

## Semester II

Course: Fundamentals of Entomology

Dr Akhilesh Tripathi

Topic

### Metamorphosis and Diapause in Insect (Part I)

#### Metamorphosis and diapause

Series of changes that takes place during the development of an insect from egg to adult are collectively known as **metamorphosis**.

Metamorphosis is derived from Greek word '**Meta**' = Change, '**morph**' = form or structure.

Metamorphosis include three developmental processes namely **growth**, **differentiation** and **reproduction** which takes place in larval, pupal and adult stages respectively.

**Instar:** It is the form of the body during two inter moults. The larva is known as first instar, immediately after hatching from egg, and as second instar after first moult and so on

**Stadium :** The interval or time period between two moults is known as stadium.

**Exuviae :** The skin shed during moulting process is known as exuviae.

**Imago (or) Adult :** It is the final stage of insect with well developed organs for reproduction, which emerges out from pupal body.

**Sub-imago:** It is a pre adult stage with fully developed wings but without reproductive organs .Eg: mayflies (**Ephemeroptera**)

#### Types of metamorphosis:

1. Ametamorphosis
2. Incomplete metamorphosis
3. Complete metamorphosis
4. Intermediate metamorphosis
5. Hyer metamorphosis

#### 1. Ametamorphosis :

Insects do not undergo any metamorphosis. When the insect hatches from the egg, it resembles the adult in all the characters except the small body size, which

later increases, until they reach sexual maturity with well developed reproductive organs.

e.g.: Apterygotes e.g.: silver fish, springtails.

## 2. Incomplete metamorphosis or hemimetamorphosis or direct development or simple metamorphosis

The life cycle includes egg, nymph and adult stages. The nymph resembles the adult in all the characters except wings. Nymphs possess wing buds which transform in to fully developed wings in adult stage. (Fig. 1). In these insects, wings develop externally and hence are also called as **Exopterygota**. Pupal stage is absent hence, development is said to be direct and simple.

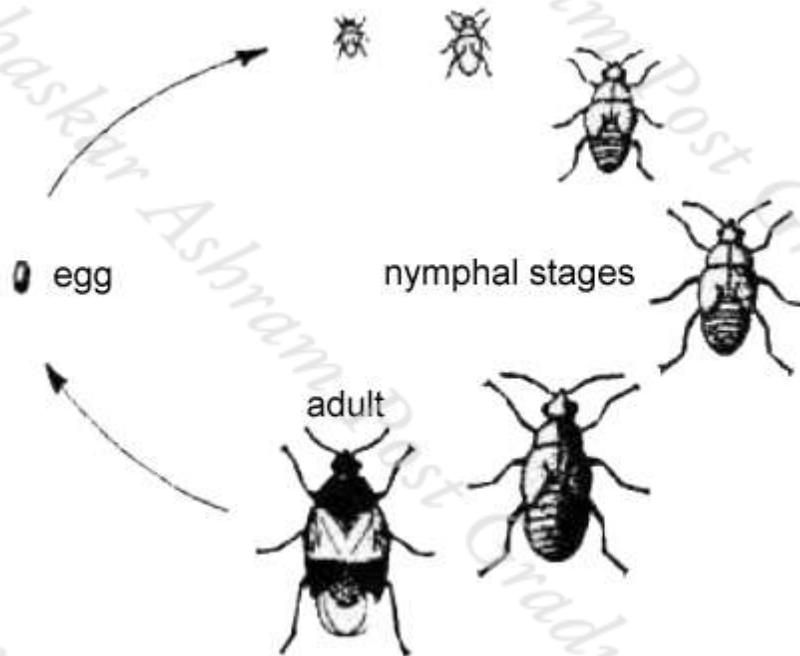


Fig. 1. Incomplete metamorphosis

## 3. Complete (or) holometamorphosis or indirect development

The life cycle includes four stages; egg, larva, pupa and adult. Larva differs from the adult both in body structure and habits. Larva has both thoracic and abdominal legs, sometimes legs may be absent in larva, whereas adult has only thoracic legs.

Compound eyes are absent in larva. Larva undergoes moulting to enter in to pupal stage from which the adult insect emerges. Wings develop **internally** during the pupal stage and hence, they are called **Endopterygotes**.(Fig. 2)

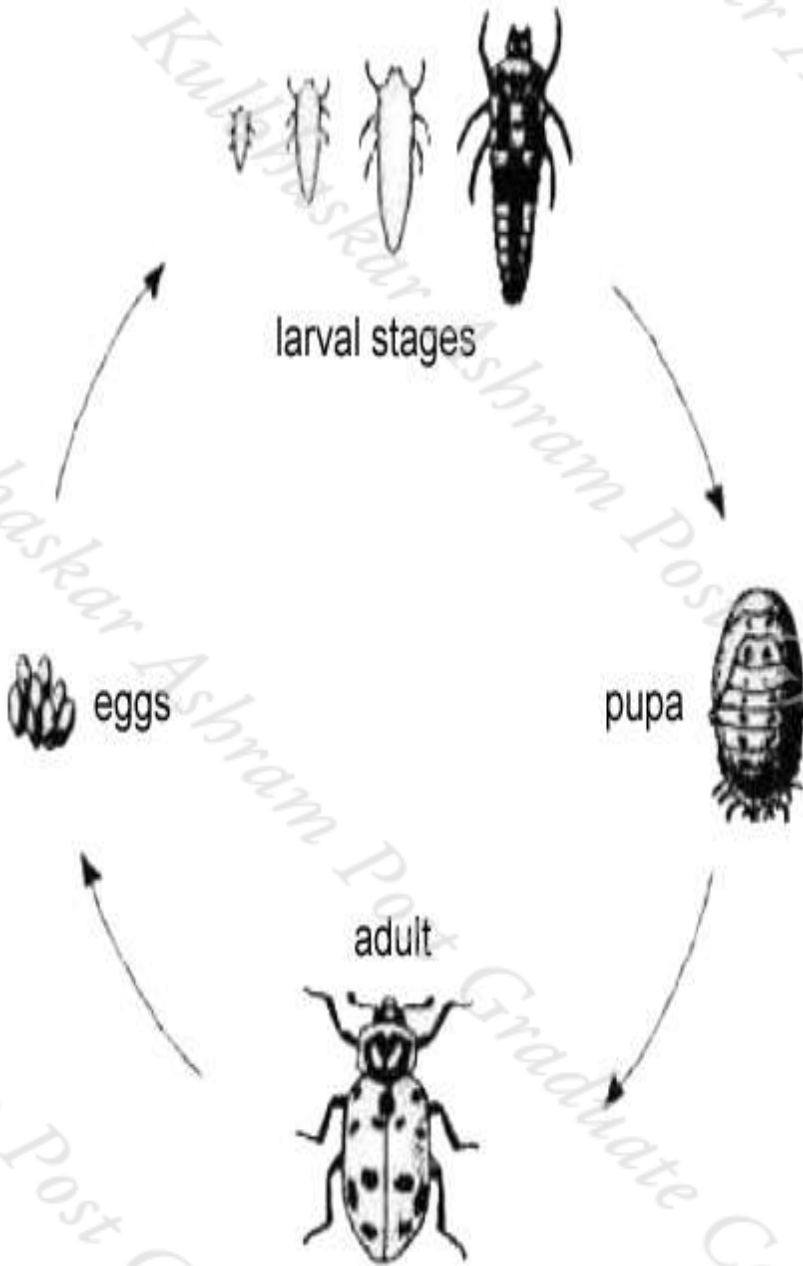


Fig.2. Complete metamorphosis

**4. Intermediate metamorphosis:** In this case, insects may undergo either **hemi** or **holometamorphosis**. If they undergo holometamorphosis, there is a short pupal stage. e.g.: coccids, thrips etc.

**5. Hypermetamorphosis:**

This is a peculiar type of development which consists of two or more types or forms of larvae in the life cycle of insects. In majority of the cases the first larval instar is **campodeiform** and the subsequent larval forms depends on type and mode of life of the larva.

E.g.: In blister beetle (Meloidae; Coleoptera), the first larval instar is **campodeiform** followed by **scarabeiform** larval type.

### Diapause

It is the period of arrested growth or development in the life cycle of the insects during which the physiological processes like **differentiation** and **reproduction** are suspended. Diapause is represented by low rate of metabolism, low O<sub>2</sub> consumption, low body weight, low body water content and vitamin deficiency in the blood. Diapause may occur in **egg, larva, nymph, pupa** or **adult** stage.

For example:

**Egg diapause** - *Bombyx mori*;

**Larval diapause**- *Euproctis* sp., *Pectinophora gossypiella*;

**Pupal diapause**- Redhairy Caterpillar (*Amsacta albistriga*) and

**Adult diapause**- Mango nut weevil (*Sternochaetus mangiferae*)

Diapause is of two types:

1. **Obligatory diapause**: It refers to the stage of suspended activity of the insect which is a hereditary character controlled by genes and is species specific.  
e.g. egg diapause in silkworm

2. **Facultative diapause**: It is the stage of suspended activity of the insect due to unfavourable conditions and with the onset of favourable condition, the insect regains its original activity.  
e.g. Cotton pink bollworm *Pectinophora gossypiella*.

The unfavourable conditions may be biotic or abiotic.

The occurrence of diapause during summer due to high temperatures is known as "**aestivation**" where as the period of inactivity during winter due to low temperatures known as "**hibernation**".

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### Reproductive System in Insect (Part I)

The reproductive system is divided into two parts namely **internal genitalia** and **external genitalia**. The internal genitalia serve to the development of **germ cells**. The external genitalia accomplish the **union of two sexes** and enable the female to **deposit eggs**.

#### Female reproductive system:

It consists of:

1. A pair of **ovaries** which possess number of ovarioles,
2. A pair of **oviducts**,
3. **common** oviduct / **Median** oviduct ,
4. **spermatheca** ,
5. A pair of **accessory glands** and
6. **Bursa copulatrix** or **copulatory pouch** or **genital chamber** or **vagina**

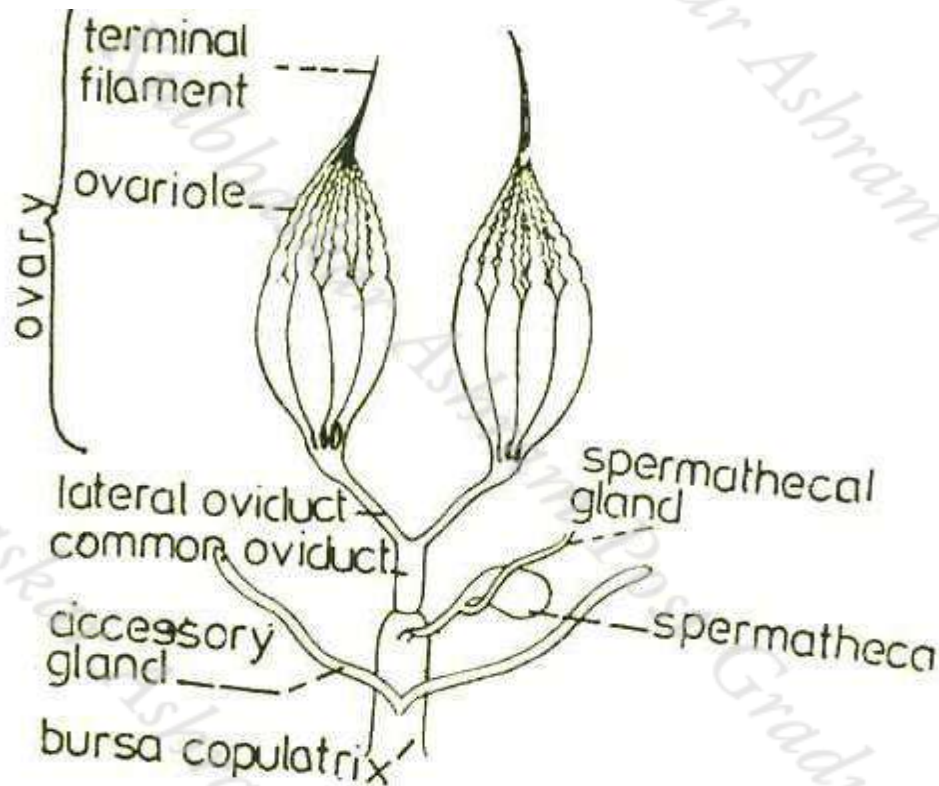


Fig. Female reproductive system

(Source: Taken from General and applied Entomology – K.K. Nayar, T.N. Ananthakrishnan and B.V. David (10<sup>th</sup> edition, 1993). Tata McGraw-Hill Publishing Company Ltd., New Delhi., India.)

**1. Ovaries :** These are the prominent visceral organs present on the either side of alimentary canal. Anteriorly the ovaries get connected with the body wall by means of thread like suspensory ligaments. The ovaries are covered with fat body and are richly covered with trachea. Each ovary consists of a no of **ovarioles** or **egg tubes**.

**Ovarioles:** Each ovariole is enveloped by a double layered cellular wall . The outer wall is called **ovarial sheath** which has an abundant supply of tracheae. The inner layer called **tunica propria** is elastic in nature. Each ovariole at its terminal has a filament which unites with other filaments to form a **suspensory ligament** . The eggs are discharged in to the lateral oviducts .

**Lateral oviducts:** Proximal end of the ovarioles of each ovary join to form a lateral oviduct on each side .The wall of oviduct is glandular and muscular

**Median Oviduct:** Two lateral oviducts combine to form a median oviduct

**Vagina:** In most of the insects median oviduct doesnot open directly to outside. It opens in to a tubular genital chamber or vagina formed by invagination of bodywall

from VIII segment . The vagina opens outside and the opening is called vulva. Vulva serves both purposes of receiving the sperms and discharging the eggs.

**Bursa Copulatrix:** In some insects the genital chamber or vagina develops a separate pouch called Bursa Copulatrix in to which insects have two reproductive openings . One is vulva for receiving the sperms open on VIII sternum and another one is ovipore or gonopore on IX segment for discharging eggs.  
Eg: Lepidoptera and water beetles

**Spermathea:** It is a sac like structure consisting of a spermathecal gland and opens in to vagina through **spermathecal duct**. This is mainly used for storing the sperms. It also produces some fluids responsible for longevity of cells for several hours.

**Accessory glands:** These are a pair of collateral glands which open in to the distal portion of vagina and secrete the substance responsible for the formation of ootheca of cockroach.

This sticky substances are useful for attachment of egg to the substrate on which they are laid.

Each ovariole in insects consists of a group of tapering units called **ovarioles**. The number of ovarioles in an ovary varies greatly in different insects , usually 4 to 8. In Isoptera more than 2000

Typical ovariole or egg tube consists of 3 parts namely

- 1.Terminal filament
- 2.Egg tube
- 3.Supporting stalk or pedicel

**Terminal filament:** of all the ovarioles in a ovary unite distally with one another in a suspensory ligament. The ligaments from the two ovaries are combined in a single median ligament which is attached to the tergal plated of thorax.

The Egg tube is divided in to two parts

- 1.Egg chamber or Germarium
- 2.Zone of growth or vitellarium

**Germarium** : Also called as egg chamber which contain the primordial germ cells or undifferentiated cells. These cells give rise to three types of cells .

- 1.Germ cells developing in to oogonia and dinally oocytes
- 2.Nutritive cells or nurse cells **trophocytes**.

### 3.Follicle cells

**Vitellarium or Zone of growth** : It occupies the major part of the ovariole and contains large number of **oocytes** and eggs in different stages of development

The egg cells grow and attain their mature stage. In the anterior region of vitellarium the nurse cells and oocytes remain mixed up and assume the central position while follicle cells take peripheral position. In posterior end oocytes are enclosed by follicle cells to form follicular layer. The nurse cells absorb nutrients from haemolymph through follicular cells and transmit them to oocytes. In some case follicle cells provide nutrients to the oocytes where nurse cells are absent.

### **Types of ovarioles :**

Based on the presence or absence of nutritive cells and their location ovarioles are categorized in to two types.

1. **Panoistic** ovarioles: In these, the nutritive cells are absent and the development of oocytes takes place with the help of follicular epithelial cells e.g.: Odonata, Dictyoptera, Orthoptera and Ephemeroptera

2. **Meriostic** ovarioles: They contain trophocytes / nutritive cells which vary in their position.

Based on the position of trophocytes **Meriostic** ovarioles are classified into

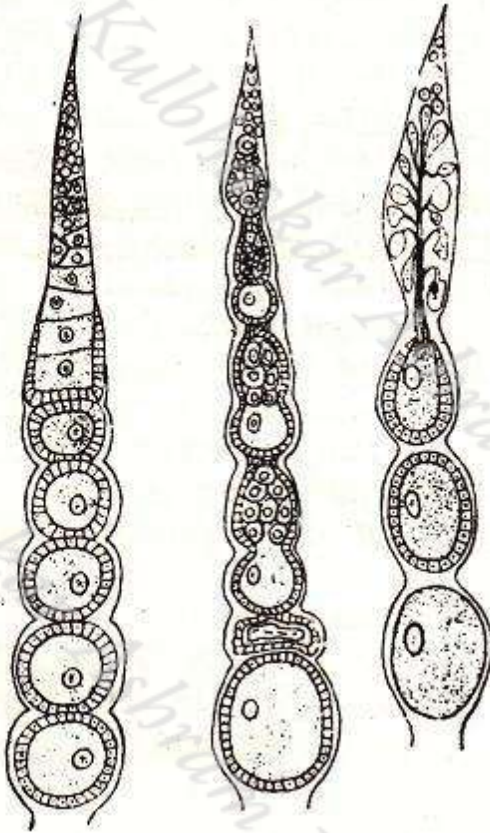
(i) **Polytrophic** ovarioles: where developing oocyte and trophocytes arranged alternatively within the vitellarium.

e.g.: Mecoptera, Dermaptera, Psocoptera

(ii) **Acrotrophic** ovarioles: Also called **teletrophic** ovarioles where the trophocytes are present in the germarium (apex) and are connected with the growing or developing oocytes by cytoplasmic strands.

e.g.: Hemiptera and Coleoptera





(A) Panoistic (B) Polytrophic (C) Acrotrophic

Fig. Types of Ovarioles

(Source: Taken from General and applied Entomology – K.K. Nayar, T.N. Ananthakrishnan and B.V. David (10<sup>th</sup> edition, 1993). Tata McGraw-Hill Publishing Company Ltd., New Delhi., India.)

## Male reproductive system

Internal male reproductive organs consists of

1. One pair of **testis** ,
2. One pair of **vasa deferens**,
3. One pair of **Seminal vesicle**
4. **Ejaculatory duct**
5. **Accessory glands a) mesodena b) ectodena** and
6. **Genitalia**

**1. Testis** : The testis lie in visceral cavity above the alimentary canal and are connected to the body wall through translucent ducts and are well supplied with trachea and fat body tissues. Each testis consists of number of oval shaped structures known as **follicles or sperm tubes**. Each follicle has a layer of epithelial cells. The entire follicle is covered by a peritoneal membrane where as the testis is completely enveloped within a coat known as **scrotum**.

### Structure of follicle

Each individual follicle is divided into a series of zones (or) areas characterized by the presence of the sex cells i.e. sperms in different stages of development. These zones are zone of germarium, zone of growth , zone of division and reduction and zone of transformation.

**(i) Germarium** : It is the region containing primordial germ cells or spermatogonia which undergo multiplication. (Zone of spermatogonia)

**(ii) Zone of growth**: It is the area where spermatogonia increase in size, undergo repeated mitosis and develop in to spermatocytes. (Zone of spermatocytes)

**(iii) Zone of division and reduction** : It is the area where spermatocytes undergo meiosis and give rise to spermatids (Zone of spermatids)

**(iv) Zone of transformation** : It is the area where spermatids get transformed in to spermatozoa. (Zone of spermatozoa)

Spermatozoa are a group of cells which are enclosed in testicular cyst cells from which they are released in to **vasa efferens**, the tubular connections of the follicles which combine together to form the vasa deferens.

**2. Vasa deferens** : These are the long tubes formed by the union of vasa efferens which receives the sperms from testis and allow their transport to the ejaculatory duct .

**3. Seminal vesicles**: Each vasa deferens become enlarged posteriorly to form a sac like structure called seminal vesicle for **storage of spermatozoa** for some time.

**4. Ejaculatory duct:** Both the vasa deferens of the two testis unite posteriorly to form a common median ejaculatory duct. The terminal section of ejaculatory duct is enclosed in a finger like evagination of body wall , male copulatory organ or aedeagus or penis.

**5. Accessory glands:** These are 1-3 pairs of glands which open in to the ejaculatory duct. In most cases their secretion mix with spermatozoa. These glands are called **mushroom glands** in cockroaches and mantids because of their appearance as mushrooms. This secretions facilitates sperm transmission from male to female.

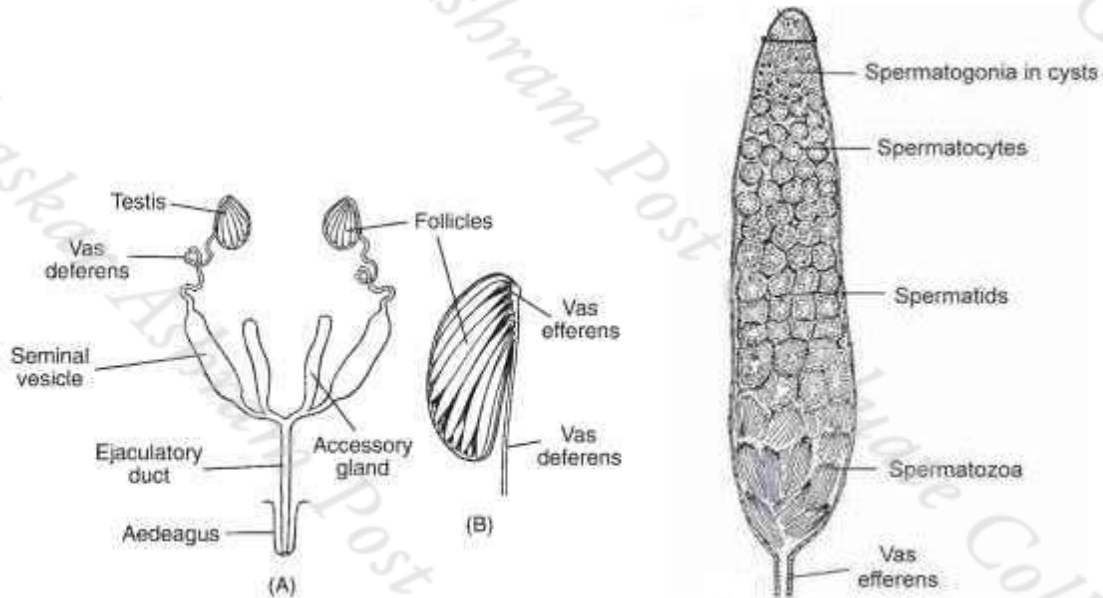


Fig. Male reproductive system

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### Types of Reproduction in Insect (Part I)

#### Types of Reproduction.

Insects are bisexual, they can undergo sexual reproduction for producing either the eggs (or) the young ones.

Different types of reproduction in insects are:

**1. Oviparity** : Insects reproduce by laying eggs by the female which later hatch and produce the young ones.

e.g. moths and butterflies.

**2. Viviparity** : It is the phenomenon of reproduction where the female gives birth to the young ones instead of laying eggs. Embryonic development is completed within the female and the embryo gets nourishment from the mother and produce the larva/young ones within the haemocoel. These young ones after some time emerges out from the mother. Viviparity is classified into 4 types.

(i) **Ovo-viviparity**: Insects retain the eggs within the genital track until the eggs are ready to hatch (or) giving birth to young ones. However immediately after hatching, the young ones will be released outside. Hence, no special structures are developed for nourishment. e.g.: Thysanoptera

(ii) **Adenoparous viviparity** : It is a type of viviparity where the eggs have sufficient yolk, complete their embryonic development and retain in the uterus. Eggs hatch and the young ones get nourishment from special nourishment glands called milk glands which contains milk that have lipids and proteins. When young ones are fully developed, it emerges from the mother and forms in to a pupa within short time and no feeding phase is seen. e.g.: *Glossina pupipara* of Diptera.

(iii) **Pseudoplacental viviparity** : It is a phenomenon where insect have eggs with little (or) no yolk. Hatching takes place within the mother and the nourishment for the young one is received through embryonic maternal structure called pseudoplacenta

e.g.: Psocoptera, Dermaptera, aphids etc.,

(iv) **Haemocoelous viviparity**: It is a type of reproduction where the eggs are retained within the haemocoel and the embryonic development as well as the nourishment of young one takes place through the transfer of nutrients from the haemolymph of mother. After development, young one comes out either through genital canal or by the rupture in the walls of the parent. e.g: strepsipterans & some larvae of cecidomyids (Diptera)

**3. Parthenogenesis** : It is the ability of the females to reproduce without fertilization / copulation with males. This usually occurs due to the genetic characters, due to heredity, failure in finding a mate, hormonal changes within the body and weather factors. This parthenogenesis is classified as

- (i) **Sporadic** parthenogenesis : occurs occasionally e.g.: silkworm.
- (ii) **Constant** parthenogenesis : occurs regularly. e.g.: thrips
- (iii) **Cyclic** parthenogenesis : it is nothing but the alternation of generations where parthenogenesis occur in alternation with the sexual reproduction. e.g.: aphids.

Based on the **sexes of the off springs produced**, parthenogenesis can be

- (i) **Arrhenotoky** : only males are produced e.g.: Hymenoptera
- (ii) **Thelytoky** : only females are produced e.g.: acridids
- (iii) **Amphitoky** : both females and males are produced e.g.: hymenopterans

**4. Paedogenesis (or) Neoteny** : It is a phenomenon where the immature insects or stages give birth to young ones. This usually occurs due to the hormonal imbalance. Most of the insects which reproduce by paedogenesis also reproduce by parthenogenesis. e.g.: cecidomyids.

**5. Polyembryony**: It is a type of reproduction where insects reproduce by giving birth to two or more young ones instead of a single one, as two or more embryos are produced from a single egg. e.g.: endo parasitic Hymenoptera like *platygaster*

**6. Hermaphroditism** : It is a type of reproduction where both male and female gonads are present in the same individual. It may be a functional hermaphroditism as in case of *Icerya purchsi* (or) non functional as in case of stonefly, *Perla marginata*

**7. Castration** : It is a type of reproduction where the separation of the individuals occurs mainly due to the development of the reproductive organs. The insects with well developed ovaries develop in to females (queens), the insects with well developed testis develop in to males (drones) and insects with underdeveloped ovaries develop in to workers. e.g.: social insects such as honey bees.

**8. Alternation of generation** : Insects reproduce by parthenogenesis and bisexual reproduction by alteration of generations. e.g.: aphids which reproduce by parthenogenesis in summer and undergo sexual reproduction in winter.