Domes: The Roofs of the Ages

Capitol Building

Native American Wigwam

Look closely at the pictures on this page. What do these buildings have in common? If you said they all had domes then you are correct! A **dome** is a type of a roof structure that looks like a half of a sphere.

People have been building domes for thousands and thousands of years. Think of the igloos built by the Inuit people, and the wigwams built by the Ojibwa. They, too, are domed structures.

Domed buildings are everywhere. They can be churches, mosques, synagogues, sports arenas, government buildings or dwellings. Perhaps you walk past a domed building every day and never noticed it before!

One of the most famous domed structures in the world is located at the Epcot Center at Disney World in Orlando, Florida. This dome is called *Spaceship Earth*. Perhaps you have visited it!

Spaceship Earth is a **geodesic dome**. A geodesic dome is a dome made from interlocking triangles. It was invented by Buckminster Fuller in the 1940s. Geodesic domes are extremely strong structures. There are many buildings in the United States, including houses, which use this type of construction.

VOCABULARY

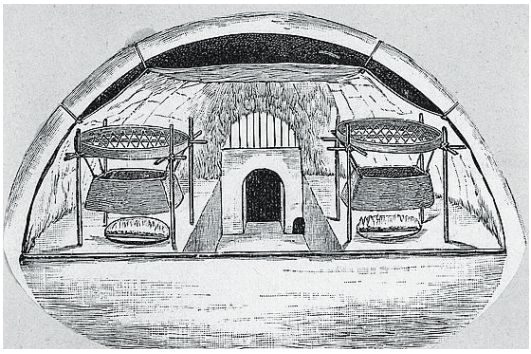
1) dome
2) geodesic dome
3) arch
4) compression
5) tension
6) gravity
7) normal force

THINK INSIDE THE BOX

Would you like to live in a geodesic dome? Explain why or why not.

If people have been building domes for so long then there must be some reason for it. Think for a moment. What are the advantages of a domed structure over a structure with an angled roof?

Perhaps this picture of the interior of an igloo will help. Look at all of the space that is available inside of the igloo. Because the structure is domed, there is no need for columns or pillars to support the roof. No interior columns equals more room for all of your stuff!



Interior of Igloo

The Climatron Greenhouse
Missouri Botanical Garden

The Ancient Romans Strike Again!

Before the Romans, all buildings in the ancient world were rectangular or square-shaped. Look at the picture of the ancient Greek temple called the Parthenon. This structure has 46 outer pillars and 23 inner pillars. The majestic pillars that are associated with Greek architecture were not there to just look pretty. The pillars of the Parthenon were there to hold up, or support the heavy marble roof that used to be on the top of this massive structure.

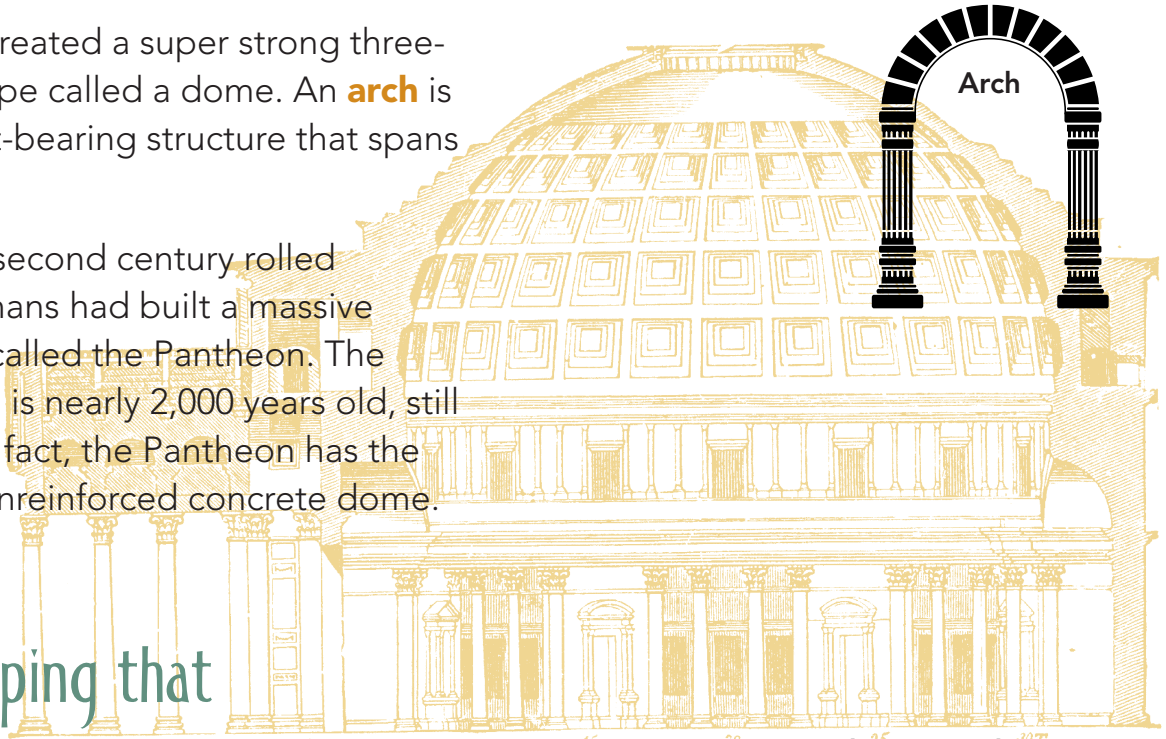
The Parthenon – 500 BCE

Enter the Romans! In 100 CE, ancient Roman builders figured out that if they rotated an arch 360

Pantheon – 2nd century CE

degrees that it created a super strong three-dimensional shape called a dome. An **arch** is a curved, weight-bearing structure that spans an open space.

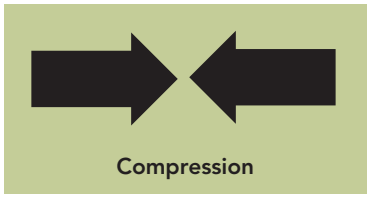
By the time the second century rolled around, the Romans had built a massive domed temple called the Pantheon. The Pantheon, which is nearly 2,000 years old, still stands today! In fact, the Pantheon has the world's largest unreinforced concrete dome.

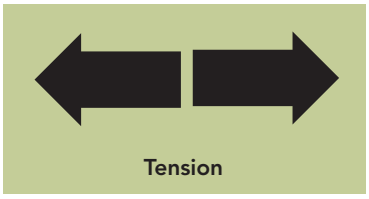


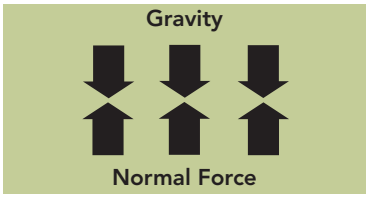
Pantheon – 2nd century CE

What's Keeping that Dome from Crashing?

Hang on a minute! If a dome, like the one in the Pantheon, is unsupported by columns, then what on earth is keeping it from tumbling down? Don't panic! The unseen forces of nature are holding all of that concrete in place.







Although you can't seem them, the normal force, along with the forces of gravity, compression, and tension, are acting against one another to hold the Pantheon, and most domes in place.

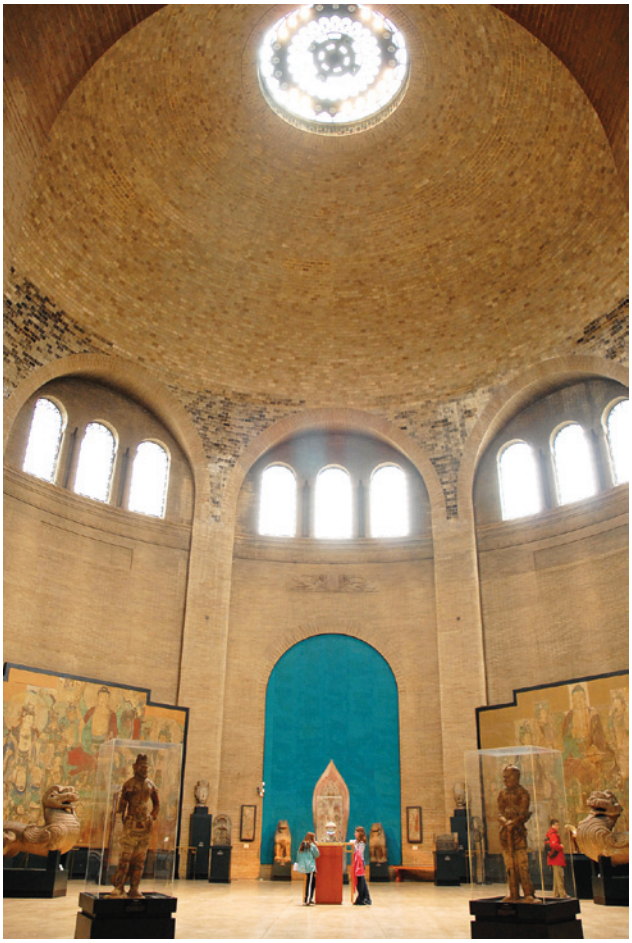
Compression forces are two forces which act on one object by moving in opposite directions toward each other. Imagine pressing or pushing the palms of your hands together. This is the compression force.

Tension forces are two forces which act on one object by moving in opposite directions away from each other. Imagine clasping the curled fingertips of both of your hands together and pulling. This is the tension force.

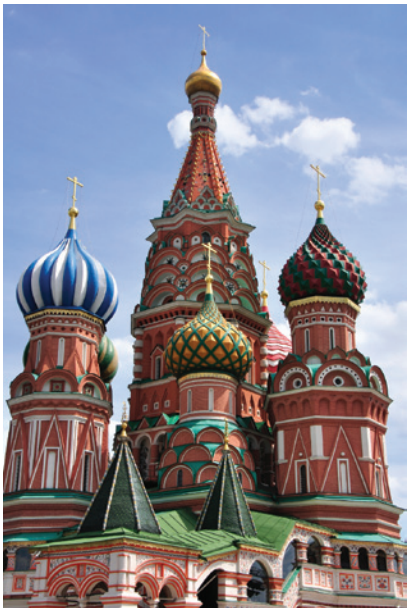
The force of **gravity** pushes downward on an object. And the **normal force** pushes in the opposite direction, upward.

Types of Domes

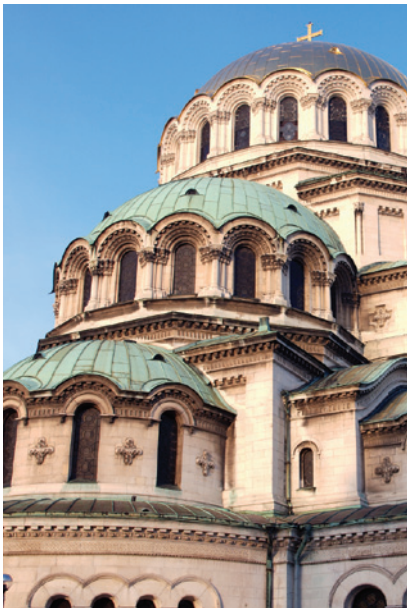
There are hundreds, even thousands of domed structures all over the world. There are onion domes, geodesic domes, oval and saucer domes, sail domes, and umbrella domes. There are ancient domes as well as contemporary domes. No matter their type or age, all domes rely on the same natural forces to keep them in place, and provide expansive and unobstructed space.



Chinese Rotunda, Penn Museum



St. Basil's Church, Moscow



St. Alexander Nevsky Cathedral, Sofia, Bulgaria

Interior of the Pantheon

Math of Domes

The Chinese Rotunda at the Penn Museum has one of the world's largest, unsupported masonry domes. That means there are no steel or supporting trusses within the dome to hold it up. The weight of the dome is carried by the eight arches that encircle the rotunda, and by the natural forces of compression, tension, gravity, and the normal force.

The design of the Museum's dome was based on the design of a much older and larger dome called the Pantheon, an ancient Roman temple.

Look carefully at the apex of both of these domes. The **apex** is the highest point of the dome. The opening located at the apex is called an **oculus**. Oculus means *eye* in Latin.

The oculus is not only a way to bring light into a domed structure, but it also *lightens* the weight of the roof.

Above, the Chinese Rotunda at the Penn Museum. Left, interior of the Pantheon.

VOCABULARY

1) apex
2) oculus
3) diameter
4) radius
5) circumference
6) area

Diameter, Radius, Circumference, and Area of Circles

Diameter, radius, circumference and area are different ways in which to measure circles. If you know one of these measurements, then you can figure out the others.

The **diameter** is the distance across a circle through its center point. If you know the diameter of a circle, then you can calculate the radius, the circumference, and the area of a circle.

The **radius** of a circle is the distance from its center to any point along its edge. It's easy to find the center of the Chinese Rotunda. Just look for the 49-pound crystal ball!

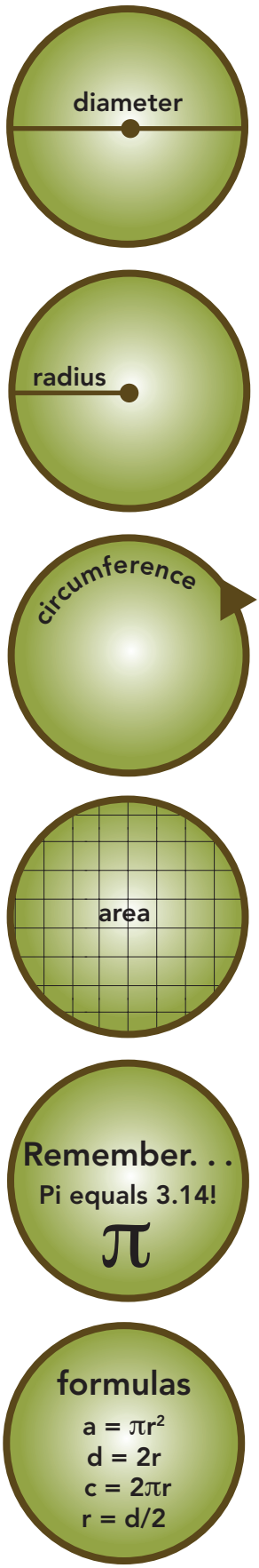
The **circumference** of a circle is the distance around it. It is the circle's perimeter.

The **area** of a circle is the number of square units it would take to fill the circle.

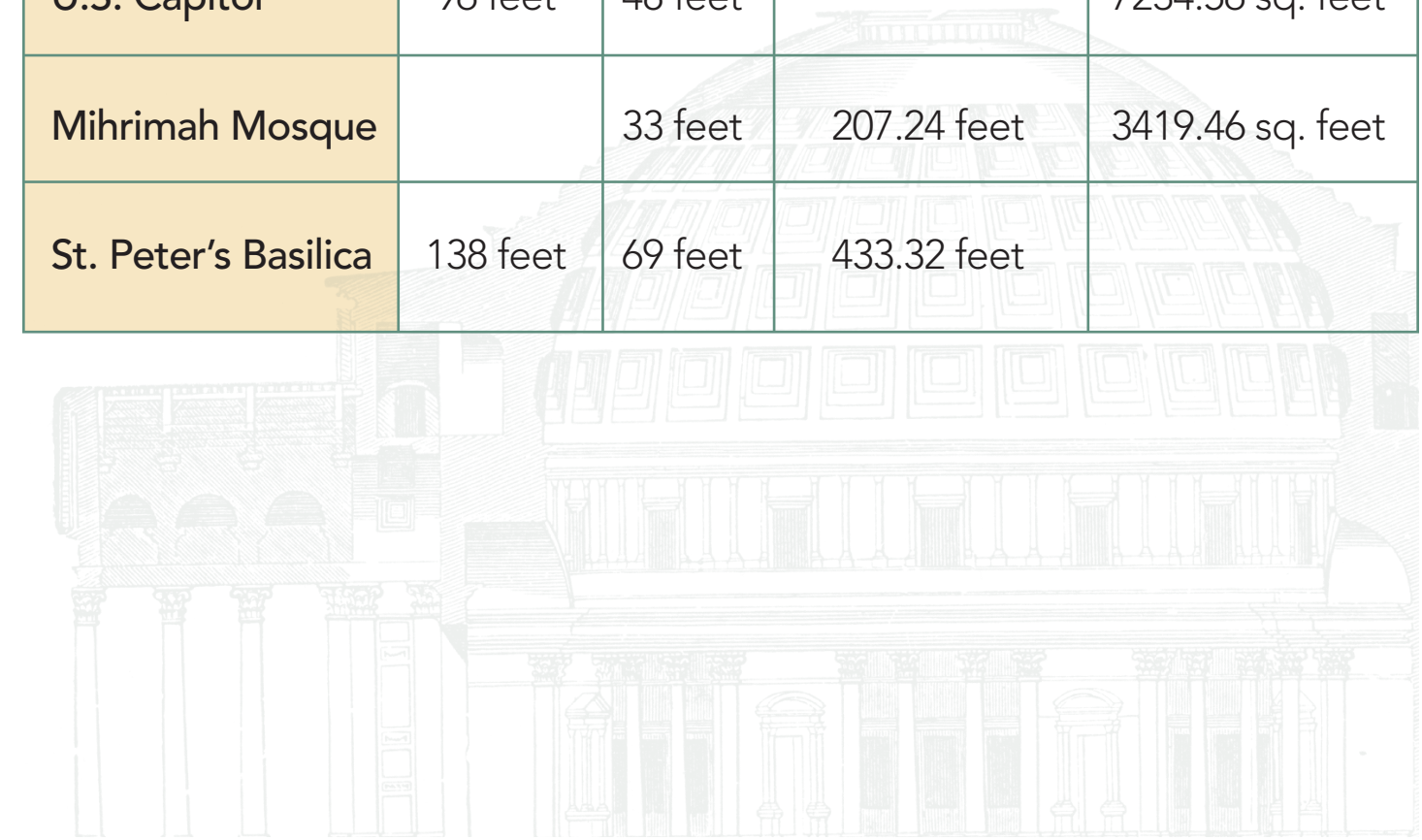
Dome of the Capitol Building.

Famous Domes of the World

Look at the chart on the next page. It has a list of eight of the world's most famous domes and information about their size. Use the correct formulas for finding diameter, radius, circumference and area to calculate the missing measurements.

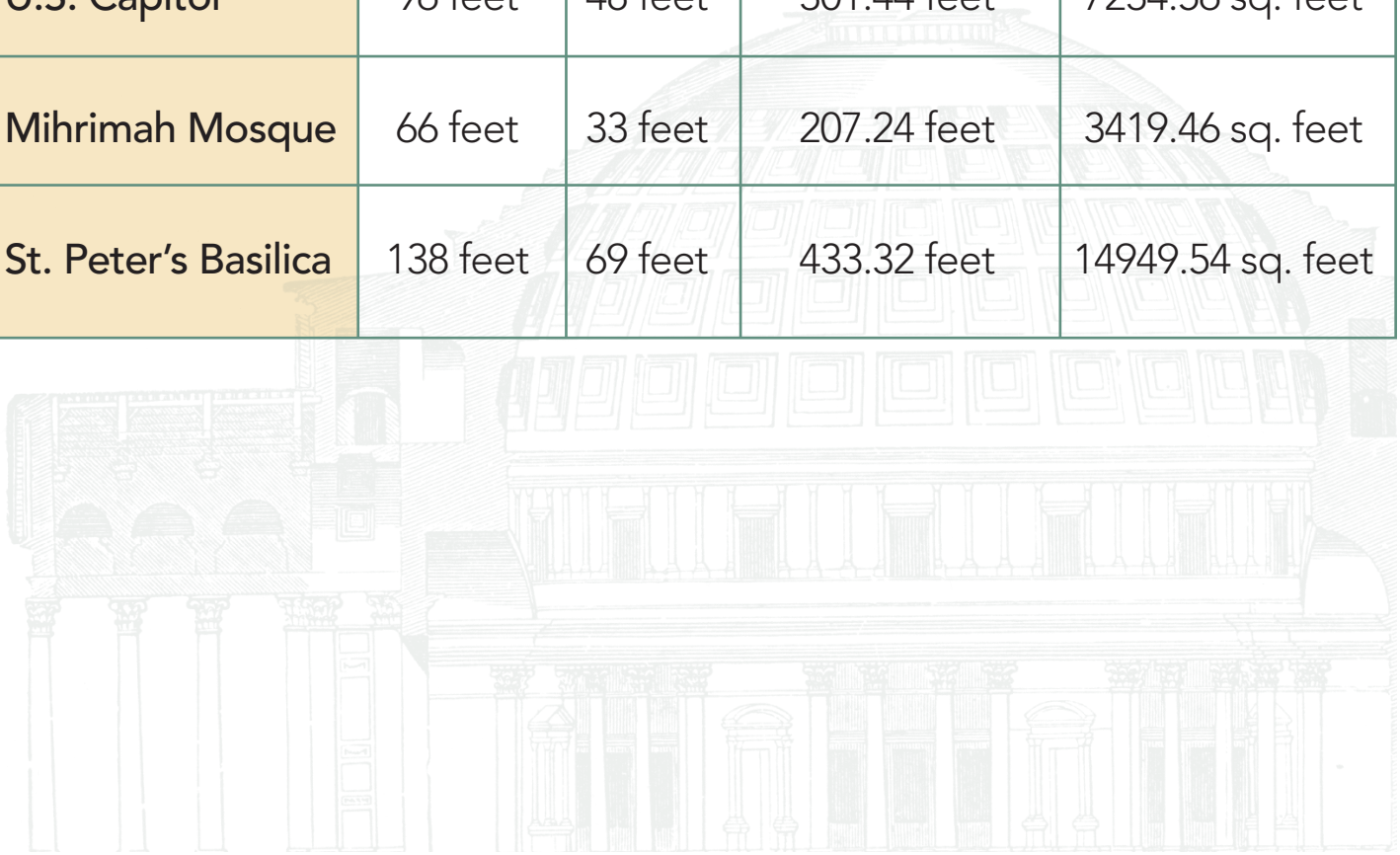


Dome	Diameter	Radius	Circumference	Area
Chinese Rotunda	90 feet	45 feet	282.6 feet	
The Pantheon		71 feet	445.88 feet	15828.74 sq. feet
Astrodome	710 feet	355 feet		395718.5 sq. feet
Georgia Dome		420 feet	2637.6 feet	553,896 sq. feet
Hagia Sophia	102 feet			8167.14 sq. feet
U.S. Capitol	96 feet	48 feet		7234.56 sq. feet
Mihrimah Mosque		33 feet	207.24 feet	3419.46 sq. feet
St. Peter's Basilica	138 feet	69 feet	433.32 feet	



Math of Domes - Answer Key

Dome	Diameter	Radius	Circumference	Area
Chinese Rotunda	90 feet	45 feet	282.6 feet	6358.5 sq. feet
The Pantheon	142 feet	71 feet	445.88 feet	15828.74 sq. feet
Astrodome	710 feet	355 feet	2229.4 feet	395718.5 sq. feet
Georgia Dome	840 feet	420 feet	2637.6 feet	553,896 sq. feet
Hagia Sophia	102 feet	51 feet	320.28 feet	8167.14 sq. feet
U.S. Capitol	96 feet	48 feet	301.44 feet	7234.56 sq. feet
Mihrimah Mosque	66 feet	33 feet	207.24 feet	3419.46 sq. feet
St. Peter's Basilica	138 feet	69 feet	433.32 feet	14949.54 sq. feet



Penn Museum 1

The Most Famous Caterpillars in the World

Emperor Minghuang's Journey to Shu

The photograph to the left is of a painting that hangs in the Chinese Rotunda at the Penn Museum. It is made of thousands of silk threads that are woven together to create a canvas on which an artist has painted.

This painting is called *Emperor Minghuang's Journey to Shu*. It is over 500 years old and tells the story of the Emperor's great love for Lady Yang. The painting is really big, about six feet high by four feet wide. But its size and age are not the most amazing things about it. Incredibly, this painting was made by caterpillars!

Okay, caterpillars didn't actually paint the picture itself, but they did supply the raw material from which this painting is made. That raw material is silk. **Silk** is a strand of fiber, produced by moth caterpillars, that is woven into textiles. **Textiles** are fabrics that are used to produce clothing and other goods.

VOCABULARY

1) silk
2) textiles
3) sericulture

Moth, Interrupted

Moths and butterflies undergo a four-step process of development.

- **First:** The adult moth lays eggs.
- **Second:** The eggs hatch and the larva, or caterpillar emerges.
- **Third:** The caterpillar pupates, or spins a cocoon, also called a chrysalis.
- **Fourth:** The adult moth emerges from the cocoon.

But things are a bit different for Bombyx mori. That's the official name of the silk moth. The Bombyx mori is the blind and flightless moth that is used in sericulture. **Sericulture** is the cultivation of silkworms for the production of silk.

The Stages of Silk Production

Moth

1
The silk moth lays eggs, about 300 at a time.

2
The eggs hatch and the caterpillars emerge.

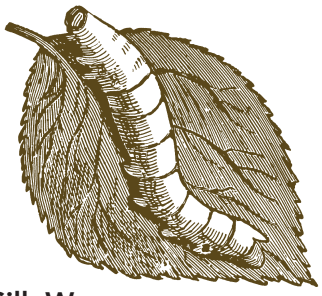
3
The caterpillars are fed mulberry leaves.

4
After 25 days of munching, they are 10,000 times heavier than when they first hatched.

5
The caterpillar forces the liquid silk out of two openings in its head called spinnerets.

6
The caterpillar uses this liquid to begin to spin a cocoon of silk around itself.

7
The liquid solidifies as it hits the air.



Silk Worm

8
The silk caterpillar completely encases itself in a silk cocoon made of a single filament, which is one mile in length.

9
After three days, the silk caterpillar pupates.

10
The silk cocoons are stored in a warm, dry place.

11
After 8 days, the cocoons are either steamed or baked to kill the worms inside of the cocoons.

12
The cocoons are placed in warm water to loosen the filament.

13
The filament is unwound onto a spool.

14
About 8 of these individual filaments are wound together to make a single thread of silk.

Chrysalis

Penn Museum 3 The Most Famous Caterpillars in the World

Shhh. . .Don't Tell Anyone!

Silk production is complex and labor intensive. The ancient Chinese were the first people to learn how to cultivate the Bombyx mori in order to produce silk. There is evidence to suggest that the ancient Chinese produced silk for over 7,000 years before anyone else figured out how to do it!

The Chinese kept the science of sericulture a secret for centuries, and silk became one of the most sought after and traded materials in the ancient world. In fact, the Silk Road, one of the oldest trade routes in the world, was named for this highly prized fabric. The production and trade of silk helped to create many powerful and influential dynasties in ancient China.

DID YOU KNOW?

It takes 2,500 cocoons to produce 1 pound of silk!