2. SILK
NATURAL PROTEIN FIBER

Can you answer ?

- *Which fiber is mostly used for producing traditional textiles in India ?*
- *What is the source of silk fiber ?*
- *Have you ever worn silk garments ? How is it different from cotton garments ?*
- *Have you read the chinese tale of silk fiber?*

Let's learn more about silk fiber in this lesson.

2.1 Introduction

Silk is a natural protein filament – It is solidified protein secretion produced by certain caterpillars. This fiber has maintained a position of great prestige and is considered a luxury fiber. It is often called **'Queen of fabrics' :**

In old English, Silk was **Sioloc.** The name is thought to have originated from the Greek Seres, meaning the people from Eastern Asia, namely Chinese.

History records the Chinese as the first people who knew how to raise silk worms and manufacture Silk and make cloth from the filament which silk worm spins into a cocoon. It was discovered in China about 2600 B.C. About 1765 B.C. the mulberry tree was cultivated to provide food for the silkworm. For approximately 2000 years China successfully held the secrete of silk and maintained virtual monopoly of the silk industry. About 300 A. D. Japan obtained the formula and today is the chief producer and exporter of quality silk. Gradually silk production spread across Asia into India and eventually Persia, Southern Europe, Spain, Italy, France.

In India, the references regarding the use of silk fabrics from the ancient times have been recorded in the scripts of Manusmruti, Ramayana, Mahabharata and Rugveda. It is believed that silk industry developed in India approximately from 140 B.C.

Internet my Friend

Find out history of silk fiber regarding chinese Empress **Siling-Chi,** wife of Emperor **'Huang-ti'**, and discuss it in your class.

Picture No. 2.1 : Processing of Silk in Ancient China

- **Silk producing countries**

Japan was the first country producing silk in large quantities by using scientific methods of cultivating silkworms on farms as well as in factories. Today Japan has been ranked highest in the production of silk. Other silk producing countries are China, India, Korea, Iran, Spain, Italy, France, Austria, Turkey, Greece, Syria, Bulgeria, Brazil, Poland Russia, Peru and Indonesia.

Karnataka, Andhra Pradesh, Tamil Nadu, West Bengal, Assam, Manipur, are the chief silk producing states in India. Apart from these states, silk is also produced in Kashmir, Himachal Pradesh, Uttar Pradesh, Nagaland etc.

A Peek into History - Silk Route

Silk Route is ancient trade route linking China with the West, that carried goods and ideas between the two great civilizations of Rome & China. Silk went westward and wools, gold, silver went East.

The Silk Route stretched from

China→India→Mesopotamia→Egypt→ The African continent→Greece→Rome & even upto Britain.

The old Silk Route through Lhasa. Sikkim & eastern India used to cross through **Nathula Pass**. The other side of Nathula Pass is Chumbi valley of Tibet.

This mountainous pass is one of the oldest trading border post connecting India & Tibet.

2.2 Manufacturing of Silk Fibre

- **Cultivated Silk**

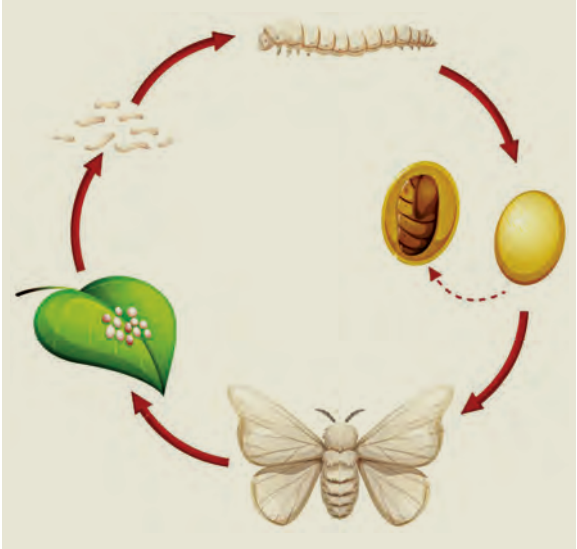
This type of silk is called cultivated Silk. Since the discovery of the silk filament as well as fabrics, silkworms have been bred for the sole purpose of producing silk. **The technique of rearing of silk worms for the productions of cocoons for their filament is called sericulture.** It is produced by species of moth called **Bombyx Mori**. These worms are fed only on mulberry leaves.

Picture No. 2.2 – Mulberry Plantation

Flow Chart No. : 2.1
Steps in Manufacturing Process of Silk Fiber

Sericulture
↓
Filature operation
↓
Degumming
↓
Weighting

- **Life cycle of the silk worms (Sericulture):** Silk worm lives for very short time, only about two months. During this period, it passes through four stages of development – i) eggs, ii) worm, (caterpillar), iii) cocoon and iv) moth. Under scientific breeding, silk worm may be hatched three times a year.
- **Eggs :** The female moth lays 350-400 eggs on special cards and die. Eggs is about the size of pinhead. The cards are examined and infected eggs are burned and only healthy eggs are allowed to hatch.



Picture No. 2.3 Life –cycle of silk worm

Picture No. 2.4 Eggs on special cards

- **Worm or Caterpillar or Larvae :-** The egg develops into larva or caterpillar or Silkworm. A tiny white worm about one fourth inch long is hatched from each tiny egg. The larva requires careful nurturing in the controlled atmosphere for approximately 20 to 30 days. During this period it is fed five times a day on chopped mulberry leaves. After four sheddings of skin or moltings, the worm reaches full growth. At this stage it is smooth grayish white caterpillar about $3 \& \frac{1}{2}$ inches long. At the end of 30 days, the worm shrinks somewhat in size and become pinkinsh and transparent. It ceases to eat and attaches itself to a piece of straw and begins to spin cocoon.

Picture No. 2.5 Silk Worm

- **Cocoons :** Two filaments are ejected from the mouth of the silkworm. It secretes a protein like substance and with a bending motion, the filament is spun around the worm in the form of figure '8". The worm completes the cocoon in about 3 days. The filament is in the form of double strand made up of **fibroin**, which is held together by a gummy substance called **sericin.** The filaments harden when exposed to air. The worm is caught inside the cocoon and remains there for a few days. This is called the 'Pupa' stage.

Picture No. 2.6 Cocoons

Picture No. 2.7 Pupa

- **Moth :** The Pupa turns into a moth. The moths emerge from cocoon by secreting an alkaline liquid that dissolves the filament and thus piercing the cocoon and breed. The female moth then lay eggs and die. Their cycle of life is completed.

Picture No. 2.8 Moth

If moth is permitted to emerge from the cocoon, the silk filament is broken into short pieces. Therefore, the cocoons are steamed or are subjected to hot air to kill the Pupa inside the cocoon. This process is called as **stoving**. Few cocoons are left aside for life cycle to continue.

- **Filature :** Once the cocoons are obtained from the silk worm, they are sorted out according to colour, size shape and texture. In the next step sericin from the silk filament is softened to permit the unwinding of the filament. As a single filament of silk is too fine; 3 - 10 cocoons are carefully unwound together to form a composite strand of silk. This process is called as **Reeling**. During the next operation desired amount of twist is given to composite strand of silk to make it into a silk yarn. This process is called **Throwing** and the silk is called as Thrown silk.

Picture No. 2.9 Filature Operation

- **Degumming :** Thrown silk threads still contain some sericin. It must be removed to bring out natural luster and the soft feel of the silk. The process of elimination of gum or sericin is known as **degumming.** It is generally carried out before dyeing process of silk. Detergent, warm water & alkaline reagents are used for degumming process. Approximately 25% of the weight is lost by the degumming process.

Picture No. 2.10 Degumming

- **Weighting :** The manufacturer buys silk by weight. Silk fibres become expensive after degumming as it results in weight loss. This loss in weight is compensated by weighting of silk. Silk fabrics are treated with metallic substances to make up for the weight loss. Weightings is done during the dyeing process or done after it. In addition to lowering the cost it gives crispness, firmer body and feel to the fabric. Weighted silk loses the natural elasticity and deteriorates when exposed to sunlight, perspiration and dry clearing. weighting of silk is considered undesirable in countries like Japan and India. It is carried out only for low quality silk (known as kora silk) in India.

Table No. 2.2
Difference between Degumming & Weighting

Degumming		Weighting	
1.	The removal of the gum 'Sericin' from the silk yarn or fabric.	1.	Increasing the weight of silk yarn or fabric.
2.	Approximately 25% of weight of silk is lost due to this.	2.	This is done to compensate for the weight loss due to degumming.
3.	This is done to bring out the natural lustre and smoothness of silk	3.	This makes the silk fabric crisp and improves its draping quality.
4.	This is done with the help of detergent and water.	4.	This is done with the help of metal salts.
5.	Usually done before dyeing process.	5.	Usually combined with dyeing process or done after it.

2.3 Properties of Silk Fiber

Microscopic Properties :

Cultivated degummed silk viewed longitudinally under a microscope resembles a smooth transparent rod. (For Diagram of microscopic appearance of Silk, refer to practical No. 6)

Microscopic characteristic of silk

- Smooth cylindrical fiber
- Highly lustrous
- Very fine
- Gum spots may be seen.

Physical Properties :

- **Length :** Silk is the only filament fiber. Silk filaments are very fine and long. They frequently measure about 900 – 1200 meters and can be as long as 2800 meters.
- **Luster :** Silk has high luster, after the sericin has been removed. Because of its exceptional lustre, Silk is known as 'Queen' of fabrics. Wild silk has less luster than cultivated silk.
- **Strength :** Silk is the strongest of the animal fiber. It loses 15 – 25 % of its strength when wet. Due to it's low wet strength it demands special care while laundering.
- **Elastic recovery and elongation :** Silk is very elastic fiber, but compared to wool its elasticity is slightly less.
- **Resiliency :** Silk has better resiliency than cellulosic fibres but less than wool and man-made fibres.
- **Moisture Absorption :** Silk has high moisture regain. Due to this property silk can be dyed and printed in brilliant colors.
- **Density :** Silk fiber is less dense than cotton, linen and wool. Density of silk is 1. 25 – 1 . 34 gm/cc. Medium density of silk makes fabric light in weight.

Can you tell ?

We usually wear silk clothes for parties & marriages why?

Special precaution is required while washing silks. Why?

We have seen that our grannies or mother wrapping heavy silk sarees in cotton fabric with napthalene balls while storing it for season. What do you think is the reason ?

We iron silks on low temp.
What do you think is the reason?

Hint : The answer lie in the properties of the fiber

Biological Properties :

- **Effect of mildew :** Silk being a protein fiber is the least damaged by mildew, but it is attacked if left in a damp condition for a period of time.
- **Effect of moth :** Being a protein fiber it is easily damaged by moth. silk has good resistance to the clothes moth but carpet beetles will eat it. So while stroring silk, care needs to be taken & some kind of insecticide should be used.

Thermal Properties :

- **Effect to Heat :** Silk is easily affected by heat. We can not use hot iron or water for silk. When approached to the flame silk will ignite and continues to burn with a smell of burning hair of feather. It leaves crisp, brittle bead.
- **Heat conductivity :** Silk has low heat conductivity. It is not a good conductor of heat. This makes it a suitable wear for winter season.

2.4 Wild Silk

There are several types of caterpillars other than Bombyx Mori, which spin cocoons. Silk obtained from such cocoons is known as wild silk.

Picture No. 2.11 Wild silk yarn

following species of silk worm are used in producing wild silk.

1) Antheraea Mylitta – Tassar silk
2) Antheraea Assamensis – Muga silk.
3) Philosamaea Risini – Eri silk.

Picture No. 2.12 Eri Silk

Picture No. 2.13 Tussar Silk

Instead of mulberry leaves, these silk worms live on oak or castor leaves. The silk produced is irregular and coarse. It is also hard to bleach or dye. The tannin in the oak leaves gives tan colour and it is generally woven with the naturally coloured thread. Wild silk is less lustrous than cultivated silk, as only low percentage of sericin is removed in degumming process. It is washable and less expensive.

Table No. 2.3

Difference between cultivated silk and Wild silk

Cultivated Silk		Wild Silk	
1.	Obtained from silk worm called Bombyx Mori.	1.	Obtained from other wild species of silk worms.
2.	Silk worms eat leaves of only mulberry tree.	2.	Silk worms eat leaves of castor or oak tree.
3.	Very smooth, lustrous and delicate	3.	Not so smooth, lustrous or delicate
4.	Cream or off white in colour	4.	Darker in colour.

2.5 Spun Silk

Short lengths or staples or inferior silk filaments, obtained from waste material are carded and combed and are spun together like cotton, linen or wool yarns. These yarns are known as spun silk.

There are various sources of staple silk.

i) Pierced cocoons from which moths have cut their way and emerged.

ii) Double cocoons produced when two silk worms spin their cocoons too close together.

iii) Floss brushed from cocoons before reeling and coarse and uneven fibre at the beginning and end of each cocoon.

iv) The machine waste or scrap left from the operation like reeling and throwing.

Spun silk is less lustrous than reeled silk and not as strong or elastic. As the yarns are made from staple fibres, spun silk fabrics tend to become more fuzzy. It is less expensive than reeled silk. Spun silk is used for shantung and pile fabrics, for dress trimmings, linings, as insulating materials.

Table. 2.4

Difference between Cultivated Reeled Silk and Spun Silk

	Cultivated Reeled Silk		Spun Silk
1.	Obtained from unbroken good quality cocoons.	1.	Obtained from damaged cocoons.
2.	Continuous, long filament.	2.	Fibres are staple in length.
3.	Very smooth, lustrous and strong.	3.	Not very smooth, lustrous and strong.
4.	More expensive	4.	Less expensive
5.	Used for making expensive party wear.	5.	Used for making lining material and blends.

2.6 Uses of Silk

Silk in universally accepted as a luxury fiber and has been the "Queen of fabrics" for centuries. Silk has a unique combination of properties not possessed by any other fiber. Silk fabrics are luxurious in appearance and feel. It is a very strong fiber in relation to its filament fineness. It is very elastic and wrinkle resistant. Because of its absorbency, it is appropriate for warm weather wear, because of its low heat conductivity it is also appropriate for cold weather wear. Silk dyes and prints readily to beautiful, brilliant shades. It is adaptable to a variety of fabric construction from very sheer chiffon to heavy, rich beautiful brocades and velvets.

- **Apparel uses :**

Silk is used primarily in apparel items and high fashion items. It is worn in festivals and traditional ceremonies, weddings. It is used for bridal wear, kurtas, tie, scraf, sarees men's jacket etc.

Picture No. 2.14 Apparel Uses of Silks

- **Household uses :**

In furnishing silk is often blended with other fibers to add a soft luster to the furnishing fabrics. Silk blends are often used in window treatments and rich luxurious upholstery fabrics. Occasionally, beautiful and expensive handmade rugs will be made of silk.

Picture No. 2.15 Household Uses

- **Miscellaneous Uses :**

Silk threads are used for embroidery purposes. Silk is also used for making fancy articles like head ornaments, hand bags, bows, ribbons, decorative articles etc.

Picture No. 2.16 (A) Miscellaneous Uses

Picture No. 2.16 (B) Miscellaneous Uses

Do You Know This ?

Silk.... Nature's luxury fiber in nine languages

Spanish	**Seda**	**Latin**	**Sericum**
Chinese	**Si**	**French**	**Soie**
Italian	**Seta**	**German**	**Seide**
Korean	**Soi**	**Japanese**	**Kinu**

English - Silk

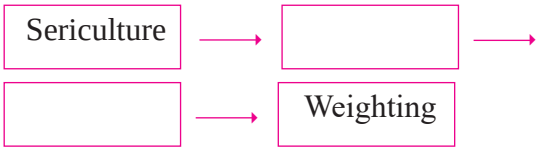
Table No. 2.5

Properties common to protein fibers

	Properties	Importance to consumer
1.	Good moisture regain & low heat conductivity	Suitable in both cold & humid climate
2.	Low wet strength	Special precaution is required while washing & during stain removal
3.	Medium Density	Light weight fabrics
4.	Harmful effect of alkali	Neutral soaps or mild alkaline soaps are recommended for laundry
5.	Low resistance to moth	Needs special precautions while storing for season

Use Your Brain Power

1. Map the silk Route of ancient time
2. Complete the flow chart



3. Can you write the correct sequence of the life cycle of the silk warm

   1) Pupa 2) Egg, 3) Moth,
   4) Stoving, 5) Caterpillar

4. Complete the given table :

Properties of silk fiber

Properties	Silk
Microscopic	
	Filament fibre
Luster	
Strength (Tenacity)	
Elasticity	
Resiliency	
Moisture absorption	
	Light weight
Effect of Mildew	
Effect of Moth	
	Easily attcated by heat
Heat Conductivity	

EXERCISE

Objective Type Questions

Match the Pairs

I.			
	A		**B**
a.	Sericulture	1.	Staple length
b.	Filature	2.	Bombyx Mori
c.	Wild silk	3.	Throwing
d.	Spun silk	4.	Muga silk
		5.	Artificial silk
II.			
	A		**B**
a.	Degumming	1.	Steaming of cocoons
b.	Stoving	2.	Twisting
c.	Weighting	3.	Unwinding
d.	Throwing	4.	Metallic salts
		5.	Removal of sericin

II. State whether the following sentences are true or false :

1. Silk is the strongest of animal fiber
2. Luster of silk is low
3. Heat conductivity of silk is low
4. Wild silk is dark in colour as compared to cultivated silk
5. Silk gum is called as fibroin
6. Cultivated silk is obtained from Bombyx Mori.
7. Silk is the only natural filament fiber.
8. Silk has medium moisture regain.
9. Silk makes light weight fabrics
10. Silk is affected by moth.

III. Select and Write the most appropriate answer from the given alternatives:

1. Natural filament fiber _____
   a) Cotton b) Silk c) Wool
2. Burning silk smells like _____
   a) Hair b) Paper c) Plastic
3. In silk manufacturing process that follows after sericulture is _____
   a) Weighting b) Degumming
   c) Filature
4. Process which removes sericin from silk filament _____
   a) Reeling b) Degumming
   c) Throwing
5. Luster of silk is _____
   a) High b) Low c) indium
6. Process by which twist is given to silk filament _____
   a) Reeling b) Throwing
   c) Sericulture
7. Absorbency of silk is _____
   a) medium b) poor c) good.
8. Source of silk filament is _____
   a) Rock b) Caterpillar
   c) Plant
9. Under the microscope silk appears like _____
   a) Transparent rod b) Scaly
   c) Twisted
10. Density of silk is _____
    a) High b) low c) medium
11. Silk is easily damaged by _____
    a) Air b) moth c) mildew
12. Silk is mainly used for _____
    a) Medical purposes b) Industrial purposes c) Apparel purposes.
13. Silk protein is called _____
    a) Fibroin b) Tannin c) Pectin

14. Silk Gum is called _____
    a) Wax b) Sericin c) Fibroin

15. Fiber termed as 'Queen of fabrics' _____
    a) Cotton b) Wool c) Silk

16. Bombyx Mori species of moth is fed on _____
    a) Mulberry leaves
    b) Oak leaves c) Mango leaves

Short Answer Type Questions

- **State whether the following sentences are true or false & explain**

1. Silk is a natural cellulosic fiber.
2. Silk has low wet strength.
3. Under the microscope silk appears twist.
4. Silk is easily affected by mildew.
5. Silk is used for party wear.

- **List in order the steps involved in the manufacture or silk filament.**

- **Circle the odd word and explain.**

1) a) Degumming b) Retting
   c) Weighting d) Stoving

2) a) Muga silk b) Eri silk
   c) Cultivated silk d) Tussar silk

3) a) Caterpillar b) Pupa
   c) Tree d) Moth

- **Name the following**

1. Silk gum
2. Silk filament protein
3. Species of moth producing cultivated silk
4. Food for Bombyx Mori
5. Process of steaming of cocoons to kill silk worm
6. Removal of sericin from silk filament.
7. Silk obtained from damaged cocoons
8. Process by which twist is given to silk.
9. Process for which metallic salts are used.
10. Silk worm lying inside the cocoon.
11. Silk worm winding filament around it's body to encase itself.
12. The process of unwinding the filament from cocoon.

- **Differentiate between :**

1. Cultivated Reeled silk and Spun silk
2. Cultivated silk and wild silk
3. Degumming and Weighting

- **Give Reasons :**

1. Silk is called 'Queen of fabrics'.
2. Special care is required while storing silk for season.
3. Hot iron should be avoided for silk.
4. Degumming is done for silk.
5. Weighting is done for silk.
6. Silk should be washed carefully.
7. Stoving is done to produce cultivated silk.

- **Answer in short :**

1. What is sericulture ?
2. Which are the Countries producing silk ?
3. What is wild silk ?
4. What is spun silk ?
5. What is cultivated silk ?
6. What is Degumming ?
7. What is weighting ?
8. Write thermal properties of silk ?
9. Write biological properties of silk ?

10. Explain microscopic properties of silk?
11. Write about moisture regain & resiliency of silk
12. Write about Density & length of silk
13. Write about luster & Elasticity of silk
14. Draw microscopic appearance of silk with diagram.

- **Write short notes :**

1. Sericulture
2. Wild silk
3. Spun silk
4. Uses of silk

Long Answer Type Question

1. Describe the life cycle of silk worm.

Self-study / Study tour / Project

- Visit sericulture plant near to your place & write a report.
- Collect samples of cultivated silk & wild silk and compare properties with your class.