Metamorphosis in Insects

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Followings are the objectives of the lecture:

What is Metamorphosis in insects?

What are the advantages and disadvantages of larval forms?

What are the types of metamorphosis in insects?

How metamorphosis is controlled by hormones in insects?

What is Metamorphosis?

There are two types of development:

1. **Direct Development:** In direct development, the embryo develops directly into a mature individual without intermediate larval stage. There is no need of metamorphosis.

Example: Reptiles, Birds, Mammals.

2. **Indirect Development:** The egg hatches into a larval stage which is different from adults. The larva is sexually immature and undergoes drastic changes to transform into adult.

Example: Insects, Echinoderms, Amphibia.

Now the question arises why some animals undergoes direct development and some indirect development.

Direct development:
The animals with microlecithal eggs (mammals) develop by forming a placenta and get the nutrition directly from the maternal tissues hence they develop into the fully grown miniature of the adult. In case of megalecithal eggs (reptiles, birds) sufficient amount of nutrition is available as yolk for the complete development thus no intermediate larval forms appear.

Indirect development:
The animals with mesolecithal eggs have the yolk or nutritive material for growth but not sufficient for the development of fully grown adult. Hence they form an intermediate stage i.e. larva which then feeds and gradually transforms into the adult one.

Metamorphosis: In case of indirect development the transformation of immature larval forms to mature adult is termed as metamorphosis.

If the immature larval forms are similar in structure to adult, it undergoes incomplete metamorphosis where the larva grows and develops wings and genitalia.

If the larval forms are completely different in appearance, and structure to adult form, it undergoes complete metamorphosis. In this case the last larval stage stop feeding and converts to resting pupal stage which finally convert to adult.

Molting: It is the process refers to cast off the exoskeleton during insect development.
Insects are covered by hardened exoskeleton which provide protection and also restrict growth. During metamorphosis when the larval forms grow in size, it needs to remove its existing exoskeleton for growth of larger one. Thus this process to shed of the old exoskeleton and development of new larger exoskeleton is termed as molting.

What are the advantages and disadvantages of larval forms?

In most of the insects immature larval forms occurs in their life cycle.
Larval forms have certain advantage as well as disadvantage:

1. In some insects larval forms help in dispersion and nutrition.
2. It feeds and store food for the transformation into adult.
3. In insects where larval forms are complete different in habitat, structure and appearance, it avoids competition between young ones and adults.

Thus the occurrence of larval forms have certain evolutionary significance. In certain forms larva has different habitats to predators thus can survive. Also the juvenile and adult form can live in the same environment without competition.

Besides these, larval forms are disadvantageous also as dispersal to unfavourable habitat, greater susceptibility to environmental changes, sometimes fail to undergoes metamorphosis due to absence of certain chemical factors.

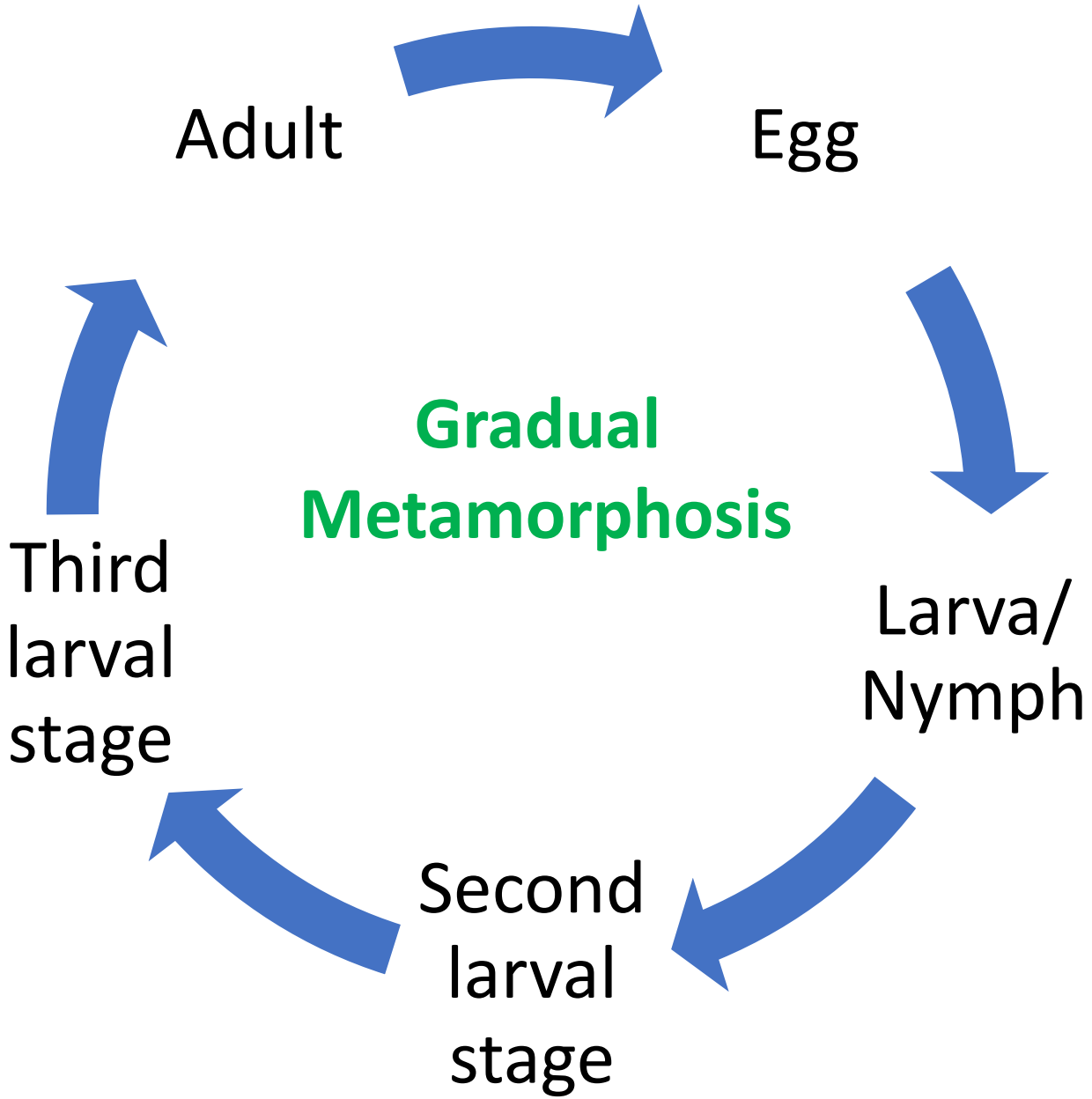
What are the types of metamorphosis in insects?

On the basis of insect development, there are two main types of metamorphosis in insects.

1. Gradual metamorphosis (Hemimetabolous):

Also termed as incomplete metamorphosis.
In this type of metamorphosis there are three stage viz; egg, nymph (larva) and adult.
The nymph or larva is the immature stage which resemble the adult in all body forms except wings and genital structure.
Egg hatches into larva or nymph which are similar in body forms as mouth parts, eye to the adult.
The habitat, food and behaviour of the nymph are similar to the adult. (in some insects as dragonfly the habitat of the nymph is different from the adult)
These larva or nymph develop gradually and moults into the next larval stage.
In the final stage of metamorphosis the adult structures develop.

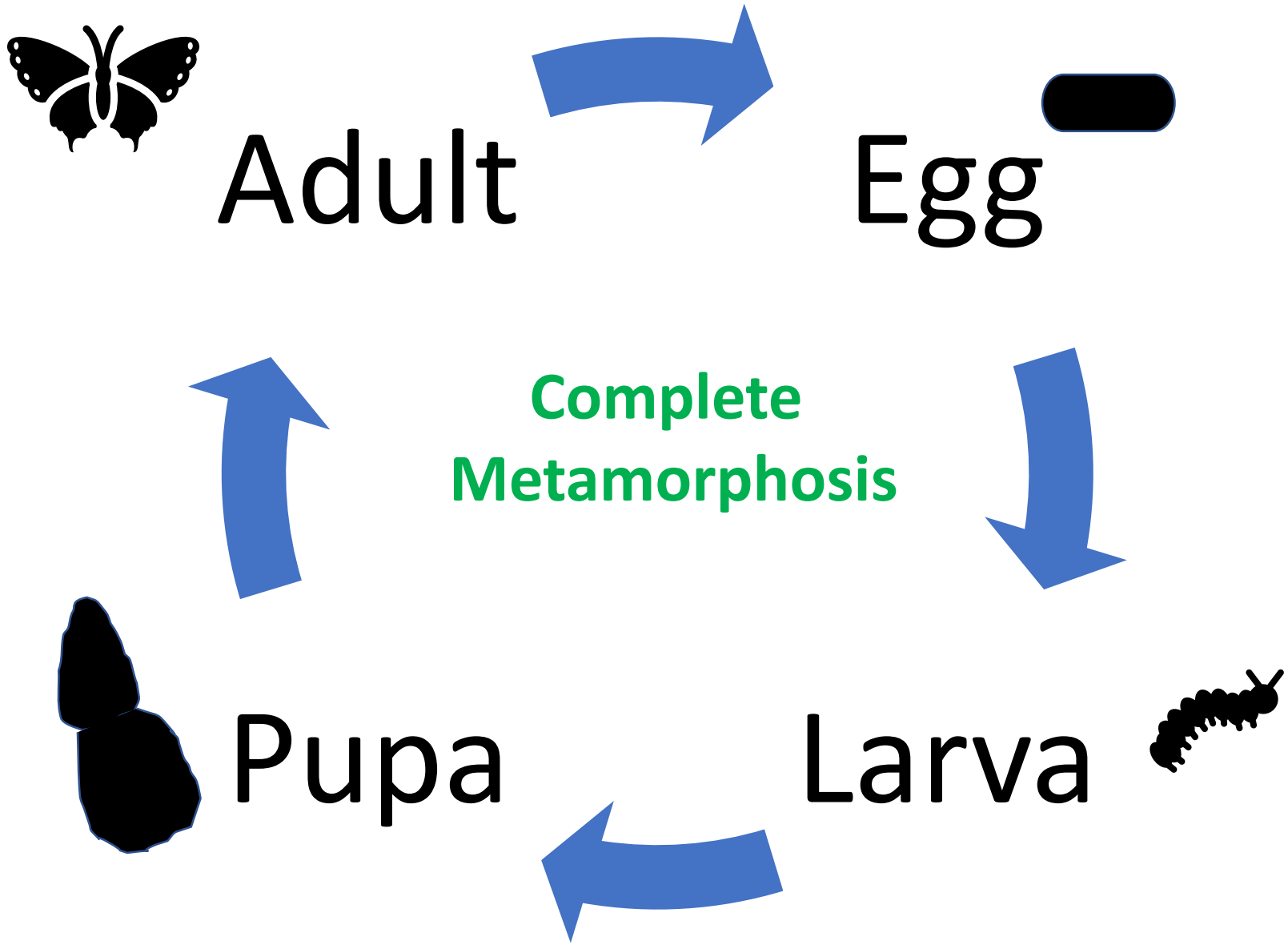
Example: Cockroach, grasshopper, termites, dragonflies etc.


Adult
Egg
Larva/
Nymph
Second
larval
stage
Third
larval
stage
Gradual
Metamorphosis

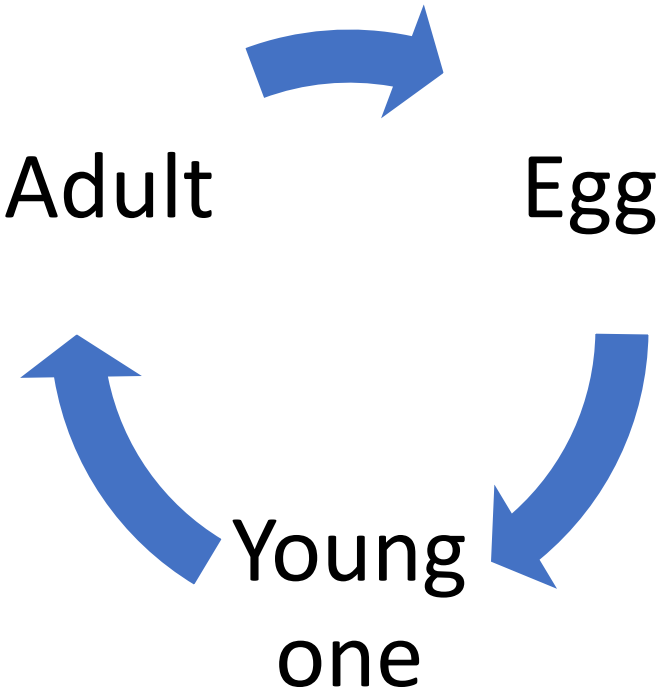
2. **Complete metamorphosis (Holometabolous):**

In this type of metamorphosis there are four life stages viz; egg, larva, pupa and adult.
The egg hatches into the larva which is active juvenile and immature form. It feed voraciously, grow and moult several times into next larval stage.
These larva are totally different in appearance, structure, body forms, mouth parts to the adult.
The habitat, food and behaviours are different from the adult.
Under hormonal control, the larva changes into the resting stage i.e. pupa.
Pupa is a quiescent stage which is surrounded by cocoon.
Inside pupa wings and genital structures develop and it reorganize into adult form.
This type of metamorphosis is called complete as the larval forms are completely different from the adult and undergo several changes.

Example: Butterfly (caterpillar larva), housefly (maggot larva) etc.


Adult
Egg
Larva
Pupa
Complete
Metamorphosis

In case of apterygote insects (insects without wings) like silver fish there is no metamorphosis hence these types of insects are termed as ametabolous.
In these insects the egg hatches into the young ones which are complete similar to the adult (tiny version) except their size. These young ones grow gradually to the adult forms.

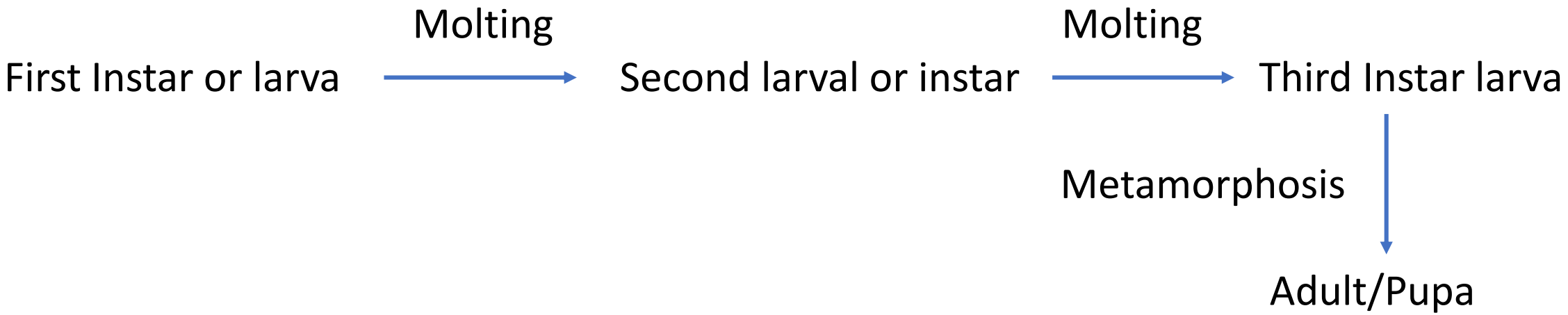


No Metamorphosis

How metamorphosis is controlled by hormones in insects?

During metamorphosis two events occur

1. Molting which results in the larval stage to next larval or instar stage.
2. Metamorphosis: In the final stage the last larval or instar changes to pupa (holometabolous) or adult (Hemimetabolous)



Metamorphosis in insects controlled by the neurohormones released from the brain.
Two effector hormones, the steroid **20-hydroxyecdysone** and the lipid **juvenile hormone** (**JH**) regulate the insect metamorphosis and molting.

1. Ecdysone (molting hormone):

- Released from prothoracic glands.
- Steroid in nature.
- Initiate and coordinate molting.
- Regulates the gene expression required during metamorphosis.

2. Juvenile hormone:

- Released from corpora allata.
- Lipid in nature.
- This hormone ensures that molting results into next larval stage. It means Juvenile hormone inhibits the expression of genes that promote the development of adult structures.

Mechanism of molting and metamorphosis:

When the larval stage grow sufficient and require the larger exoskeleton, the older exoskeleton needs to shed off.

The neurosecretory cells in the brain release brain hormone which in turn stimulates corpora cardiaca to release their store PTTH (prothoracicotropic hormone). PTTH then trigger the prothoracic gland to release ecdysone hormone.

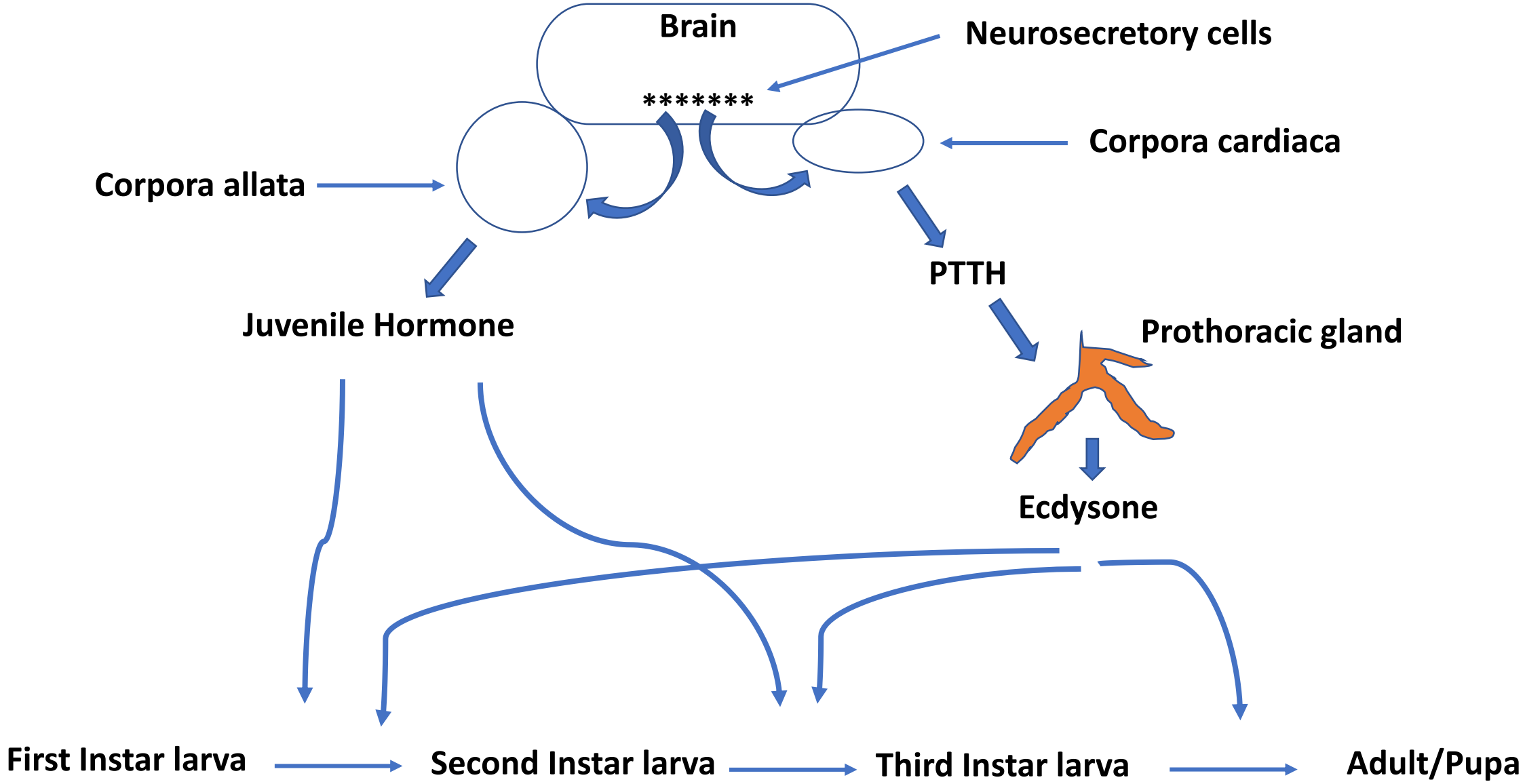
The ecdysone hormone becomes active in the molting hormone 20-hydroxyecdysone in the peripheral tissues.

20-hydroxyecdysone hormone initiate the molting process.
This hormone also induce the gene expression that are required for the formation of adult structure like wings, genital structures etc.

In immature stage i.e. larval stage another hormone, Juvenile hormone (JH) is secreted by corpora alllata.

Juvenile hormone regulates the molting process by preventing the ecdysone mediated gene expression that are required for metamorphosis (development of adult structure). Juvenile hormone confers that molting result in next larval stage which is also an immature stage.

In the final stage of molting i.e. metamorphosis, the secretory cells of corpora allata becomes inactive and the level of JH falls thus the ecdysone induced metamorphic gene expression can not be inhibited and the final larval or instar stage changes into adult or pupal stage.



Control of metamorphosis in Insects

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THANK YOU