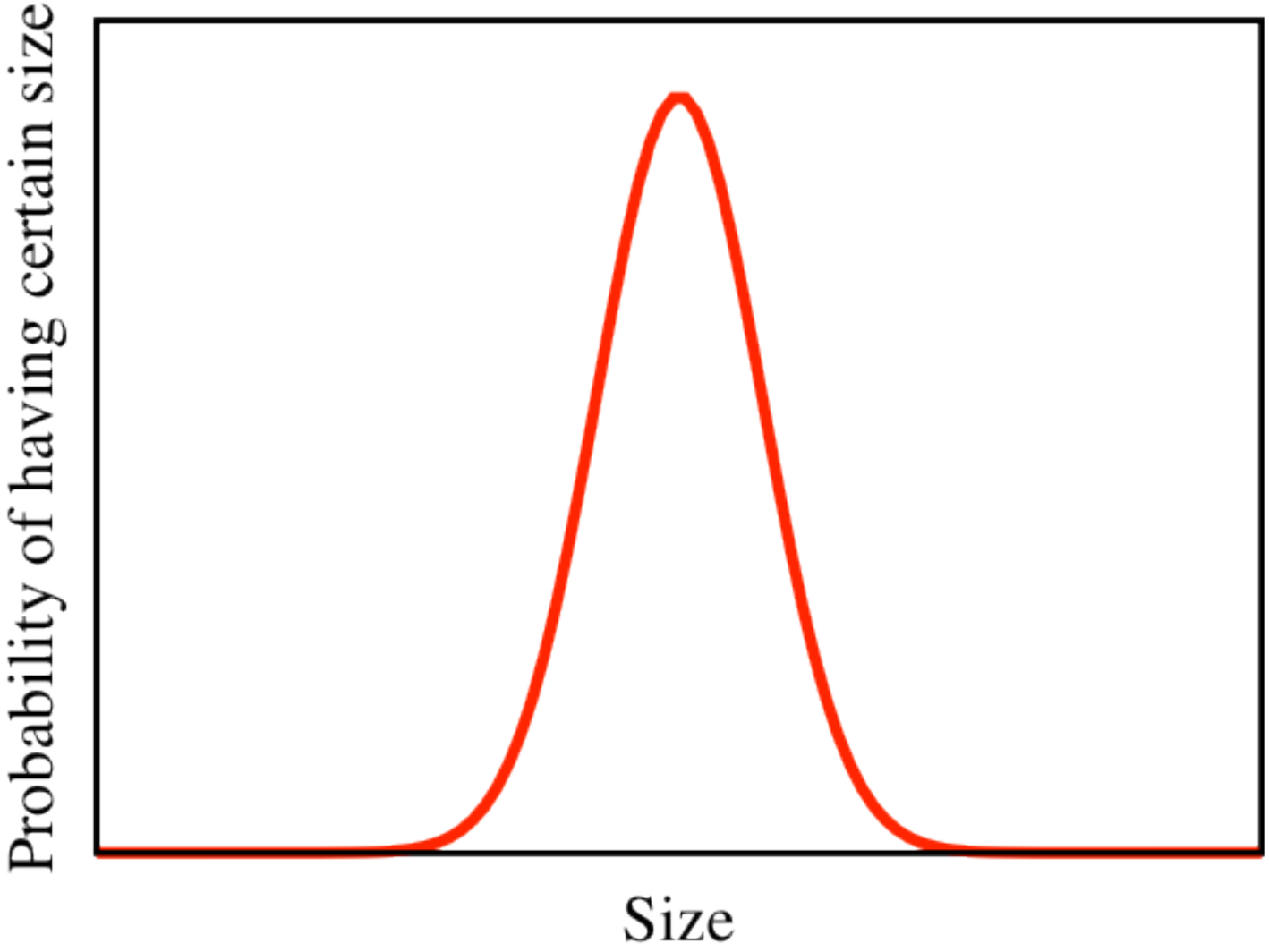


Why mathematics ? : Statistics

Statistics

- Most biological processes can only be described statistically.
- Almost all measurements we do involves statistical variability
- Hence the need to understand statistics to extract meaningful information from available data

Size variability



Probability

- Probability of an enzyme (protein) binding to a target

Summary

- Why mathematics ?
  - Describe natural phenomena
  - 3D structure of bio-molecules
  - Statistical analysis

In this course, we will learn how to use Mathematics to understand different biological systems