See the small world

Subject Area(s)
Chemistry, Life science, Physical Science, Science & Technology, measurements

Associated Unit: None

Associated Lesson:

Activity Title: See the small world

Image 1
ADA Description: A person trying to see something which is small by looking through magnifying glass
Image file name: Magnifying-glass

Grade Level: 11 (9-12)

Activity Dependency

Time Required: 30 minutes

Group Size: No group is required

Expendable Cost per Group US$0

Summary

This activity has been developed as a complement to the high school curricular science while introducing the nanoscale which is base of the frontier research topic, nanoscience. This activity is integrated in particular, with the standard science subjects such as measurements, scientific digit & significant digit, and structure of the atom. Nanotechnology is based on the science at the very small scale. Working in that scale looks like science fiction for kids. This activity has been developed to help the students get better idea of how small a nanometer is with comparing to some other things.

Engineering Connection

Nanotechnology has the potential to change every part of our lives and is the foundation of major future advances in different field of science and engineering. Nanoscale science and technology work with a very small dimension of the matters and it gives us tremendous powerful tools to understand, study, design, manipulate and view things from bottom to up. Scientists are looking to nanotechnology to find possible approaches to solve some of the world's most serious problems.

Engineering Category

Provides complete engineering design process.

Keywords

Nanoscience, nanotechnology, macroscale, microscale, nanoscale, nanometer, scientific digit, significant digit, structure of the atom, measurements

Educational Standards

- Science: (D) evaluate the impact of research on scientific thought, society, and the environment

Pre-Requisite Knowledge: None

Learning Objectives

After this activity, students should be able to:

- Recognize the different length scales and define macro, micro and nano scale.
- Explain how small a nanometer is, compare to some other small things that they know.
- Explain the devices that are used to visualized nanoscale.
- Explain why nanoscale materials are important.

Materials List

To share the video, images or other files with the entire class a video projector is needed.

Introduction / Motivation

In learning science it is important to get an idea of how big different things are. How big is an atomic nucleus? An atom? A cell? A planet? A galaxy? Often it's good enough to just have a rough idea.
Here we introduce three different length scales that are used a lot in engineering works and focus more on introducing the nanoscale.

Macroscopic scale is the length scale on which objects or processes are of a size which is measurable and observable by the naked eyes. Anything that applies to physical objects or physical settings having a geometric extent larger than one millimeter is called macroscopic.

Microscopic or *Micro scale* is a term used to describe objects smaller than those that can easily be seen by the naked eye and which require a lens or microscope to see them clearly. The units used to describe objects on a microscopic length scale are most commonly the Micrometer (μm) - one millionth of 1 meter, 10^{-6} and smaller units.

Nanoscale is the length scale of the objects in the nanometer. A nanometer is one billionth of a meter. In mathematical notation, it is shown by 10^{-9} of a meter**.** Nano material is a material that has at least one of its dimensions between size of one or two atoms and less than 100 nanometers.

Figure #2

ADA Description: Mathematical representation of the nanometer

Caption: Figure #2. This is how nano is represented mathematically. Ten to the negative 9th equals one billionth or 1/1,000,000,000

Image file name: nanopower.jpg

Source/Rights: Copyright © www.discovernano.northwestern.edu

It would be helpful to get an idea about this small size by comparing to some ordinary objects. Thickness of one paper is about 100,000 nanometers. A very fine human hair is about 10,000 nanometers wide, which is the smallest dimension we can see with the naked eye [1]. The nano size objects can not be seen by the regular microscopes which use light to visualize the objects. It is because that the wavelength of light is much larger (between 400 and 750 nanometer) than the size of a nano material. Instead some specialized microscopes have been invented which uses contacting probes or emitting electron. With these microscopes, a very small, very sharp tip on the end of a lever is across a nanoscale object. The movement of the lever is monitored with a computer, which creates an image. The method is much like a person moving their fingers over words written in Braille to read. This tip-scanning method is known as Scanning Probe Microscopy (SPM). Electron microscopes are similar to light microscopes except instead of directing light to a sample, they direct electrons to the sample [1].

The properties of the materials at nanoscale are quite different than the properties at the bulk. Microscale objects are widely used but they haven't caused the same excitement as nanoscale materials. The reason is that microscale objects have essentially the same properties as bulk material. However, at the nanoscale the fundamental properties of materials depend on their size, shape, and composition in a way that they don't at any other scale. So, the nanoscale is a different kind of small and this id the reason that nano materials have the potential to significantly impact both science and industry [1].

Nanoscience and nanotechnology that has been going on for more than 30 years is a very big field which is itself a unifying technology. Nano scale science and technology gives us tremendous powerful tools to understand study, design, manipulate and view things from bottom to up. Scientists are looking to nanotechnology to find possible approaches to solve some of the world's most serious problems.

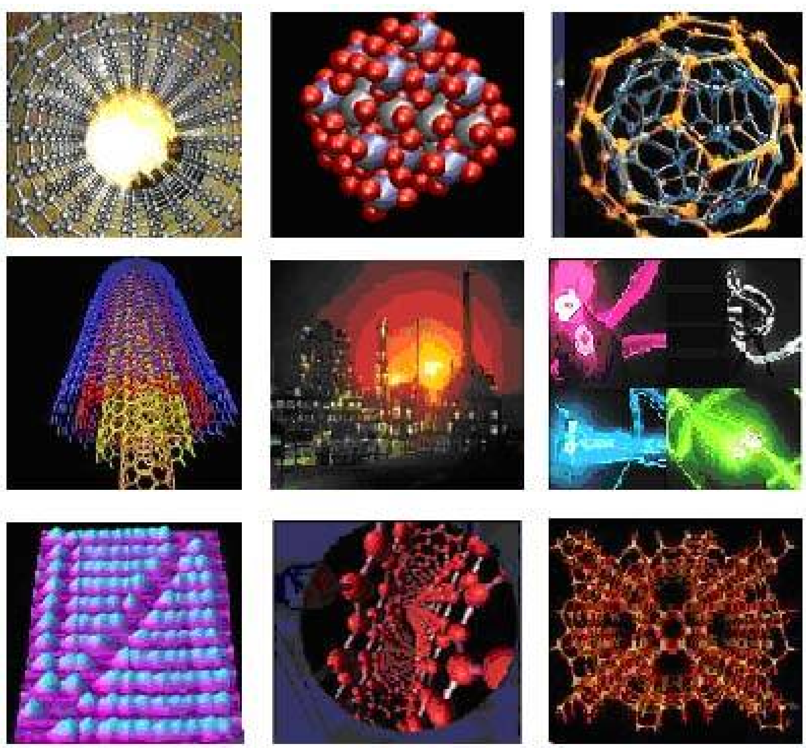

Figure #3

ADA Description: Different images on nanoscience

Caption: None

Image file name: nanotechnology.jpg

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caxton.emich.edu/guide/guide.php

Vocabulary / Definitions

Word	Definition
Macroscale	is a length scale on which objects or processes are of a size which is measurable and observable by the naked eyes
Microscale	is a length scale on which objects or processes are of a size which require a lens or microscope to see them clearly
Nanoscale	is the length scale of the objects in the size of nanometer which is much smaller than microscale
Nanoscience	A science in nanometer scale
Nanotechnology	A powerful technology which uses nanoscience and has the potential to solve tremendous problems of society

Procedure

This activity is started with asking the following questions from the students.
What do you think the most serious problems facing our life and society today are?
Can you name some technologies that need to be improved?
So, here the teacher can start to introduce the nanoscience and nanotechnology as a powerful science to solve a lot of problems in a near future that uses the science in the nanometer scale and explain some of the impacts that nanotechnology may have on the society.
Since the students may not have any idea about nanometer scale or length scales in general, it would be helpful for them if they see a video that shows traveling between different length scales in the universe. The video[2] which is addressed here in the attachment can be downloaded as a power point presentation file and is a very fantastic trip from the biggest to smallest length levels jumping distances by factor of ten. It starts with 10^0 meter equivalent to 1 meter, and increasing sizes by factor of 10s, or 10^1 (10 meters), 10^2 (10x10=100 meters), 10^3(10x10x10=1000 meters), so on, until the limit of our imagination in directions to the macrocosms. Later the video returns up to the point where it started and continues the trip in the opposite direction reducing distances of travel by factor of ten into the microcosms. Noting that going “downward” we could only go to the power of minus 16 of 10 and reached the limits of the matter. But “upwards” we went to the power of 23 of 10 and stopped. The video assists the students to observe the constancy of the laws of the universe and think about how much the human race still needs to learn.
After viewing this video, a scale ladder[3] hands-on paper which is attached here is distributed to the students. The scale ladder is focusing on a smaller range of length scale which gives direction towards understanding the nanometer scale. It shows the three major length scale categories in physical science and technology. These length scale ranges are called: macroscopic scale, microscopic scale and nanometer scale shorten as macroscale, microscale and nanoscale, respectively. The scale ladder that can be simultaneously viewed on a large screen shows the human body in macroscopic, microscopic and nano scale. The scale ladder starts from the size of a human body and gradually shows the next smaller length scale by a negative power of 10 and finally will be ended by the size of an atom which is called angstrom.

Attachments

- Fantastic trip[2] power point that can be downloaded from:

http://www.authorstream.com/Presentation/puneetsharma20-235498-Power-10-Fantastic-Trip-Puneet-Education-ppt-powerpoint/

- Scale-ladder[3]

Safety Issues

Use ordinary laboratory safety procedures.

Activity Extensions:

This activity can be extended by give an introduction about various applications and impacts that nanotechnology may have on society. There are a lot of power point presentations available on the webs for this topic.

Assessment

Post-Activity Assessment
Title: Assessment on nanometer scale

Additional Multimedia Support

www.discovernano.northwestern.edu

www.Nisenetwork.com

www.nanosense.org

http://www.authorstream.com/Presentation/puneetsharma20-235498-Power-10-Fantastic-Trip-Puneet-Education-ppt-powerpoint/

References

[1] Discover Nano, Northwestern University
www.discovernano.northwestern.edu

[2] http://www.authorstream.com/Presentation/puneetsharma20-235498-Power-10-Fantastic-Trip-Puneet-Education-ppt-powerpoint/

[3] www.Nisenetwork.com

Other

Redirect URL

Owner

National Science Foundation GK-12 Program, University of Houston

Contributors

Parnia Mohammadi, Roberto Dimaliwat

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Assessment on nanometer scale

Choose False or True answer for each question.

1. Nanoscience is the science which uses the science in the nanometer scale.
    - True
    - False

2. Nanometer scale is larger in length than microscale.
    - True
    - False

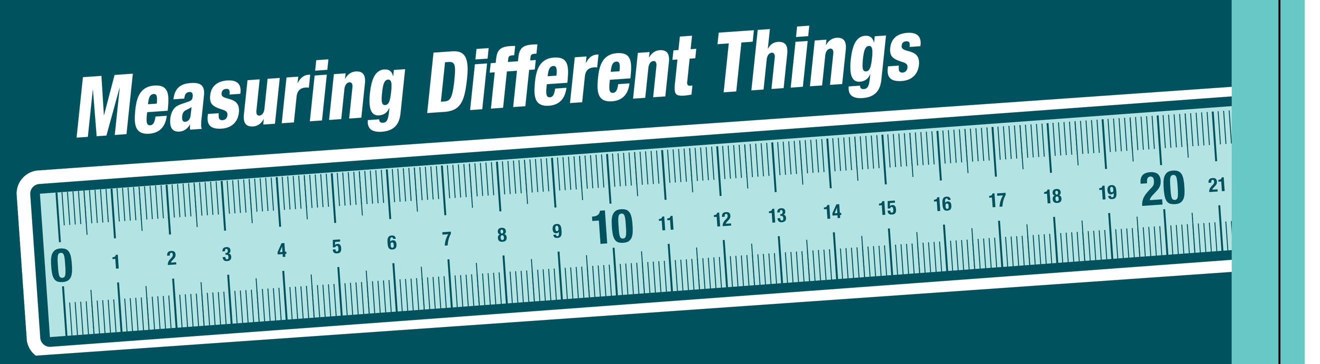
3. Macroscopic scale is larger in length than microscale.
    - True
    - False

4. Length scale which is in range of 10^{-5} is in nanoscale range.
    - True
    - False

5. The size of an atom is in order of 10^{-10} of the meter.
    - True
    - False
6. Nanometer size materials can be seen by naked eyes.
    - True
    - False
7. Scale of an atom is the smallest limit of length in the universe that humans could reach.
    - True
    - False
8. Humans hair is 1000 times ticker than size of an atom
    - True
    - False

9. Thickness of a page of paper is in the range of nanometer
    - True
    - False

HOW SMALL IS NANO?



Macrosize
meters, decimeters, centimeters, millimeters

Child


10^{0}

A child is about 1 meter tall
1 meter = 1,000,000,000 nm
(1 billion nanometers)

Hand


10^{-1}

A hand is about 1 decimeter wide
1 decimeter = 100,000,000 nm
(100 million nanometers)

Pinky Finger

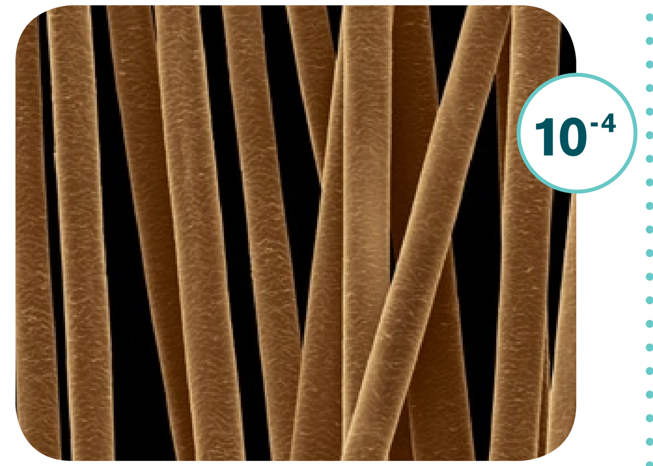

10^{-2}

A pinky finger is about 1 centimeter wide
1 centimeter = 10,000,000 nm
(10 million nanometers)

Freckle


10^{-3}

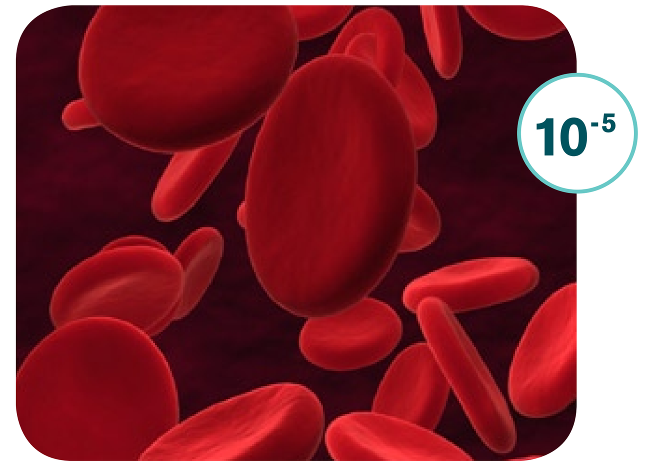
A freckle is about 1 millimeter wide
1 millimeter = 1,000,000 nm
(1 million nanometers)

Strand of Hair


10^{-4}

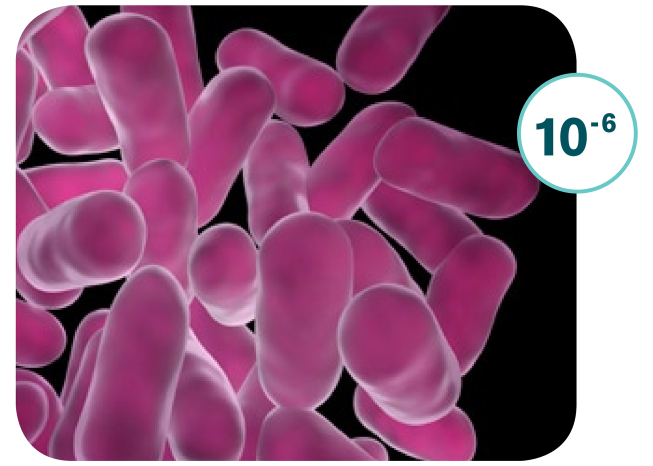
A hair is about one tenth of a millimeter wide
0.1 millimeter = 100,000 nm
(100 thousand nanometers)

Microsize
micrometers

Red Blood Cell


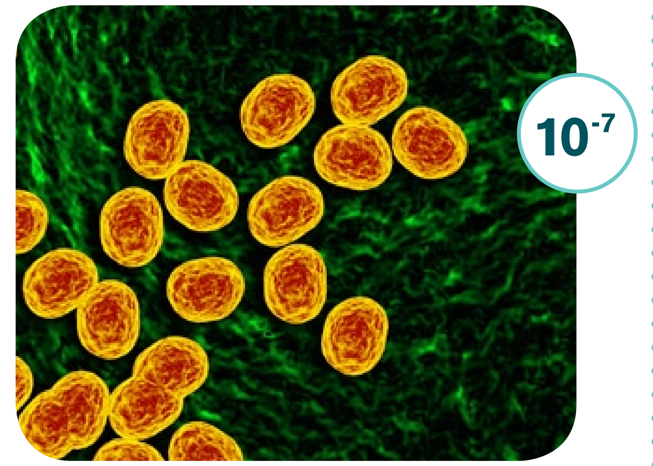
10^{-5}

A red blood cell is about 10 micrometers wide
10 micrometers = 10,000 nm
(10 thousand nanometers)

Bacteria


10^{-6}

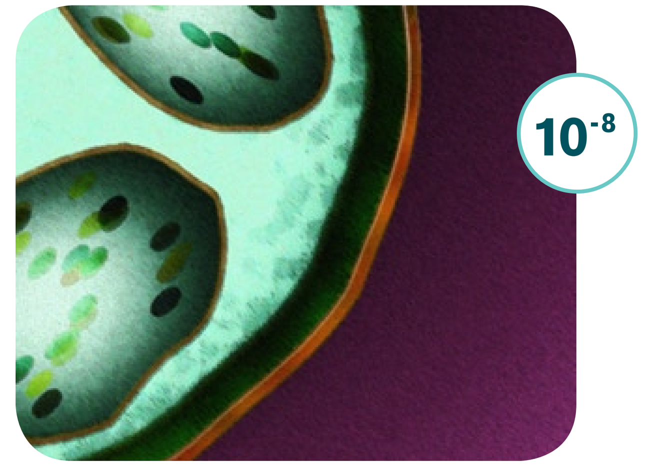
A bacteria is about 1 micrometer wide
1 micrometer = 1,000 nm
(1 thousand nanometers)

Virus


10^{-7}

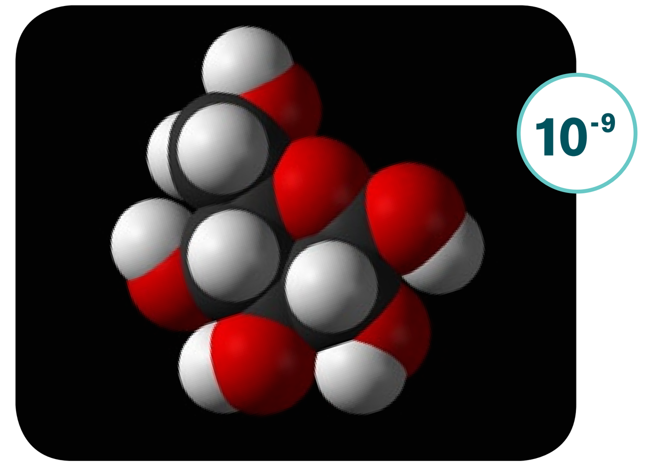
A virus is about one tenth of a micrometer wide
0.1 micrometer = 100 nm
(1 hundred nanometers)

Nanosize
nanometers

Cell Membrane


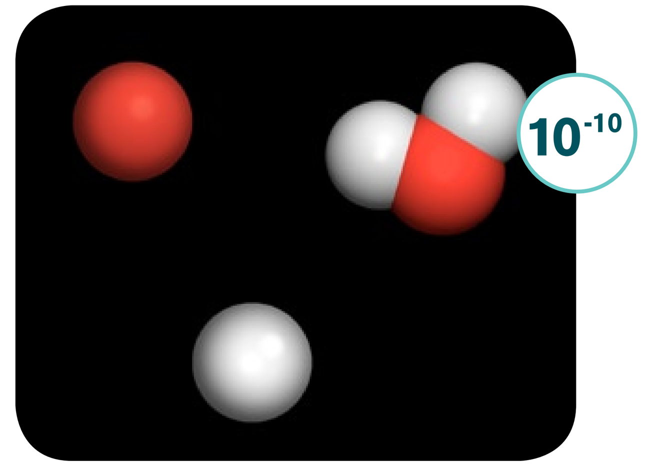
10^{-8}

A cell membrane is about 10 nanometers wide
10 nanometers = 10 nm

Sugar Molecule


10^{-9}

A sugar molecule is about 1 nanometer wide
1 nanometer = 1 nm

Atom


10^{-10}

An atom is about one tenth of a nanometer wide
0.1 nanometer = 0.1 nm

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Accompanying book available for purchase at www.lulu.com

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54 x 12.5

HOW SMALL IS NANO?

Measuring Different Things

Macrosize

Macrosize
meters, decimeters, centimeters, millimeters

Child
A child is about 1 meter tall
1 meter = 1,000,000,000 nm (1 billion nanometers)

10^{0}

Hand
A hand is about 1 decimeter wide
1 decimeter = 100,000,000 nm (100 million nanometers)

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Pinky Finger
A pinky finger is about 1 centimeter wide
1 centimeter = 10,000,000 nm (10 million nanometers)

10^{-2}

Freckle
A freckle is about 1 millimeter wide
1 millimeter = 1,000,000 nm (1 million nanometers)

10^{-3}

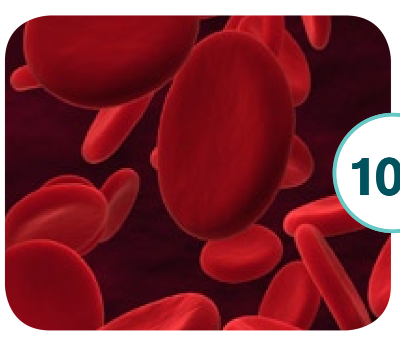
Strand of Hair
A hair is about 0.1 (one tenth) of a millimeter wide
0.1 millimeter = 100,000 nm (100 thousand nanometers)

10^{-4}

Microsize

Microsize
micrometers

Red Blood Cell
A red blood cell is about 10 micrometers wide
10 micrometers = 10,000 nm (10 thousand nanometers)



10^{-5}

Bacteria
A bacteria is about 1 micrometer wide
1 micrometer = 1,000 nm (1 thousand nanometers)

10^{-6}

Virus
A virus is about 0.1 (one tenth) of a micrometer wide
0.1 micrometer = 100 nm (1 hundred nanometers)

10^{-7}

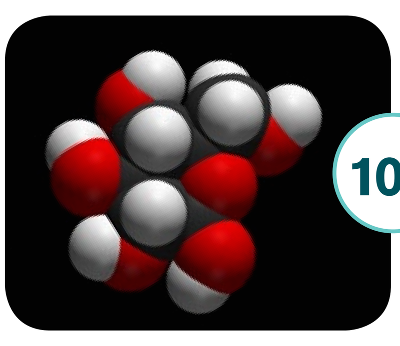
Nanosize

Nanosize
nanometers

Cell Membrane
A cell membrane is about 10 nanometers wide
10 nanometers = 10 nm

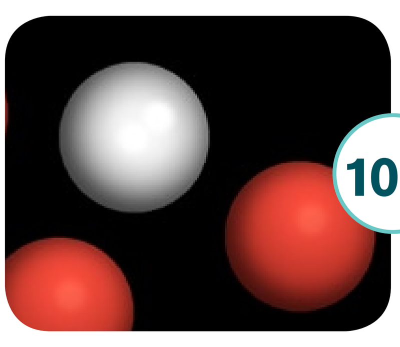
10^{-8}

Sugar Molecule
A sugar molecule is about 1 nanometer wide
1 nanometer = 1 nm



10^{-9}

Atom
An atom is about 0.1 (one tenth) of a nanometer wide
0.1 nanometer = 0.1 nm



10^{-10}

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Emily Maletz graphic design
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