Insect Endocrine System

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Primary Function of Hormones

- Homeostasis
- Growth and Development
- Reproduction
- Energy Metabolism
- Behavior

Endocrine system

- Nervous system regulate all physiological requirements of an insect including growth, reproduction, and protein formation throw the endocrine system via hormones.
- Hormones complement the nervous system, which provides short term coordination, and the activities of both systems are closely linked.

- Hormones:

Chemical substances that are transported in the insect's body fluids (haemolymph) that carry messages away from their point of synthesis to sites that where physiological, behavioural and developmental processes are influenced.

- The endocrine organs of insects are of two types (most of which are within the central nervous system):

1- Specialized endocrine glands

2- Neurosecretory cells

Endocrine glands
1- Glands producing ecdysteroids

- In the immature stages of all insects, molting hormones are produced by the prothoracic glands.
- In females, where the same hormones are produced to regulate embryonic development, the follicle cells in the ovary are the principal source.
- It may also produced in the abdomen of some insects.

Prothoracic glands

- Diffuse, paired glands located at the back of the head or in the thorax.
- These glands secrete an ecdysteroid called ecdysone, or the moulting hormone, which initiates the epidermal moulting process.
- Additionally it plays a role in accessory reproductive glands in the female, differentiation of ovarioles and in the process of egg production.

Corpora allata

- Small, paired glandular bodies usually one on either side of the oesophagus.
- They produce the juvenile hormone, which regulate metamorphosis and yolk synthesis and deposition in the oocytes of adults.

Corpora cardiaca

- A pair of neuroglandular bodies that are found behind the brain and on either sides of the aorta.
- The corpora cardiaca store and release hormones from the neurosecretory cells of the brain, to which they are connected by one or two pairs of nerves.

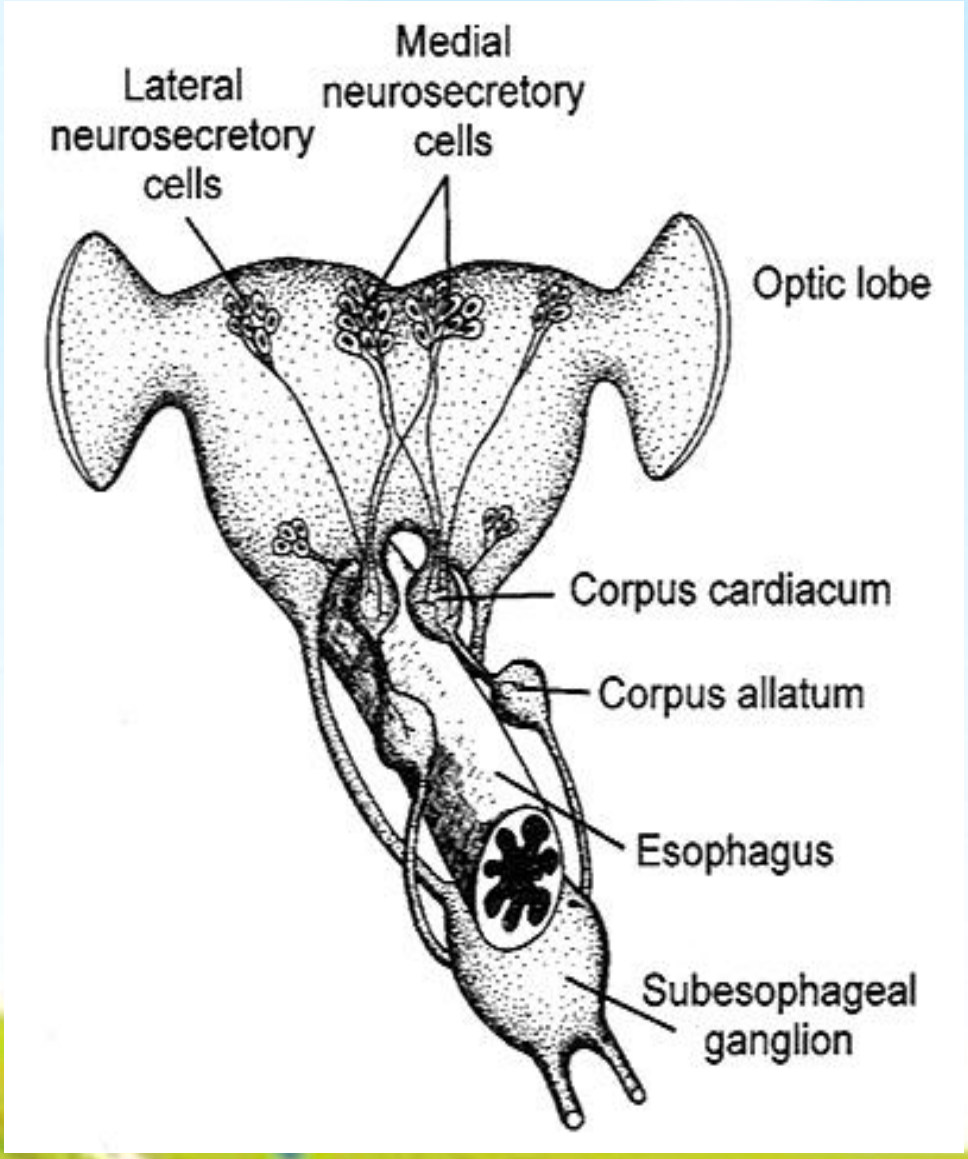
Endocrine cells of the midgut

- These are isolated cells scattered a amongst the principal midgut cells.
- They secrete some peptides which have a hormonal function relating to digestion and absorption, perhaps regulating the synthesis of digestive enzymes and post-feeding dieresis.
- Other cells may have different functions, perhaps including the regulation of gut motility.

2- Neurosecretory cells

- Occur in the ganglia of the central nervous system.
- These cells secret hormones that may affect growth, reproduction, homeostasis and metamorphosis.
- In the brain, two main groups of neurosecretory cells on each side.
- The secretions of neurosecretory cells are usually neruopeptides.

- The most common hormones that are secreted by these cells are:
  - **Ecdysiotropin** (Protocerebrum secretes ecdysiotropin or prothoracicotropic hormone (PTTH) or brain hormone (BH) that acts on ecdysial glands)
  - **Bursicon** (Tanning hormone): triggers the tanning or darkening of adult cuticle
  - **Eclosion** hormone: It is stored in the corpora cardiaca and is released into the blood at the time of switchover from pupal to adult stage initiate the pre-eclosion behavior.


Medial
neurosecretory
cells
Lateral
neurosecretory
cells
Optic lobe
Corpus cardiacum
Corpus allatum
Esophagus
Subesophageal
ganglion

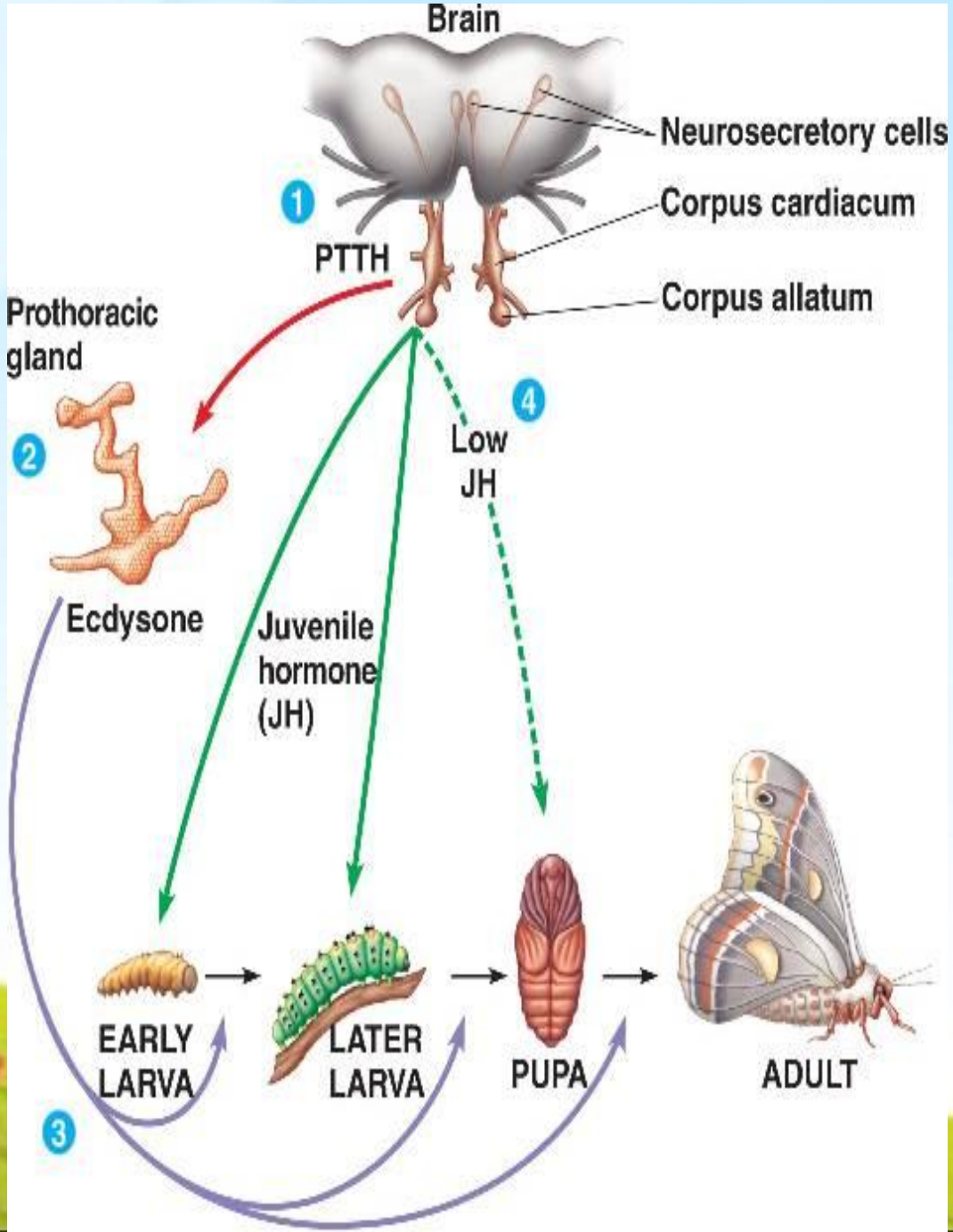

Brain
Neurosecretory cells
Corpus cardiacum
Corpus allatum
1
PTTH
Prothoracic gland
2
Ecdysone
4
Low JH
Juvenile hormone (JH)
EARLY LARVA
LATER LARVA
PUPA
ADULT
3

Table 7.21 : A selected list of Insect nonneural, neural and peptide hormones

Active Principle	Origin	Target	Functional Role
I. Nonneural hormones			
A. Immature insects			
Ecdysone (moulting hormone)	ecdysial gland	epidermis	initiates moult
Juvenile hormone	corpora allata	epidermis	controls or directs facets metamorphosis of male
B. Adult insects			
Ovarian hormone (= ecdysone)	ovarian tissue and probably follicle cells	fat body	initiates and regulates production of vitellogenin
Juvenile hormone	corpora allata	fat body	primes the fat body to become competent to produce vitellogenin
Juvenile hormone	corpora allata	follicle cells	activates uptake of vitellogenin in follicle cells
II. Neural hormones and peptide hormones			
Ecdysiotropin (= prothoracicotropic hormone)	brain (protocerebrum)	ecdysial glands	developmental–stimulus and regulates production and release of ecdysone
Bursicon	MNSC and thoracicoabdominal ganglion, brain of pre-ecdysis moths	epidermis	developmental–stimulus sclerotisation and melanisation of cuticle
Eclosion hormone		abdominal ganglia (possibly the epitracheal glands,	behavioural–synchronisation of eclosion
Allatostatins	brain	corpora allata	developmental/behaviour and homeostasis–inhibit JH production
Allatotropin	brain	corpora allata	developmental/behavioural and homeostasis–stimulates JH production and release
Diuretic hormone	brain/corpora cardiaca and thoracic ganglia	Malpighian tubules and rectum	homeostasis—controls diuresis or fluid secretion
Mating inhibition hormone	accessory reproductive glands of male	brain	behavioural—prevents remating
Oviposition initiation hormone	accessory reproductive glands of male	oviduct ?	behavioural—initiates egg laying
Cardioaccelerator hormone	brain/corpora cardiaca	myocardium	homeostasis—increase in frequency and amploid of muscle contraction
Proctolin	brain/corpora cardiaca	hindgut and possibly visceral muscle in general (heart and oviduct)	homeostasis—muscle contraction, defecation, egg-laying, ...

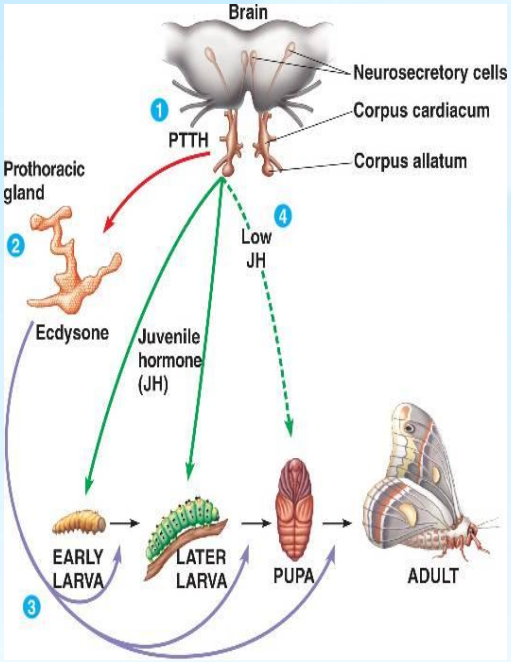
Endocrine Control of Growth and Metamorphosis

- Upon emergence from the egg, the immature insects gradually increase in size to reach adults through some mechanisms called moulting.
- Moulting involves the periodic digestion of old cuticle, secretion of new cuticle (usually with larger surface area than the older one) and shedding of undigested old cuticle.
- shedding of undigested old cuticle- is commonly referred to as ecdysis

- Each developmental stage of the insect itself is called an instar, and the interval of time passed in that instar is referred to as stadium.
- The whole developmental process by which the first instar immature stage of an insect is transformed into the adult insect is called metamorphosis
- Hormones required: Brain hormone, Ecdysone, Juvenile hormone.

- **Brain hormone (prothoracicotropic hormone (PTTH))**:

- Protocerebrum secretes brain hormone (BH) or prothoracicotropic hormone (PTTH) or ecdysiotropin which accumulate in the carpora allata and subsequently released into the haemolymph (except in Lepidoptera, in other insects BH is stored in corpora cardiaca). Through the haemolymph, PTTH reach to prothoracic gland and stimulate its secretory activity
- The prothoracic glands secrete α-ecdysone or moulting hormone (MH) which through haemolymph reach the target (epidermis)



- which initiates the growth and moulting activities of the cells.
- Ecdysone fovours the development of adult structures and favours the moulting processes that terminate into successive larval instars
- The corpora allata secrete juvenile hormone (JH), which promote larval development and inhibit development of adult characteristics
- In fact, JH interacts with MH to stimulate larval maturation during each stage of development. The concentration of JH evidently decreases toward the end of a larval instar, allowing the ecdysone to cause moulting.

- The total picture here should be one of balanced interaction-synergism—between these two hormones to induce normal growth and differentiation, rather than a simple antagonism.
- During the last immature instar, two separate and distinct peaks of ecdysone are present in both the holometabola and hemimetabola. The first one is low and in absence of JH, the epidermal cells are reprogrammed from larval to pupal commitment in holometabolous insects, and from nymphal to adult stage in hemimetabolous insects.

Eclosion

- Eclosion hormone or EH is released from brain by a circadian clock and declining ecdysteroid titers. If ecdysone titer is artificially kept high, the release of eclosion and its activity are inhibited.
- This hormone influences many aspects of pupal-adult ecdysis, including the behavior associated with ecdysis and subsequent degeneration of abdominal inter-segmental muscles used in the act of ecdysis

Ecdysis triggering hormone

- It is the most recent hormone discovered that plays an important role in ecdysis. This 26 amino acid peptide hormone is synthesised by the epitracheal glands that are located segmentally in larvae, pupae and adults of *Manduca sexta*. According to Zitnan (1996), this hormone may act upstream from the eclosion hormone in a series of cascade events leading to ecdysis.

Bursicon (Tanning hormone)

- Bursicon, commonly found in neurohaemal organs associated with the ventral chain ganglia is suggested to stimulate tanning and sclerotisation of the cuticle following ecdysis.

Hormonal control of reproduction

- Like other higher multicellular organisms, reproduction in insects is a complex process.
- Different stages of reproduction, starting from the production of male and female gametes to oviposition, are seem to be influenced by several hormones.

Spermatogenesis

- Ecdysone controls the permeability of the testis walls to the humoral factor differentiating the spermatocytes.
- Juvenile hormone is shown to have some inhibitory effects on spermatogenesis in many insects.

➢Oogenesis

- Hormones from corpora allata help in egg maturation through the incorporation of yolk into the oocyte.
- In addition to secretions from brain cells and corpora allata, ecdysone has been found to be involved in control of oogenesis in female mosquitoes. Following a blood meal, lateral neurosecretory cells secrete egg development neurosecretory hormone, which in turn, induces the ovary to secrete ecdysone. Ecdysone, in turn triggers the synthesis of yolk protein vitellogenin in the fat bodies.
- Juvenile hormones secreted by corpora allata also activate fat body and ovaries.

➢Fertilization

- In many insects studied, ovulation (the passage of egg from the ovary into the oviduct) and oviposition, (passage of fertilized eggs to the outside, are closely linked. Both these events are affected by some peptides secreted by female accessory glands and neurosecretory products of brain.
- The process of reproduction involves both the nervous and endocrine systems. The major centers are the neurosecretory cells of brain and the major events are the secretion of juvenile hormone by corpora allata, and either ecdysone production by ecdysial gland in immature insects or ecdysone biosynthesis by the ovary in adult insects. Both hormones act either independently or together in association with nervous system to make reproduction success.

➢Vitellogenesis

- Vetellogenesis or egg yolk synthesis is also known to depend on JH from the corpora allata. In mosquitoes, juvenile hormone is required for egg development only during the early previtellogenic stages of development of the follicles.

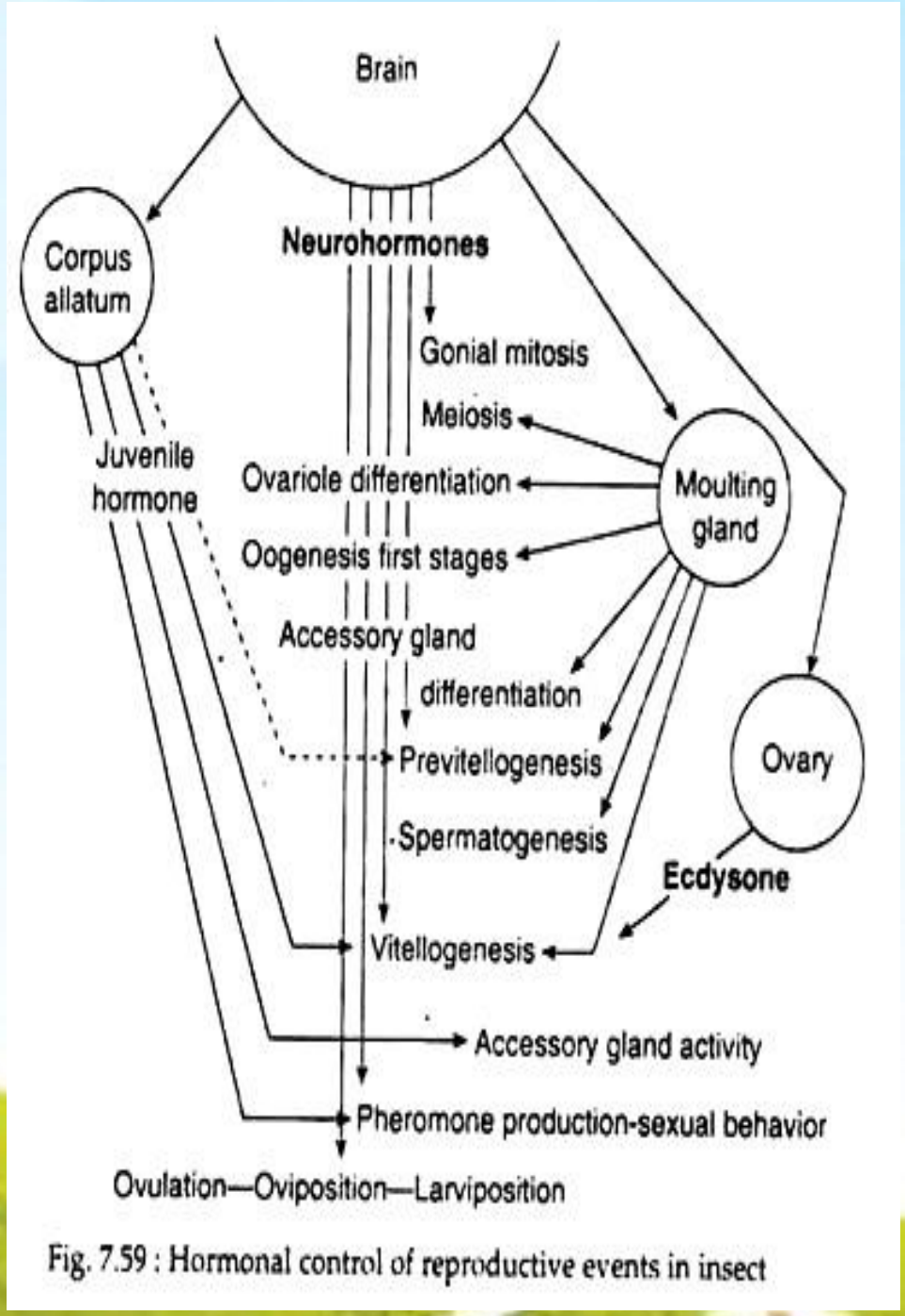
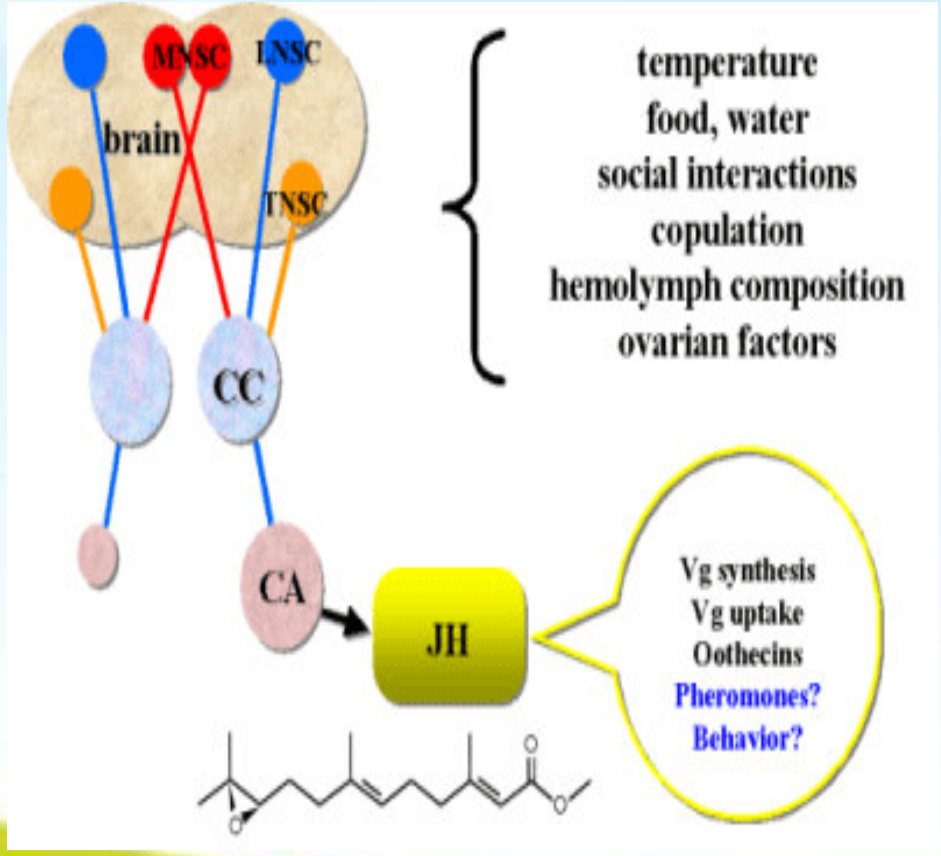


Fig. 7.59 : Hormonal control of reproductive events in insect

Endocrine System




Any questions?