

The Scale of Biomolecules Activity

Instructor Guide

Notes to Instructor

This activity is an exploration of the scale of biomolecules (nucleic acids, carbohydrates, proteins, and lipids). It provides the participants the opportunity to explore biomolecules by relating the size of biomolecules to other molecules and cells. This activity is a revision of the scale activity found in SCME's *Biomolecular Applications for BioMEMS Learning Module*.

The *Comparison of Scale Learning Module* consists of the following:

- A Comparison of Scale: Knowledge Probe (KP) Pre-test
- A Comparison of Scale: Macro, Micro, Nano (PK)
- Scale Inquiry Activity: Cut to Size
- **The Scale of Biomolecules Activity**
- Scale Activity: Zoom in / Zoom Out
- A Comparison of Scale Assessment

This companion Instructor Guide (IG) contains all of the information in the PG as well as answers to the Post-Activity questions.

Description and Estimated Time to Complete

This activity is an exploration of the scale of biomolecules (nucleic acids, carbohydrates, proteins, and lipids). You will identify the relationship between the sizes of different biomolecules and cells. An understanding of the size of cells and biomolecules allows you to better understand how these components can be used within MEMS devices and as bioMEMS devices.

Estimated Time to Complete

Allow approximately 45 minutes to complete

Introduction

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.
- Describe two applications of biomolecules in MEMS.

Activity Outcomes

You will become familiar with the scale of cells and biomolecules and how they are used in bioMEMS devices.

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

Complete *one of the following two procedures* using the table on the next page – Relative Size of Biomolecules in Nanometers.

Procedure 1:

Using a graphics program or a large sheet of graph paper and printed or drawn pictures, create a scaled 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 table Relative Size of Biomolecules in Nanometers.

Procedure II:

Using a graphics program or a large sheet of graph paper and printed or drawn pictures, create a scaled graphic of ALL of the objects in the table (Relative Size of Biomolecules in Nanometers) illustrating relative sizes and 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	

Post-Activity Question

Briefly discuss two applications of biomolecules as a component in a MEMS or bioMEMS device. Your discussions should include the sources of your information as well as how the devices works and the function of the biomolecule within the device.

Answer: Answers will vary depending on the applications found.

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 incorporate nanosize particles such as short chains of DNA, antibodies, proteins, and other biomolecules into a fabricated MEMS.

SCME Resources

- [Biomolecular Applications for bioMEMS Learning Module](http://scme-nm.org) (Can be downloaded from scme-nm.org. Select Educational Materials/BioMEMS)

Support for this work was provided by the National Science Foundation's Advanced Technological Education (ATE) Program through Grants. For more learning modules related to microtechnology, visit the SCME website (<http://scme-nm.org>).

This Learning Module was developed in conjunction with Bio-Link, a National Science Foundation Advanced Technological Education (ATE) Center for Biotechnology @ www.bio-link.org.