E-CONTENT PREPARED BY

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E-Content prepared for students of

M.Sc.(Semester-IV) in Conservation Biology

Name of Course:
Forest Wealth (Major Elective)

Topic of the E-Content:
Insect Metamorphosis

METAMORPHOSIS IN INSECTS

Endocrine cells, specially neurosecretory cells have been identified in all invertebrates. Most insects fall into two groups—

(i) Holometabolous insects: The egg develops into a larvea (maggot, caterpillar), which grows through several instars. The last larval stage moults to become a pupa, an outwardly dormant stage in which extensive internal re-organization takes place to give rise to the adult form. Eg. Diptera (flies), Lepidoptera (butterflies & moths) and Coleoptera (Beetles).

(ii) Hemimetabolous insects: Egg develops into a immature nymphal stage. The nymph eats & grows & undergoes several ecdyses. The final nymphal instar gives rise to an adult stage. Eg Hemiptera (Bugs), Orthoptera (locusts, crickets) & Dictyptera (Cockroaches & mantids)

The first experiments demonstrating endocrine control of insect development were done between 1917 & 1922 by S. Kopec

INSECT DEVELOPMENT ENDOCRINE GLANDS:

(a) Pars intercerebralis which has special neurosecretory cells, & is a part of the brain. It secretes Prothoracicotropic Hormone (PTTH).

(b) Corpora allata is a neuro hormonal organ that is structurally similar to vertebrate adenohypophysis. It secretes Juvenile Hormone (JH).

(c) Prothoracic Glands are situated near the oesophagus & are responsible for secreting moulting hormone i.e Ecdysone

ENDOCRINE HORMONES FOR INSECT DEVELOPMENT:

	Hormone	Tissue of Origin	Structure	Target Tissue	Primary Action	Regulation
1	BURSICON	Neurosecretory cells in brain & nerve cord.	Protein. MW ~ 40,000	Epidermis	Promotes cuticle development; induces tanning of cuticle of newly moulted adult.	Stimuli associated with molting stimulate secretion.
2	Ecdysone (Moulting Hormone)	Prothoracic glands. Ovarian follicles	Steroid	Epidermis. Fat Body. Imaginal Disc	Increases synthesis of RNA, protein, mitochondria & ER; promotes secretion of new cuticle.	PTTH stimulates secretion
3	Eclosion Hormone	Neurosecretory cells in brain.	Peptide	Nervous system	Induces emergence of adult from puparium	Endogenous "CLOCK"
4	Juvenile Hormone (JH)	Corpus allatum	Fatty acid derivative	Epidermis, Ovarian follicles, sex accessory glands, fat body.	In larva, promotes synthesis of larval structures & inhibits metamorphosis; In adult, stimulates synthesis of yolk protein; activates ovarian follicles & sex accessory glands	Inhibitory & Stimulatory factors from the brain control secretion
5	Prothoracicotropin (PTTH)	Neurosecretory cells in brain	Small Protein (MW ~ 5000)	Prothoracic Gland.	Stimulates ecdysone release	Various environmental & internal cues (eg photoperiod, temp, crowding, abdominal stretch); JH inhibits release in some species

…on, but acts as the storage for Eclosion hormone & Bursicon that are secreted by neurosecretory cells of brain.

* Prothoracic gland secrete a pro-hormone α-ecdysone, that is converted to physiologically active 20-hydroxyecdysone or β-ecdysone, in target tissues.

METAMORPHOSIS : α-ecdysone → [Target cells] → β-ecdysone

(i) During growth & development, the epidermis undergoes conspicuous changes.
(ii) A chitinous horny covering develops over the epidermis - CUTICLE.
(iii) PTTH secreted from the brain stimulates the Prothoracic gland to release Ecdysone*
(iv) The old cuticle detaches from the underlying epidermis. This is called APOLYSIS.
(v) Ecdysone initiates formation of new cuticle from epidermis.
(vi) The old cuticle is slowly digested by enzymes present in moulting fluid.
(vii) If JH conc. is high in circulation a new larval cuticle is formed; whereas low JH conc. results in adult cuticle.
(viii) Eclosion hormone is related to terminal phases of metamorphosis. JH helps in shedding of cuticle in pupa resulting in emergence of adults.
(ix) The pale soft cuticle of newly moulted insect is expanded by respiratory movements of the insect to the next larger stage.
(x) The cuticle is hardened under the effect of Bursicon.

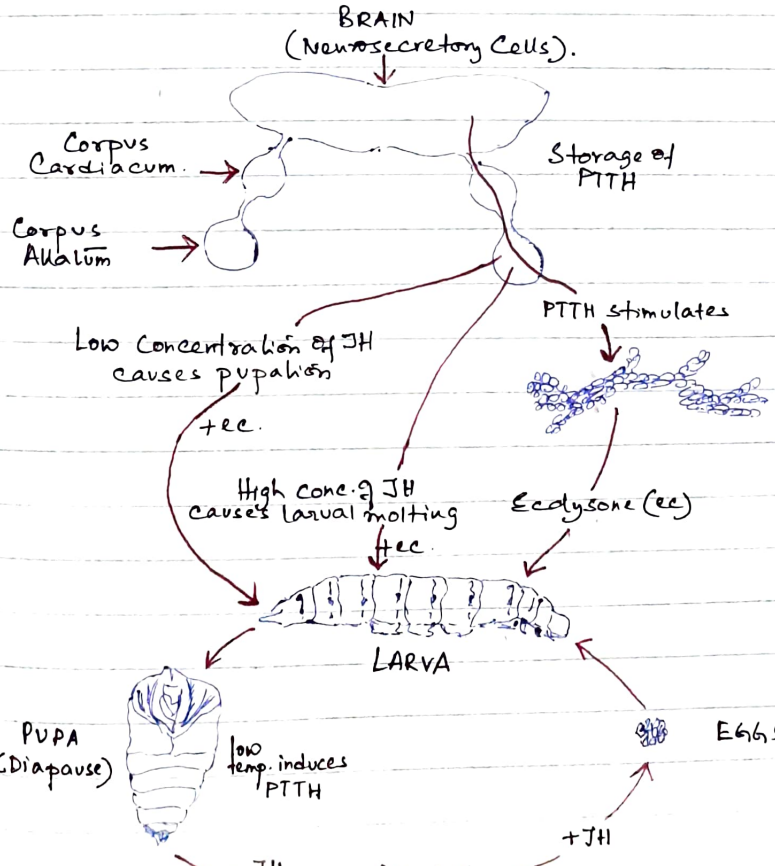

Fig1: Interaction of JH & Ecdysone regulate metamorphosis in holometabolous insects. → cecropia moth (Hyalophora cecropia) {Adapted from Sprath 1971}

Fig 2: The tobacco hornworm (*Manduca sexta*) molts in response to the molting hormone, ecdysone. Whether the molt results in another larva, a pupa or an adult is determined during a relatively short critical period of a day or two. If JH is present above threshold level, the larva molts into a larger, but otherwise a similar larva. If JH has fallen below threshold level before Critical Period (Sensitive Period), the next molt results in a pupa. In constant absence of JH, development progresses to the next stage & an adult emerges.

[H F Nijhout, based on Nijhout & Wheeler, 1982]