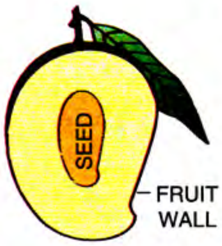
6 SEEDS — STRUCTURE AND GERMINATION

Syllabus : Fruit and seed (definition and significance). Structure of dicot and monocot seeds. Germination of seeds, types, and conditions for seed germination.

Structure and germination of Bean seed and Maize grain. Differences between monocot and dicot seeds. Differences between hypogeal and epigeal germination. Conditions for seed germination to be explained and supported by experiments.

6.1 WHAT IS A SEED ?

Before we talk about the germination of seeds it will be appropriate to refresh your knowledge what the three terms FRUIT, SEED and GRAIN actually mean.



Fruit is the enlarged ripened **ovary**, the ovarian wall forming the fruit wall enclosing the seed. The fruit protects the seed and helps in seed dispersal. *Examples*. Mango, pea pod.

Seed is the ripened **ovule**. It contains embryo which develops into a new plant. The seed coat protects the embryo from mechanical damage. *Example* : Bean seed, peas.

Grain as found in maize, wheat, etc, is actually the fruit in which the fruit-wall and the seed coat are fused together to form a protective layer.

MORE ABOUT SEED

— It is a mature ovule **after fertilisation**.

— It contains a tiny living plant the **embryo** (developed from the fused sperm nucleus and the egg nucleus).

— The embryo remains in an inactive (dormant) state until exposed to favourable conditions when it germinates.

— The seed also contains **food material** for the nourishment of the embryo during germination.

— The embryo can withstand unfavourable conditions of temperature, drought, etc. (Some seeds are known to remain dormant even up to 100 years or more).

6.2 CLASSIFICATION AND STRUCTURE OF SEEDS

Types of Seed

Broadly the seeds are of two kinds — **monocotyledonous** and **dicotyledonous**.

— Monocotyledonous seeds contain one cotyledon (seed-leaf) e.g. maize, grasses.

— Dicotyledonous seeds contain two cotyledons e.g. pea, gram, bean.

Seeds vary in size.

— Some are so **small** that they are barely visible to the naked eye e.g. poppy seeds, orchid seeds.

— Some are **quite large** as in watermelon and pumpkin or even in mango (the stone).

— **Largest** seeds are those of coconut and double coconut.

The size, shape and structure of seeds of different plants vary considerably but the basic structure of most seeds is same.

On the **basis of endosperm**, seeds are classified as :

(i) ***Albuminous*** (endospermic) cotyledons are thin and membranous and endosperm persists e.g. Dicot albuminous seeds : poppy, custard apple. Monocot albuminous seeds : cereals, millets, palm.

(ii) ***Exalbuminous*** (non-endospermic) - In such seeds, the cotyledon stores food and becomes thick and fleshy e.g. Dicot exalbuminous seeds - Gram, pea, mango, mustard and Monocot exalbuminous seeds - Vallisneria, orchids, amorphophallus.

1. THE BEAN SEED (Fig. 6.1)

There are a number of different kinds of beans such as broad bean, lima bean, french bean, etc., but the general structure of their seeds is the same. Most are kidney-shaped with a convex and a concave side.

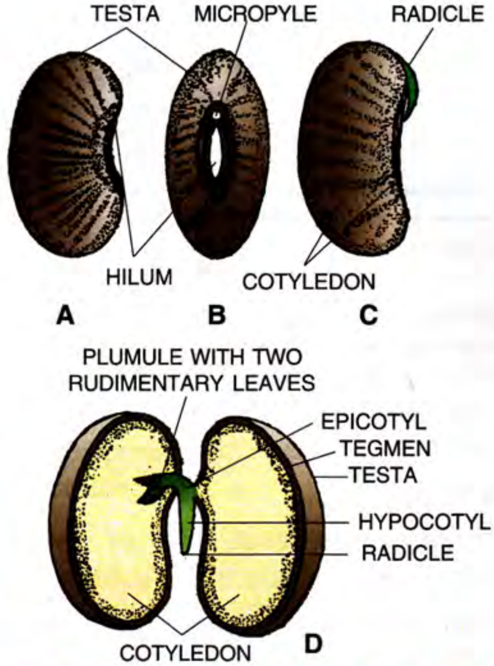


Fig. 6.1 Structure of Bean seed. A & B—External structure, C—Testa removed, D—Seed cut open to show various parts.

Seed coat consists of the **testa** the outermost hard brownish covering. It protects the delicate inner parts of the seed from injury and from the attack of bacteria, fungi and insects and **tegmen** (Fig. 6.1 D) is a thin inner layer lying next to the testa, and this also is protective.

Hilum is a distinct whitish oval scar on the concave side of the seed. It represents the spot where the ovule (now the seed) was attached to the ovary wall through placenta.

A tiny pore **micropyle** is situated close to the hilum. It marks the opening through which the pollen tube had entered the ovule. Micropyle serves two functions :—

(1) When soaked in water the seeds absorb water mainly through this micropyle and make it available to the embryo for germination.

(2) It provides for the diffusion of respiratory gases for the growing embryo.

Below the seed-coat are two thick **cotyledons** which contain food for the embryo and protect it.

On carefully separating the two cotyledons the tiny **embryo** can easily be seen attached to one of the cotyledons. The embryo consists of two parts—the **radicle** which later forms the root and the **plumule** which later forms the shoot. The plumule consists of a short stem with a pair of tiny leaves and a growing point between them.

(Do not misspell radicle as "radical" which is a term in chemistry. If you do so, you may lose marks in the examination)

2. MAIZE GRAIN (Fig. 6.2)

The maize grain is actually a one seeded fruit in which the ***fruit wall and the seed-coat are fused*** together to form a protective layer. Therefore, we call such a fruit as ***grain***.

On one side of the grain occurs a small light-coloured oval area which marks the location of the embryo inside. The remaining major part of the grain contains a large endosperm which is rich in starch. The endosperm and the embryonic part are separated from each other by a thin epithelial layer. The outermost layer of the endosperm is rich in protein and is called **aleurone layer.**

The **embryo** consists of a single cotyledon here called **scutellum**, a radicle and a plumule. The radicle is towards the pointed end and it is enclosed in a protective sheath, the **coleorhiza**. The plumule is towards the upper broader side of the embryonic region and is enclosed in a protective sheath, the **coleoptile.**

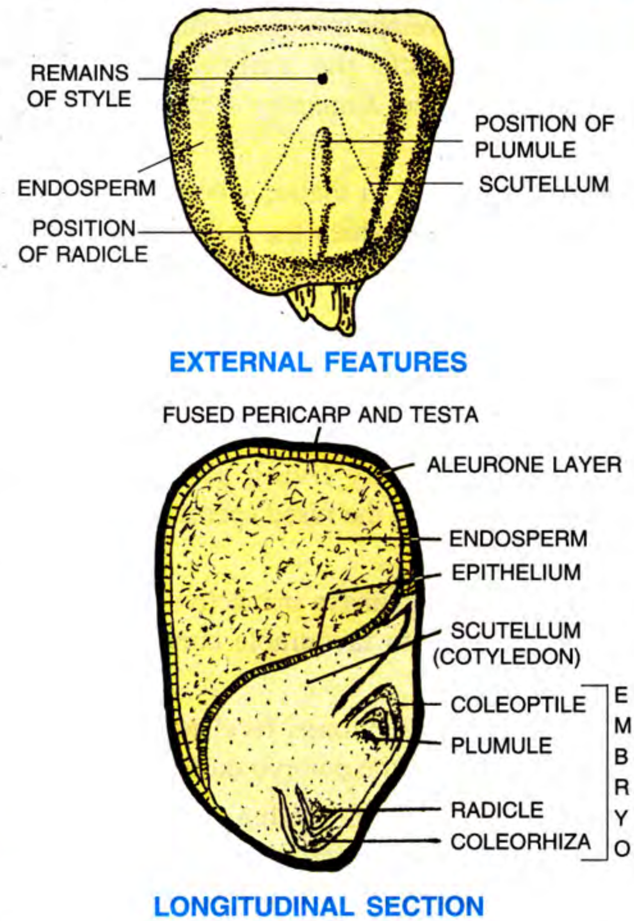


Fig. 6.2 Maize grain

The maize grain is monocotyledonous and endospermic. Some other examples of this type of grain are rice, wheat and oat.

MAJOR DIFFERENCES BETWEEN BEAN SEED AND MAIZE GRAIN

BEAN 	MAIZE 
1. **Two** cotyledons.	**One** cotyledon (scutellum)
2. **No** endosperm.	**Large** endosperm present.
3. **Large** embryo.	**Small** embryo.
4. Plumule leaves **folded**.	Plumule leaves **rolled**.
5. Plumule **large**.	Plumule very **small**.
6. Hilum and micropyle **visible**.	Hilum and micropyle **not visible**.
7. Seed separately contained **in the fruit** called pod.	The seed wall and the fruit wall fused to form **a single grain** with no separate seed.

? PROGRESS CHECK

1. **Mention whether the following statements are True (T) or False (F)**

(i) Plumule is the future root and radicle the future shoot of the plant. (T/F)
(ii) Micropyle serves for the emergence of the radicle. (T/F)
(iii) Cotyledons in castor are a big store of food for the embryo. (T/F)
(iv) Maize gain has a large endosperm. (T/F)
(v) Tegmen is the outermost layer of the seed (T/F)

6.3 GERMINATION

The seed contains a dormant embryo. In a dry seed the embryo is inactive. It is said to be in a state of **dormancy (a period of rest.)** Outwardly, it appears to be without life, but in fact all the chemical activities of life are going on in it although they are very slow and little food is utilized. The dry seeds consume oxygen and give out carbon dioxide, both in extremely minute quantities, and they release some heat as well. When placed under proper conditions the dormant embryo awakens, *i.e.* it becomes active and starts growing into a seedling. All the changes leading to the formation of a seedling are collectively called **germination. Germination** is the process of **formation of a seedling developed from the embryo.**

A fresh seed from a plant normally does not germinate even if the conditions for germination are favourable. It must pass through a period of dormancy during which it undergoes physiological maturation.

CONDITIONS NECESSARY FOR GERMINATION

Water, suitable temperature and air (oxygen) are necessary for germination.

1. Water : The seed obtains water from its environment, *i.e.* from the soil, in natural conditions. The water is absorbed all over the surface but mainly through the micropyle. Two main uses of water are:

(i) The seed swells and consequently the seed-coat ruptures allowing the elongating radicle to come out and form the root system.

(ii) Water is necessary for chemical reaction and for the enzymes to act upon the food stored in the cotyledons or endosperm so that it may convert into a diffusable form dissolved and utilized by the growing embryo.

2. Suitable temperature : Both very low and very high temperatures are unsuitable for germination. A very low temperature inhibits the growth of the embryo and a very high temperature destroys its delicate tissues. A moderately warm temperature (25°C to 35°C) is usually favourable for germination and it is also called **optimum temperature.** Seeds of tropical plants often need a higher temperature for germination than those of the temperate regions.

3. Oxygen : During germination there is rapid cell division and cell growth for which energy is required. This energy is available only by respiration (oxidation of food) and hence the need for oxygen (or air).

Seeds sown very deep in soil fail to germinate

Two main reasons :

1. No proper supply of oxygen (for respiration)
2. Insufficient pushing force in the embryonic parts (hypocotyl or epicotyl) to break through the upper layers of soil.

6.4 SOME EXPERIMENTS ON GERMINATION

1. Experiment to prove that water is necessary for germination.

Take two beakers and mark them A and B. In beaker A place some seeds of green gram (or pea, etc.) on **wet** cotton wool. In beaker B place some similar seeds on **dry** cotton wool. Keep both the beakers in an ordinary room. In a day or two, the seeds in beaker A will germinate but not in beaker B, showing that water is necessary for germination.

2. Experiment to prove that a suitable temperature is necessary for germination.

Take two beakers and name them A and B. Place some green gram seeds on wet cottonwool in each of the two beakers. Keep beaker A in an ordinary room and beaker B in a refrigerator. In a day or two, the seeds in beaker A will germinate, showing the importance of a suitable temperature for germination. The seeds in beaker B may not show signs of germination, or may germinate after several days though not to the extent the seeds in beaker A germinate.

3. Experiment to prove that air (oxygen) is necessary for germination (Fig. 6.3).

Take two conical flasks. Name them A and B. Spread **wet** cottonwool in each flask and place on it some **soaked gram seeds**. Lower a small test-tube containing alkaline ***pyrogallic acid, which absorbs oxygen***, in flask B by means of a thread, taking care that not a single drop of the chemical falls on the seeds, or the cotton-wool. Keep the tube hanging by fixing a cork on the mouth of the flask. Arrange flask A in the same way, except that the test-tube in this flask contains plain water. Place the two flasks in an ordinary room. The seeds in flask A will germinate showing the importance of oxygen for germination. The seeds in flask B do not germinate because there is no oxygen (there may at the most be very slight germination due to anaerobic respiration in the absence of oxygen).

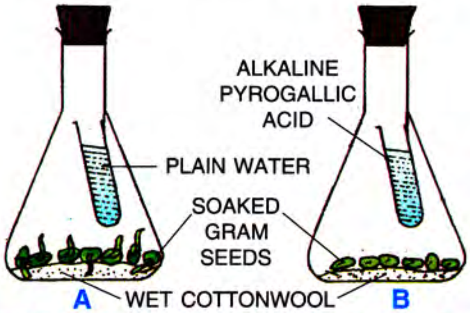


Fig. 6.3 Seeds require air (oxygen) for germination. A—Seeds germinate in ordinary air, B—Seeds do not germinate in air without oxygen

4. The three–bean seeds experiment (Fig. 8.4).

In this experiment three mature air dried bean seeds are taken and tied to a glass slide at three positions as shown in the figure. This slide is kept in a beaker containing water in a manner that the top seed is well above water, the middle one is just at the water level and the bottom one is deep in water. The **experimental** set-up is left in a warm place for a few **days and the** result is as follows :-

- The **middle seed** germinates. It gets **both oxygen** and water.
- The **top seed** does not germinate at all. **It gets only** oxygen but no water.
- The **bottom seed** does not germinate or **stops** germinating after the emergence of a **small radicle**. It gets water but very little oxygen (**from the air** dissolved in water)

The experiment conclusively proves that **water is** essential for germination, but the other **requirement** of oxygen is not fully demonstrated.

Fig. 6.4 The three-bean experiment to demonstrate germination

6.5 TYPES OF GERMINATION

The region of the axis between the point of attachment of cotyledons and the plumule is called **epicotyl**. The region of the axis below the cotyledons is called **hypocotyl**. Both the epicotyl and hypocotyl of a seed never elongate together during germination. It is either the epicotyl or the hypocotyl that elongates. If the epicotyl elongates, the cotyledons remain underground (or on the ground if the seed is just on the ground) and the germination is then called **hypogeal** *e.g.* pea and gram. If the hypocotyl elongates, the cotyledons are pushed above the ground and this type of germination is called **epigeal** (*e.g.* castor, bean, *etc.*).

HYPOGEAL GERMINATION	EPIGEAL GERMINATION
1. Cotyledons remain underground.	1. Cotyledons pushed above the ground.
2. Epicotyl elongates.	2. Hypocotyl elongates.

A method to observe stages of germination. Put sterilized sand in a glass vessel in which filter paper or ordinary white paper is lined beside the inner wall, and place seeds in between the paper and the glass. When water is added to the sand in the vessel, seeds will absorb the water and germinate in a few days.

6.6 GERMINATION IN SOME COMMON SEEDS

Pea seed (Fig. 6.5) (Hypogeal) : The seed absorbs water and swells considerably. The testa softens and bursts. The radicle emerges, grows downwards and forms the root system. The plumule grows upwards and forms the shoot of the seedling. In the earlier stages of development, the plumule is arched and thus protects the young shoot from injury during its emergence from the soil. The cotyledons supply food till the seedling is able to exist independently. Later they wither and shrivel up. The ***cotyledons remain underground*** and germination is **hypogeal** (***hypo :*** below + ***geo :*** earth).

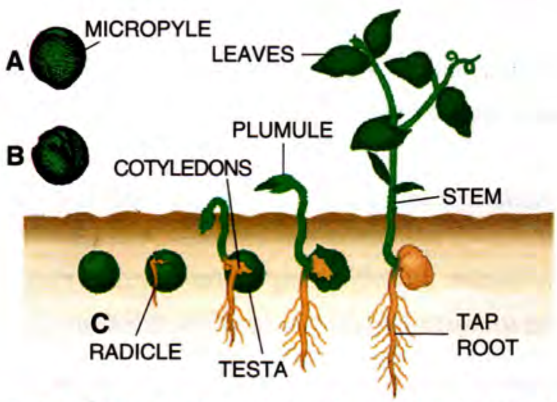


Fig. 6.5 Germination of pea. A—Seed (outer view), B—Seed showing emergence of radicle, C—Stages of germination in soil ; note that the cotyledons remain underground (hypogeal)

Bean seed (Fig. 7.6) (Epigeal) : The seed absorbs water and swells. The radicle grows downwards to form the root system. The arched hypocotyl grows forming an arch/loop above the soil, it then straightens

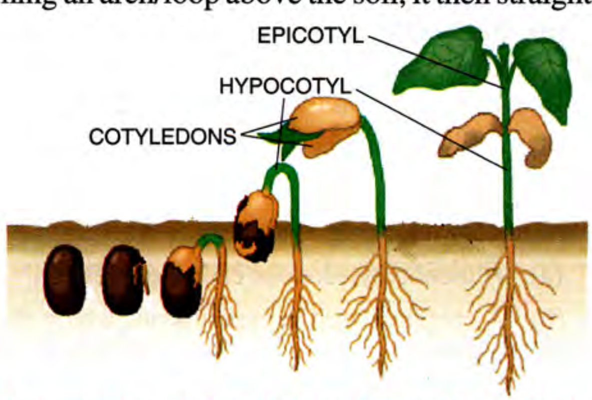


Fig. 6.6 Germination of bean. Hypocotyl (region below cotyledon) elongates to push the cotyledons up above the ground(Epigeal)

bringing the cotyledons above the soil. Germination is, therefore, **epigeal** (***epi :*** above; ***geo :*** earth). The cotyledons become the first green leaves and soon fall off after the foliage leaves grow.

Maize grain (Fig. 6.7) (Hypogeal) : The grain imbibes water and swells considerably. The radicle pierces through the protective root sheath (coleorhiza) and the fruit wall and grows downwards to form the root system, but it dies off soon. New roots develop fror

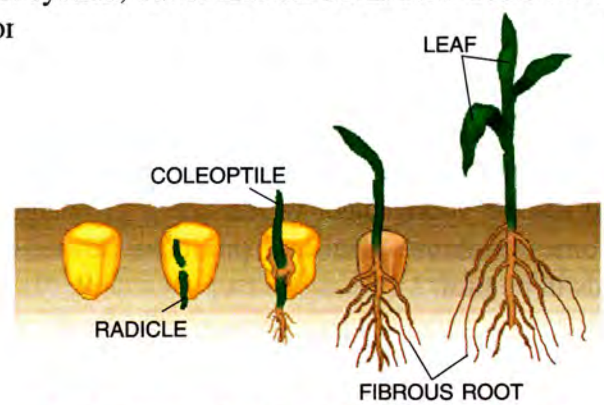


Fig. 6.7 Germination of maize. Hypocotyl does not elongate (Hypogeal)

The plumule pierces through its protective sheath, coleoptile, and grows straight upwards. The two protective sheaths, coleorhiza and coleoptile, may be seen as a membranous covering on the axis of the seedling.

The cotyledon (scutellum) absorbs food from the endosperm till it is exhausted. The hypocotyl does not elongate. Germination is **hypogeal.**

Viviparous germination - (a special type) - The mangrove plants like *Rhizophora* (Fig. 6.8) and *Sonneratia*, show a special mode of seed germination

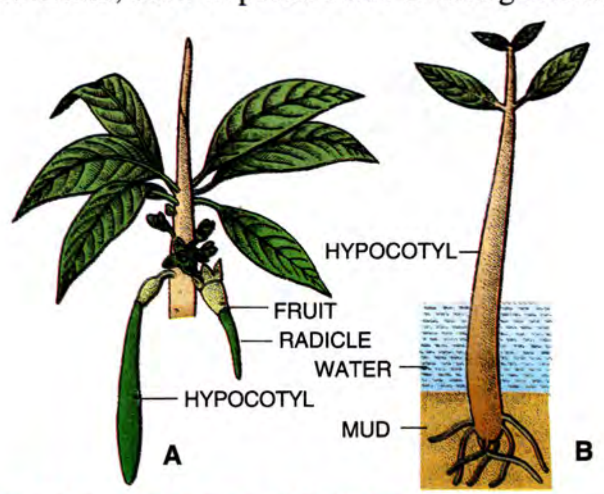


Fig. 6.8 Vivipary. A—Twig of *Rhizophora* showing viviparous germination; B—Seedling growing in mud.

called vivipary in which **seed germinates inside the fruit while it is still attached to the parent plant**. After germination, the plant drops the seedling into the soil which develops root and fixes itself. (*Viviparous :* producing live young ones)

THE SEEDLING

Germination in any plant ends with the formation of a seedling.

Seedling is a stage in the growth of a plant from a seed before it has become wholly independent of the food stored in it.

The roots of the seedling absorb water and minerals from the soil. The leaves start manufacturing food for the young plant which keeps growing and becomes a mature plant and produces flowers and seeds in its turn.

? PROGRESS CHECK

1. Fill in the blanks by choosing the correct alternative
   (i) In a dry seed the embryo is in .... state (active/quiescent)
   (ii) Water is absorbed by the seed mainly through .... (entire surface/micropyle)
   (iii) Very low temperature .... the growth of embryo (inhibits/destroys).
   (iv) Germination in pea is .... (epigeal/hypogeal).
   (v) Coleoptile is a part found in the germinating ______ .... (castor/maize).
   (vi) Alkaline pyrogallic acid is used for absorbing ______ .... during experiments on germination (oxygen/carbon dioxide)

POINTS TO REMEMBER

- ***A dicot seed consists of an embryo with two cotyledons enclosed in a seed coat.***
- ***The embryo consists of a radicle (small root) and a plumule (small shoot)***
- ***The cotyledons contain the food for the embryo***
- ***A monocot seed such as the maize grain has a single cotyledon, a large endosperm, a small embryo in which the plumule is small with rolled plumule leaves.***
- ***Three conditions necessary for the germination of seeds are water, suitable temperature and oxygen.***
- ***Germination of seeds may be hypogeal (cotyledons remaining underground) or epigeal (cotyledons carried above the soil)***

REVIEW QUESTIONS

A. MULTIPLE CHOICE TYPE

1. **Which one** of the following plant parts is **correctly matched** with one of its stated characteristic?
   (a) Mango seed ——— aleurone layer
   (b) Bean seed ——— endosperm
   (c) Maize grain ——— coleoptile
   (d) Wheat grain ——— exalbuminuous
2. Seeds sown very deep in the soil fail to germinate **because** they
   (a) cannot exert enough force to push the soil upward.
   (b) do not get enough sunlight.
   (c) get too much water.
   (d) do not get enough oxygen.

B. VERY SHORT ANSWER TYPE

1. Are the following statements ***true*** (T) or ***false*** (F) ?
   (a) Some seeds have no cotyledons at all. (T/F)
   (b) Maize grain is fruit and not a seed. (T/F)
   (c) Seeds fallen in a flower-bed from the previous crop usually do not germinate until the next sowing season. (T/F)
   (d) Oxygen is necessary for the germination of seeds. (T/F)
2. **Name** the following :
   (a) A monocotyledonous endospermic seed.
   (b) A chemical used in experiments, which absorbs oxygen.
   (c) Part of the plumule above the embryonic axis of the seed.

(d) A plant which shows viviparous germination.
(e) The layer of endosperm of maize, rich in protein.
(f) A seed with folded plumule leaves.

3. **Fill in** the blanks :
   (a) In bean seeds, ... grows faster and the seeds are brought .... ground.
   (b) .... is a protective layer of radicle and .... protects the rolled plumule.
   (c) A seed is protected by .... and ....
   (d) Seeds absorb water through .... which also helps in diffusion of respiratory gases.
   (e) Rice, wheat, and maize are rich in .... food.

4. Arrange the following set of terms in order, so as to be in logical sequence. Rewrite the correct order.
   (a) Embryo, 1st male gamete, zygote, egg cell, micropyle.
   (b) Zygote, embryo, seed, allogamy, tusion of gametes.
   (c) Seed coat bursts, hypocotyl elongates, radicle grows downward, hypocotyl forms loop above the soil, epicotyl elongates.

C. SHORT ANSWER TYPE

1. What is the **difference** between an embryo and a seed?
2. Give any *two* **examples** each of endospermic (albuminous) seeds, and non-endospermic (exalbuminous) seeds.
3. Germinated grams are considered highly nutritive. **What** is the reason for this belief ?
4. **Why do we not use the terms** maize fruit and maize seed ? What do we say instead?

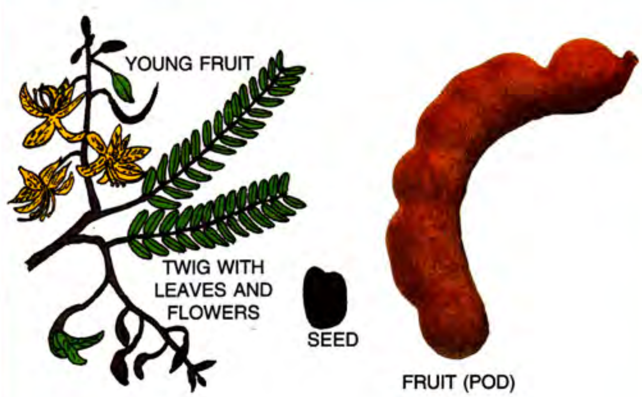
D. LONG ANSWER TYPE

1. What are the **functions** of the following in a seed?
   (a) Seed coat (b) Micropyle
   (c) Cotyledons (d) Radicle
   (e) Plumule
2. Suggest **an experiment** to prove that a suitable temperature is necessary for germination.
3. Sometimes the potatoes kept in a basket during the late rainy season start giving out small shoots. **Would you call it germination? Give reason** in support of your answer.
4. Give *two* **differences** in each of the following pairs :
   (a) Epigeal germination and hypogeal germination
   (b) Coleorhiza and coleoptile.
   (c) Bean seed and maize grain.
5. **Differentiate** between germination and vivipary.
6. Justify the statement that the maize grain is a 'one seeded fruit'.
7. What is the role played by the hypocotyl in epigeal germination ?
8. With regard to germination in bean seed, answer the following questions :
   (a) State the function of the 'Micropyle'.
   (b) Name the part of the seed that grows into the seedling.
   (c) Draw a neat labelled diagram of the structure named above.
   (d) Name the part of the seed that provides nutrition for the growing seedling.

TAMARIND

("Tamar-i-Hind" meaning "Date of India")

*The English name **"tamarind"** for this plant is derived from the Persian word **"Tamar-i-Hind"** which means "Date (khajur) of India". Just as "khajur" is everywhere in "Persia" so is tamarind in India.*



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