

The Scale of Biomolecules Activity

Instructor Guide

Notes to Instructor

This activity provides the participants with the opportunity to further explore biomolecules by relating the size of biomolecules to other molecules and cells. This activity can be completed prior to or after the primary knowledge unit for Biomolecular Applications for bioMEMS. The instructor may choose the order in which to use each of these units. One or more of the activities could be used as inquiry activities prior to the primary knowledge unit or to break up the information of the primary knowledge unit.

This activity is part of *Mapping Biological Concepts* which contain the following learning modules:

- DNA Overview
- DNA to Protein Overview
- Cells – The Building Blocks of Life
- Biomolecular Applications in bioMEMS

This activity is one of three activities for the *Biomolecular Applications for bioMEMS Learning Module*:

- Biomolecular Applications for bioMEMS Primary Knowledge
- Biomolecular Functions - Activity
- **The Scale of Biomolecules – Activities**
- Biological Motors – Activity
- Biomolecular Applications for bioMEMS Assessment

Description and Estimated Time to Complete

This activity is one of three activities in the Biomolecular Applications for bioMEMS Learning Module. This activity allows you to explore the relationship between the sizes of different molecules and cells. An understanding of the size of cells and molecules allows you to better understand how these components can be used within MEMS (MicroElectroMechanical Systems) devices and as bioMEMS devices.

Estimated Time to Complete

Allow approximately 45 minutes to complete

Nanoscience is concerned with the study of novel phenomena and properties of materials that occur at extremely small scales. Nanotechnology is the application of nanoscale science, engineering and technology to produce novel materials and devices.

"Nanotechnology is the understanding and control of matter at dimensions of roughly 1 to 100 nanometers, where unique phenomena enable novel applications. Encompassing nanoscale science, engineering and technology, nanotechnology involves imaging, measuring, modeling, and manipulating matter at this length scale." National Nanotechnology Initiative (NNI)

BioMEMS is one of the outcomes of the merging of Nanotechnology and Microelectromechanical Systems (MEMS). Biomolecules are enabling the design and fabrication of MEMS devices with components in both the micro and nanoscales. BioMEMS takes advantage of the properties of biomolecules to do the same work as fabricated components.

To better understand Micro and Nanotechnologies, it is important to understand the components and the size of these components relative to each other.

Activity Objectives and Outcomes

Activity Objectives

- Demonstrate your understanding of the relative size of biomolecules by creating an illustration that consists of correctly proportioned molecules joined to other molecules and cells.

Activity Outcomes

You will become familiar with the scale of cells and biomolecules. This knowledge will assist you in the design of a bioMEMS. (See the "Biomolecular Applications – Activity")

Supplies

This activity can be completed using a graphics software program such as PowerPoint. If no such program is available, then a paper graphic can be constructed with the following supplies.

Per participant or team

One large sheet of graph paper

Ruler

Colored markers

Pictures of items in the following table - "Relative size of Biomolecules in Nanometers". Pictures can be drawn or downloaded from the internet. If downloaded, adjust the size of each object relative to the size given in the activity table before printing.

Activity – The Scale of Biomolecules

Using a large sheet of graph paper or a graphic program, create a graphic of the following:

A **red blood cell** attached to a **spore**, which is attached to a **bacterium**, which is attached to a **liposome vesicle**, attached to a **tobacco mosaic virus**.

Add a **porin channel** to the liposome vesicle.

Place a **10,000 nm long flagellum** on the bacterium.

Even though your graphic will be in the macroscale, you must maintain the correct proportion to the actual sizes of the objects. The actual size of each object is listed in the following table.

***Variation of activity:** Create a scaled graphic of ALL of the objects in the table illustrating the correct size proportions.*

Relative Size of Biomolecules in Nanometers

Object	Diameter (nm)	Inside diameter (nm)
Hydrogen atom	0.1	
Water molecule, H ₂ O	0.3	
Amino acid	1	
DNA (width)	2.5	
Cell membrane	5-9	
Ferritin iron-storage protein	12	8
Bacterial S-layer	5-35	2-8
Porin channel	4-10	2-3
Actin filament	5-9	
Intermediate filament	10	
Microtubule	25	12-15
Bacterial flagellum	12-25	2-3
Tobacco mosaic virus	18	4
Magnetosome crystals	35-150	
Liposome vesicle	100 (minimum)	85 (minimum)
Pores in synthetic membrane		200 (minimum)
Bacterial cell	250 (minimum) 1000 (maximum)	
Spores	1,000-8,000	
Red blood cell	6,000-8,000	
Human hair	60,000 to 100,000	

Summary

It is important to understand the actual size of an object to better understand its function and application in a bioMEMS device. The nanoscale of biomolecules enables functions to be performed that were not possible a few years ago. We now have the technology to manipulate nanosize objects that can further manipulate or destroy single cells.

References

- Biomolecular Applications for bioMEMS
- DNA Overview
- DNA to Protein Overview
- Cells: The Building Blocks of Life

Disclaimer

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