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. The presence of hard exoskeleton on the body prevents the growth of larva. The series of moults during larval stage allow them to increase their bod ysize/growth. The number of moults in general may vary from 5-6.

Types of metamorphosis:

1- Ametamorphosis (Development without metsamorphosis) :

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. The degree of change from juvenile to adult form is slight and is manifest primarily in increased body size and development of functional genitalia. Juvenile and adult apterygotes inhabit the same ecological niche, and the insects continue to grow and molt after reaching sexual maturity. The number of molts through which an insect passes is very high and variable. For example: Thermobia domestica, between 45 - 60 molts have been recorded.

2-**Gradual Metamorphosis**

The simplest form of metamorphosis is a gradual change in body form that occurs between molts. The life cycle includes egg, nymph and adult stages. Cockroaches, grasshophers, earwigs, termites, lice, trips, bugs, aphids, and scales are representative of the insects that undergo gradual metamorphosis. Since the immature stages, commonly called **nymph** requires about the same kind of habitat and food as the adults. 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. 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**. The reproductive organs and wings of the adult remain inactive as imaginal discs for several molts. When wings begin to develop during the last two molts before the adult molt, they appear first as small

external buds, become about one third the adult size with the next molt, and finally reach adult size and function after the last molt at which time, the insect is also reproductively mature.

3-Incomplete Metamorphosis

A more extensive form of metamorphosis is termed incomplete metamorphosis. Insects that use this mode of development pass through several nymphal stages before the nymph molts to the winged adult. These insects are usually aquatic with external gills. Aquatic insect such as Odonata (dragonflies), Ephmeroptera (Mayfly) and Plecoptera (stoneflies) are placed by some author in a group called the Hemimetabola, a group having incomplete metamorphosis (Hemimetabolous development). The aquatic nymph called (naiads) and adults of insect with incomplete metamorphosis live in entirely different habitat, the aquatic nymph have tracheal, anal or rectal gills; their legs are modified for clinging, climbing, or burrowing, their bodies modified for swimming; and their mouthparts are modified for taking food in the water. The adult, being aerial, require different methods of capturing food (dragonflies and damselflies) or they may little or no food, but inflate the alimentary canal with air to aid in flight (mayflies).

4- 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. **These great differences between adults and their offspring allow them to avoid intraspecific competition for food and habitat.**

Many features, including the legs, wings, structures on the head, genitalia, and parts of the changing epidermis, arise from internal imaginal discs that differentiate and evert during the pupal stage and the metamorphosis to the adult. **Stemmata**, optical units of low resolution, are present in larvae and are replaced by the higher resolution **compound eyes** in adults, ocelli are absent in larvae but may bepresent in adults.

Larva has both thoracic and abdominal legs, sometimes legs may be absent in larva, whereas adult has only thoracic legs. Larva undergoes moulting to enter in to pupal stage from which the adult insect emerges. Wings develop internally duringthe pupal stage and hence, they are called **Endoptreygotes.** Complete metamorphosis occurs in endopterygotes.

4. 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. eg.in blister beetle (Meloidae; Coleoptera), the first larval instar is **campodeiform** followed by **scarabeiform** larval type.

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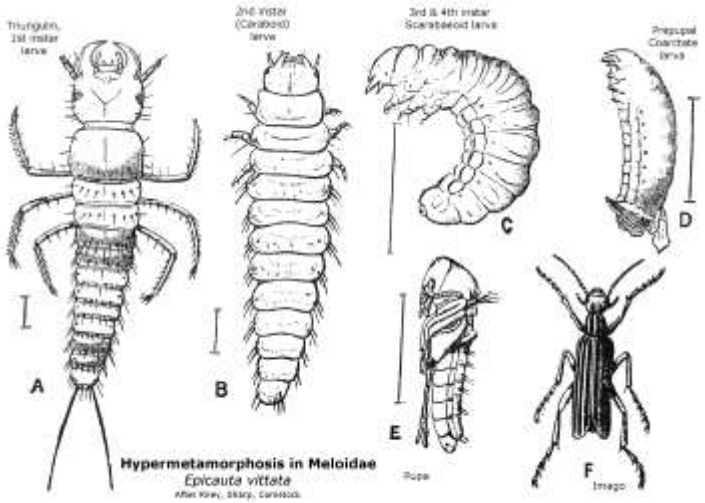
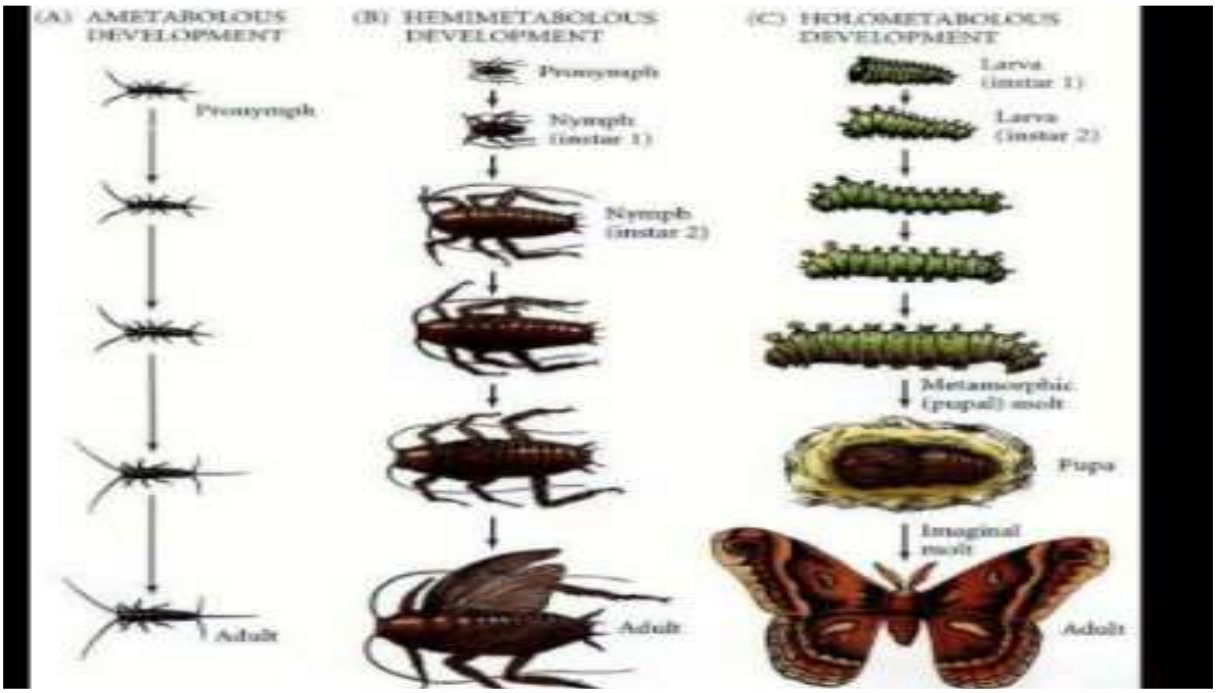

Triungulin, 1st instar larva
2nd instar (Carabiform) larva
3rd & 4th instar Scarabaeoid larva
Prepupal Coarctate larva
A
B
C
D
E
F
Pupa
Imago
Hypermetamorphosis in Meloidae
Epicauta vittata


(A) AMETABOLOUS DEVELOPMENT
Prenymph
Adult
(B) HEMIMETABOLOUS DEVELOPMENT
Prenymph
Nymph (instar 1)
Nymph (instar 2)
Adult
(C) HOLOMETABOLOUS DEVELOPMENT
Larva (instar 1)
Larva (instar 2)
Metamorphic (pupal) molt
Pupa
Imaginal molt
Adult

Differences between larva and nymph

Larva	**Nymph**
It is an immature stage of endopterygotes	Immature stage of exopterygotes
It undergoes holometamorphosis	It undergoes hemimetamorphosis
Body is vermiform which differs from the adult both in structure and feeding habits	Body resembles the adult in all the characters except wings
Consists of ocelli and reduced antennae	Have compound eyes and antennae
Possess both thoracic and abdominal legs	Possess only thoracic legs.
The larva is different from adult in feeding habits and behaviour	Nymph resembles the adult in feeding habits and behavior
The larva enters pupal stage	No pupal stage
Eg: Lepidoptera, Coleoptera	Hemiptera, Orthoptera

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 O2consumption, low body weight, low body water content and vitamin deficiency in theblood. Diapause may occur in **egg, larva, nymph, pupa** or **adult** stage.For example: **Egg diapause** – *Bombyx* mori; **Larval diapause**- *Euproctis* sp., *Pectinophoragossypiella*; **Pupal diapause**- Red hairy Caterpillar (*Amsactaalbistriga*) and **Adult diapause**- Mango nut weevil (*Sternochaetusmangiferae*)

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 unfavorable conditions and with the onset of favorable condition, the insect regains its original activity.

e.g. Cotton pink bollworm *Pectinophora gossypiella*.The un- favorable conditions may be biotic or abiotic. Biotic conditions are natural enemies, population density etc. Whereas abiotic conditions are temperature, rainfall, humidity, photoperiod, type of food material etc.The occurrence of diapause during summer due to high temperatures is known as**"aestivation**" whereas the period of inactivity during winter due to low temperaturesknown as "**hibernation**".