Insect Endocrine System

Structure & function

Lec. 9

5/20/2024

The endocrine system Questions

- How are endocrine and exocrine glands similar and different in function?
- Why would an insect secrete chemicals to the outside world?
- What are the major endocrine glands?
- Which glands release JH, Ecdysone, and PTTH? Why are these hormones important?

The endocrine system

- System = glands and what they produce
- 2 classes of GLANDS
  - Both innervated by nervous system

EXOCRINE GLANDS

- Send chemicals/signals outside body

ENDOCRINE GLANDS

- Send chemicals/signals inside body

The endocrine system

EXOCRINE GLANDS

What would an insect excrete?

Semiochemicals: Chemical odors important in both **inter**specific and **intra**specific communication (both across and within species).

The endocrine system

EXOCRINE GLANDS

What would an insect excrete?

Allelochemicals: Chemical odors important to interspecific communication only.

The endocrine system

EXOCRINE GLANDS

Many chemicals released from the exocrine glands are **Semiochemicals.** Some examples include…

1) Defense chemicals/signals
   - venoms, alarm pheromones
   - Bombardier beetles

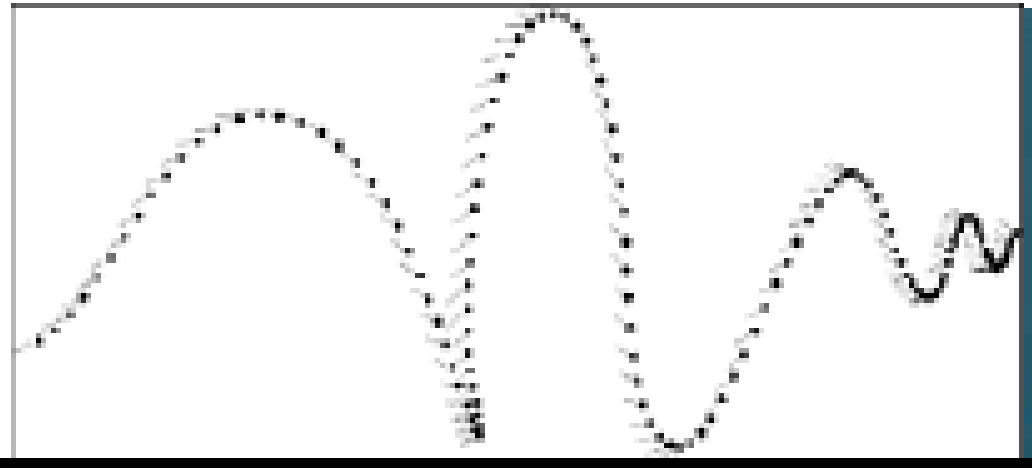
The endocrine system

EXOCRINE GLANDS

Many chemicals released from the exocrine glands are **Semiochemicals.** Some examples include…

2) Mate attraction chemicals/signals

- Sex Pheromones



The endocrine system

EXOCRINE GLANDS

Many chemicals released from the exocrine glands are **Semiochemicals.** Some examples include…

3) Trail-marking pheromones, aggregation pheromones

The endocrine system

ENDOCRINE GLANDS

- Can be one cell or clusters of cells
- No "ducts" and no association with epidermis
- A LOT more complex than exocrine system
- Cascading affects
- Complex combinations of hormones
- All endocrine functions started and regulated by nervous system!

The endocrine system

MAJOR ENDOCRINE GLANDS

CORPORA CARDIACA

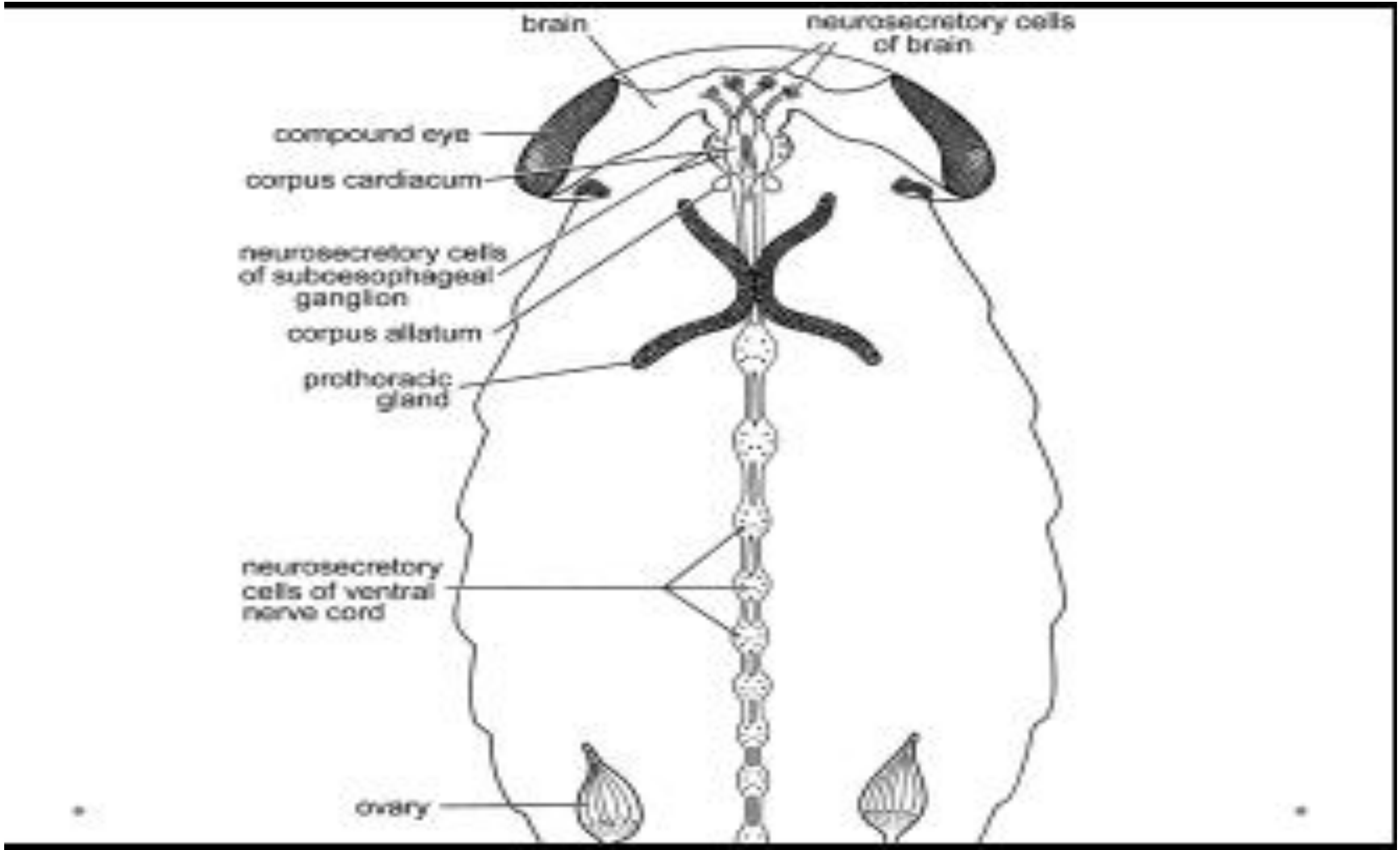
- Pair of glands behind brain
- Store and release NEUROHORMONES
- Major one: **PTTH** (prothoraciotropic hormones)

CORPORA ALLATA

- Smaller, secrete **JH** (Juvenile Hormone)

PROTHORACIC GLANDS

- Large glands in thorax
- Secrete **ECDYSONE** (molting hormone)


brain
neurosecretory cells of brain
compound eye
corpus cardiacum
neurosecretory cells of subœsophageal ganglion
corpus allatum
prothoracic gland
neurosecretory cells of ventral nerve cord
ovary

FUNCTIONS OF THE NEUROENDOCRINE SYSTEM

Along with the nervous system, hormones provide the necessary communication between all the cells that constitute a multicellular animal

Nervous system-Is involved in rapid transfer of short-term events and coordination of short-term events. Electrochemical information involving neurons.

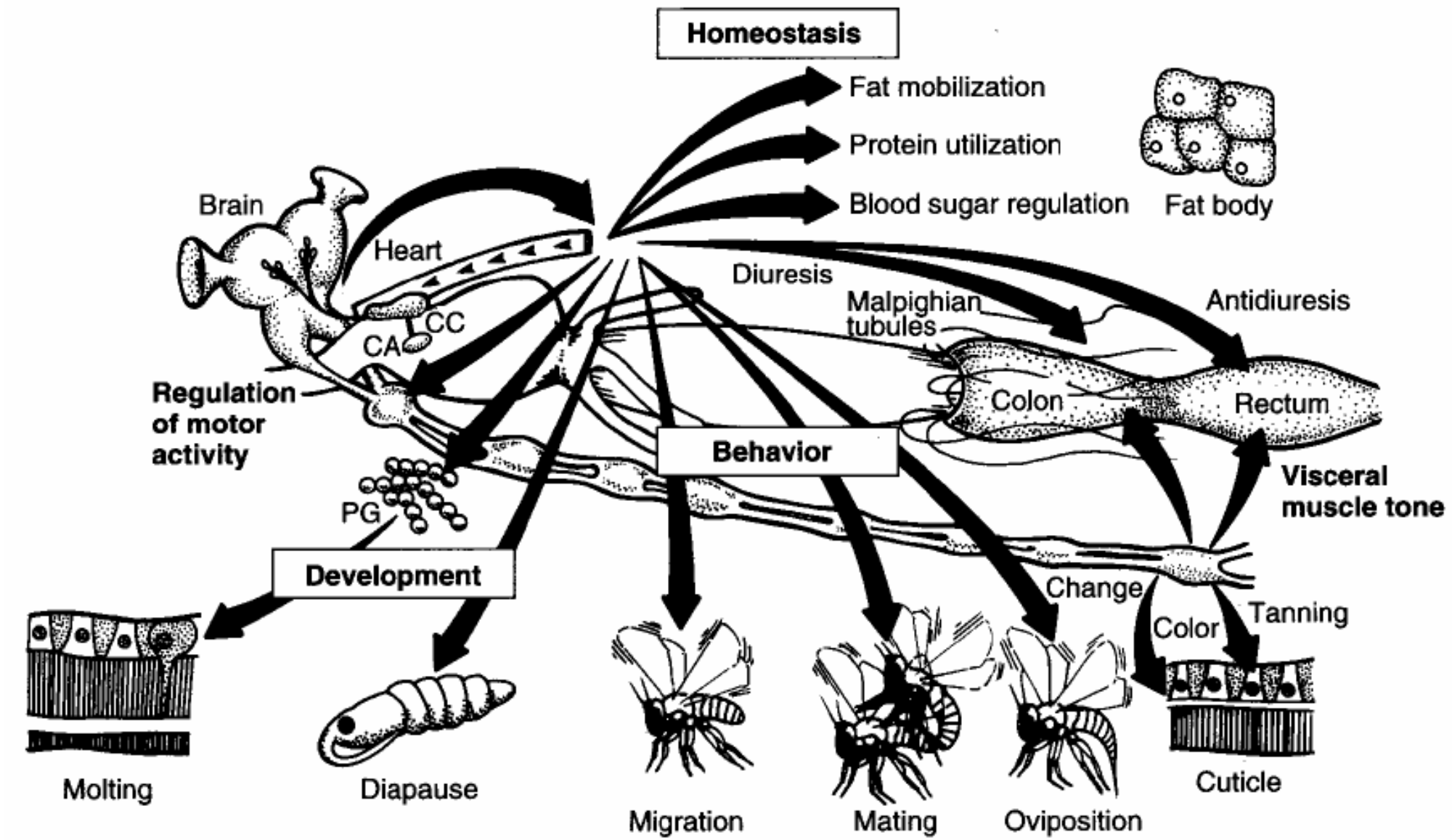
Neurosecretory cells-Neurons have electrical activity but involved in the production and release of neurosecretion that produces their effect as chemicals.

Endocrine system-Is involved in the integration and coordination of long-term events through chemicals called hormones.

Areas of insect biology that hormones play a major role

1. Regulation of molting
2. Determination of form at metamorphosis
3. Effects on polymorphism
4. Regulation of diapause
5. Involvement in reproduction
6. Regulation of metabolic activities and general body functions
7. Regulation of behavior
8. Regulation of preprogrammed cell death

Major physiological functions regulated by neurohormones



Insect endocrine glands & neurosecretory cells & location

Active Principle	Origin	Target	Role/function
I. Nonneural hormones			
A. Immature insects			
Ecdysone	ecdysial gland	epidermis	initiates molt
Juvenile hormone	corpora allata	epidermis	controls or directs fate of metamorphosis at molt
B. Adult insects			
Ovarian hormone (ecdysteroids)	ovarian tissue-follicle cells	fat body	initiates + regulates the production of vitello-genin (VG)
Juvenile hormone	corpora allata	fat body	primes fat body to become competent to produce vitellogenin

Insect endocrine glands & neurosecretory cells & location

Active Principle	Origin	Target	Role/function
Juvenile hormone	corpora allata	ARG's	affects development and production of glandular secretion
Juvenile hormone	corpora allata	follicle cells	activates patency and uptake of VG by the follicle cells

Insect endocrine glands & neurosecretory cells & location

Active Principle	Origin	Target	Role/function
II. Neural hormones and peptide hormones			
A. Ecdysiotropin (PTTH) (=prothoracicotropic hormone)	brain hormone protocerebrum	ecdysial glands	developmental-stimulates and regulates production and release of ecdysone
B. Bursicon	MNSC and thoracicoabd. ganglion of flies	epidermis	dev.-stimulates sclerotization and melanization of cuticle
C. Eclosion hormone	brain of pre-ecdysis moths	abdominal ganglion	behavior-synchron. of eclosion with photoperiod
D. Ecdysis-triggering	epitracheal glands (ventrolateral tracheal tube near each spiracle)	CNS (abdomin. ganglia)	Beh.-synchron. of eclosion
E. Allatostatins	Brain	corpora allata	dev./beh/homeostasis inhibits JH production
F. Allatotropin	Brain	corpora allata	dev./beh/homeostasis stimulates JH production
G. Diuretic hormone	brain/cc and thoracic ganglia	Malpig. Tubules	homeostasis-controls diuresis or fluid secretion

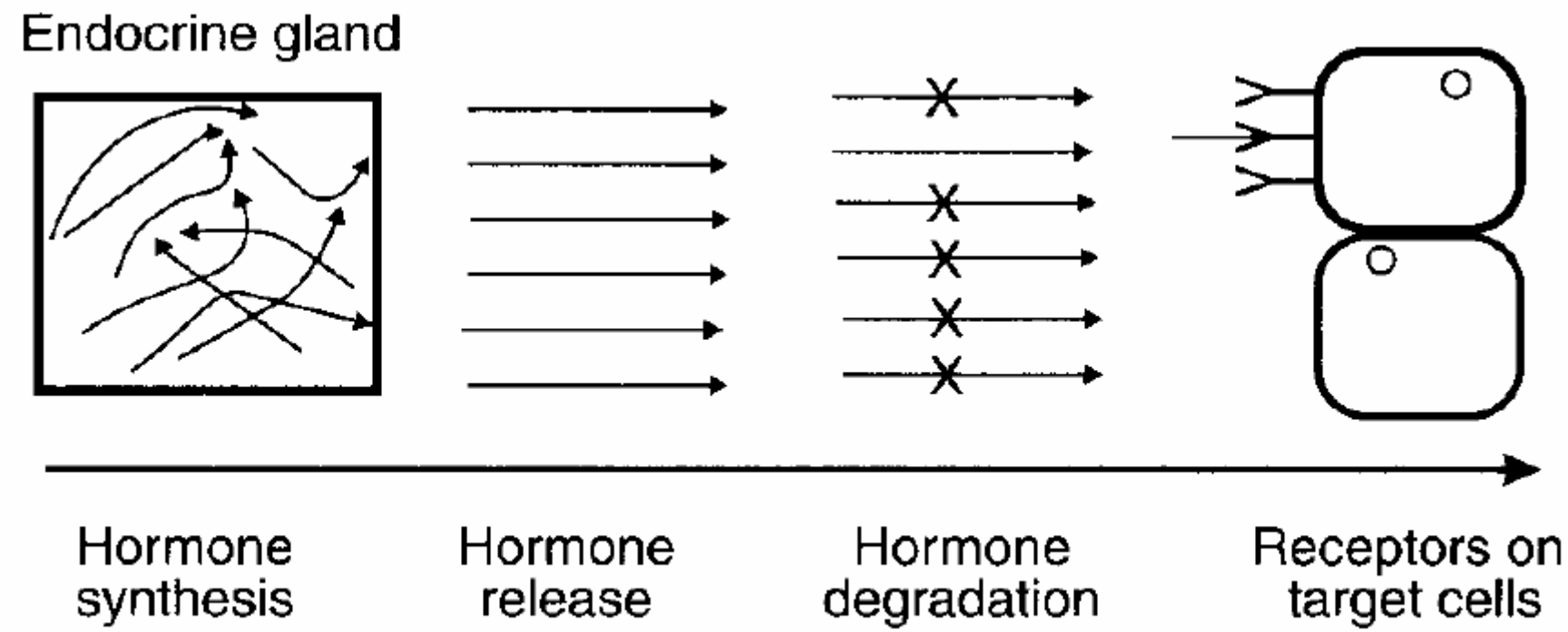
Insect endocrine glands & neurosecretory cells & location

Active Principle	Origin	Target	Role/function
H. Mating inhibition	ARG of male	female's brain	beh.-prevents remating
I. Oviposition initiation	ARG of male	oviduct?	beh.-initiations egg laying
J. Cardioacelerator	brain/CC	myocardium	Homeostatis-increase in freq. + amplitude of muscle contraction
K. Proctolin	brain/CC	hindgut and poss. Visceral muscle in general	homeo.-muscles contraction, defecation, egg-laying, + heartbeat
L. Dromyosuppresin	brain/CC	muscles of crop	inhibits muscle contract
M. Ovarian ecdysteroidogenic hormone (OEH) (also know as EDNH) (these may be similar to PTTH)	brain	ovaries	stimulate ovarian tissue to produce ecdysteroids

HORMONES-Chemicals produced in a gland that are released into the blood and have their effect somewhere else in the animal

Hormonal activity in the blood is influences by

1. **Hormone synthesis-The effective titer must be research to work**
2. **Hormone release**
3. **Hormone degradation**
4. **Receptors on the target cells-These change in number in**



LOCATION OF ENDOCRINE GLANDS IN DIFFERENT INSECTS

Not only does the location of the glands different in different insect orders but the hormones used for various functions may also vary.

Prothoracic glands------Produce ecdysone

Corpora allata----------Produces JH

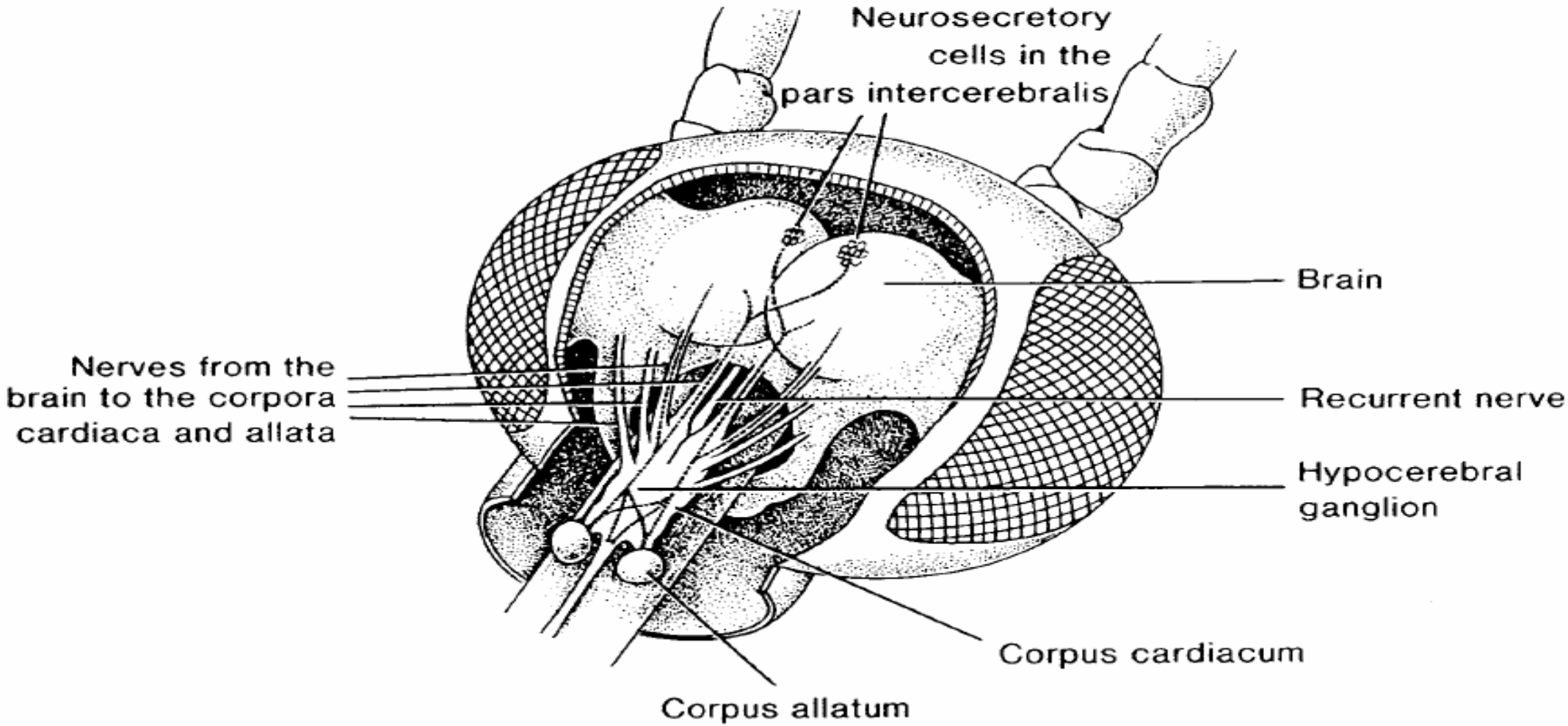
Corpora cardiaca-------Stores and releases brain hormones. Also produces and releases some peptides such as adipokinetic hormones

Midgut endocrine cells-Produce various peptides. Open + closed cell types.

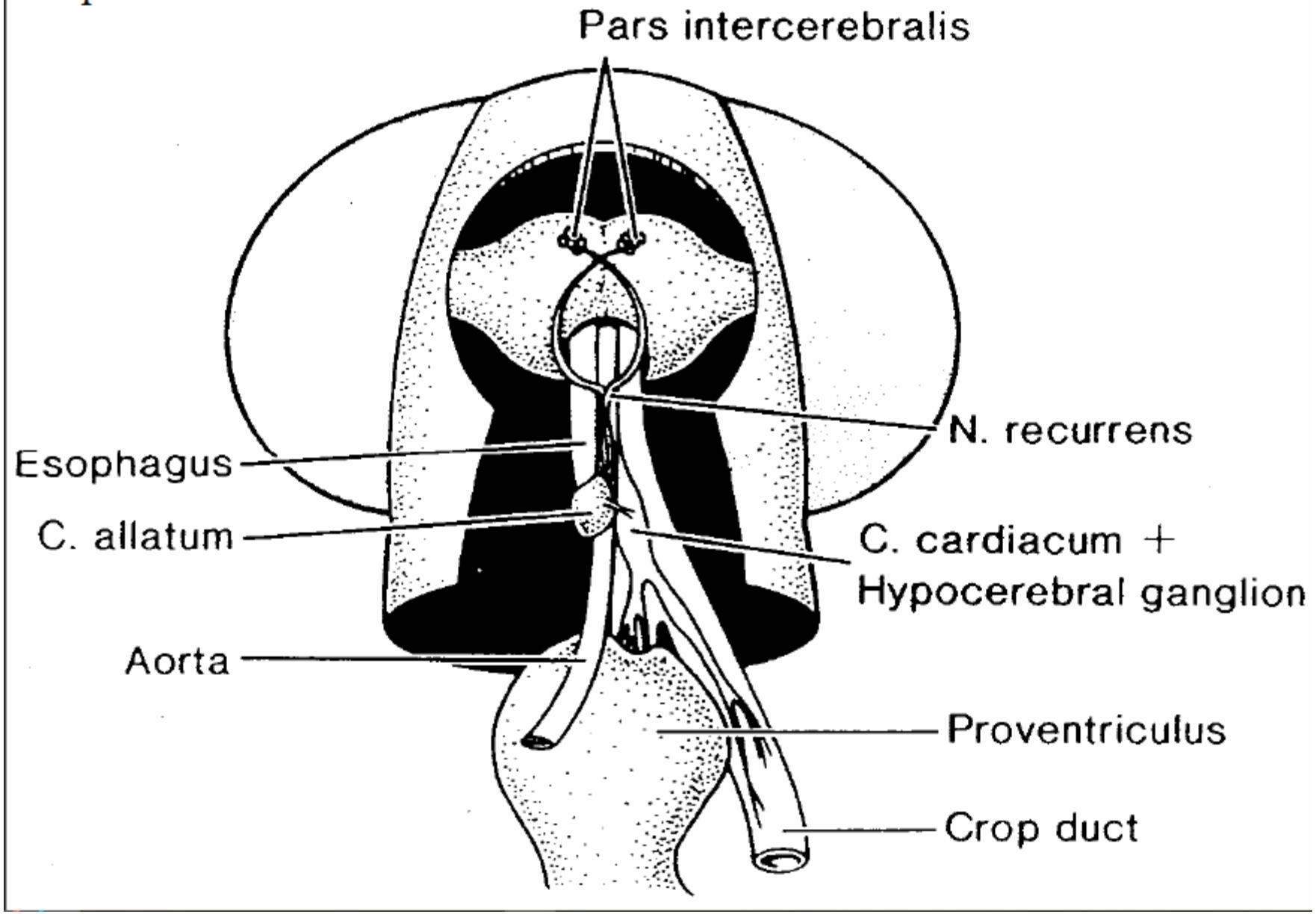
Epitracheal glands------Produce the ecdysis triggering hormone in Lepidoptera

Neurosecretory cells----Produce neurosecretion (peptides or biogenic amines); located in the various ganglia of CNS

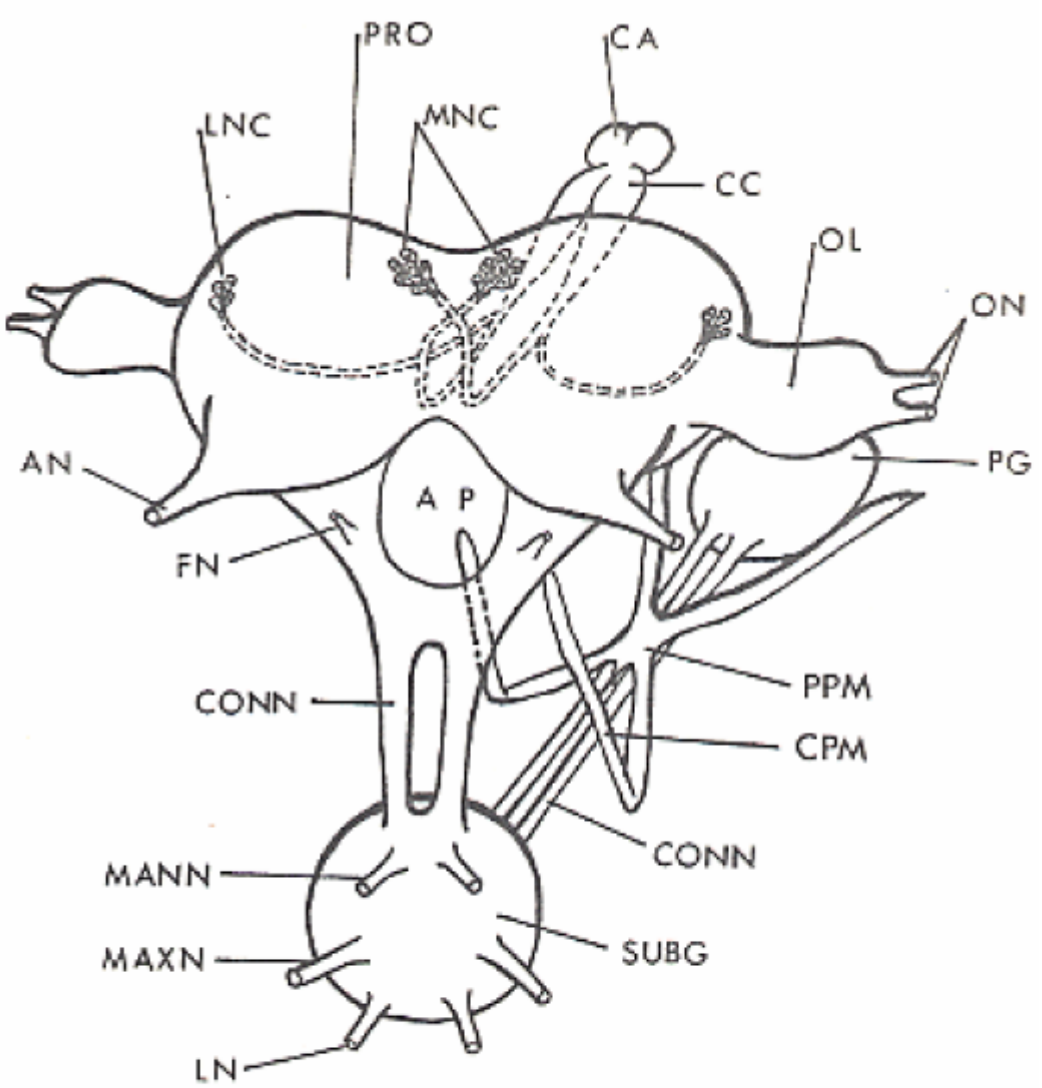
Orthoptera


Neurosecretory cells in the pars intercerebralis
Brain
Nerves from the brain to the corpora cardiaca and allata
Recurrent nerve
Hypocerebral ganglion
Corpus cardiacum
Corpus allatum

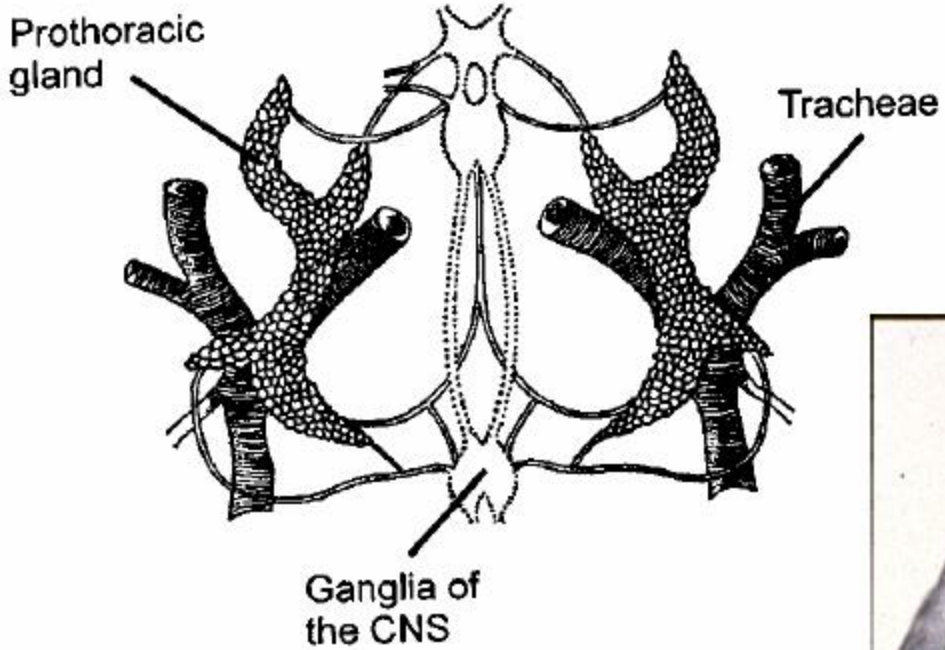
Diptera


Pars intercerebralis
N. recurrens
Esophagus
C. allatum
C. cardiacum +
Hypocerebral ganglion
Aorta
Proventriculus
Crop duct

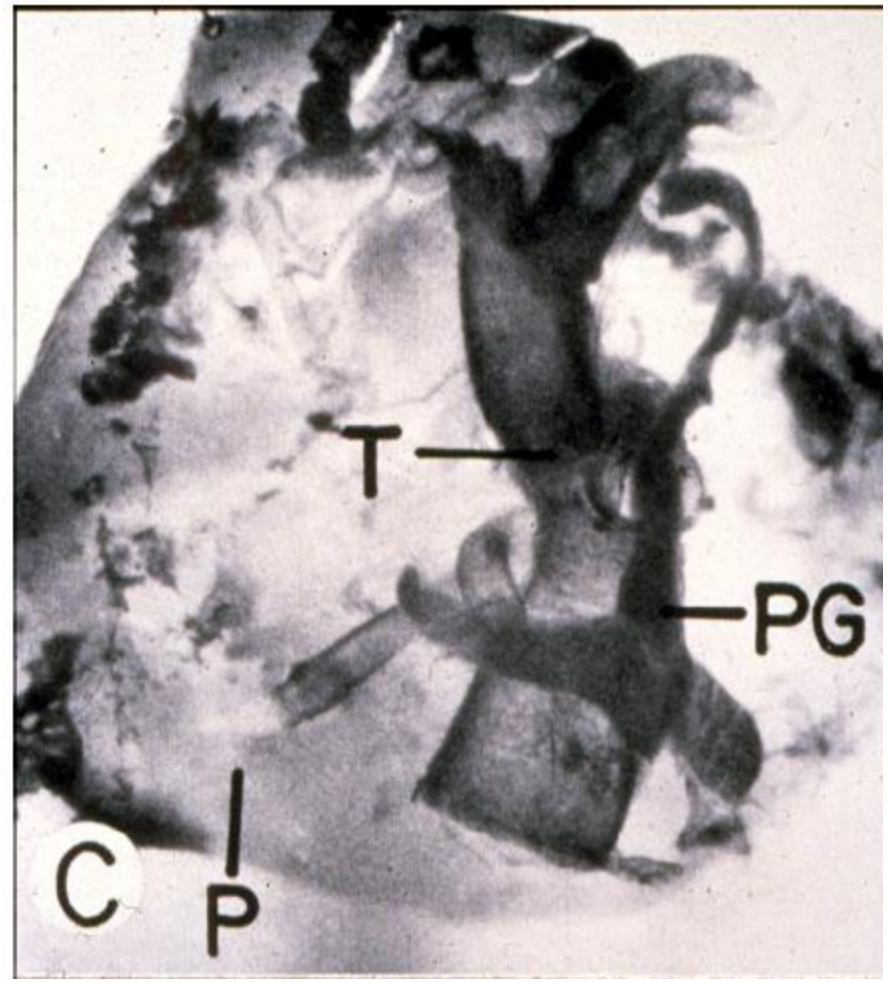
LNC=lateral neurosecretory cell
PRO=protocerebrum
MNC-median neurosecretory cell
CA=corpus allatum
OL=Optic lobe
ON=Optic nerve
PG=prothoracic gland
CPM=cephaic portion of the PG
CONN=Connectives
SUBG=suboesophageal gland
LN=labial nerve
MAXN=macillary



Endocrine glands in relation to head central nervous system in *Zootermopstis angusticollis*. From Yin. 1972. PhD. Disseration



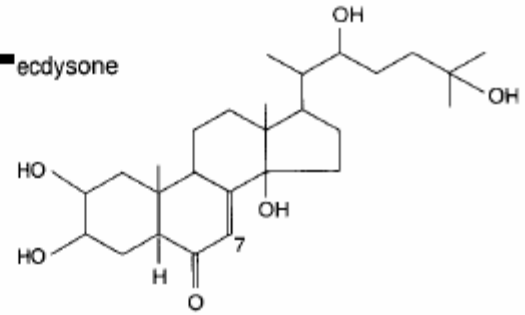
Prothoracic glands of Lepidoptera.
PG=prothoracic gland
T=trachea



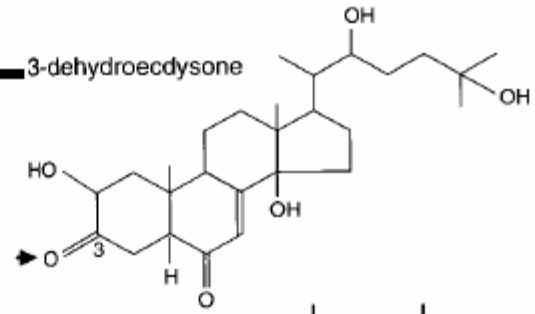
ECDYSTEROIDS-

1. Ecdysone is a steroid hormone
2. Insects cannot synthesize sterols, they must get them in their diet (cholesterol or phytosterol)

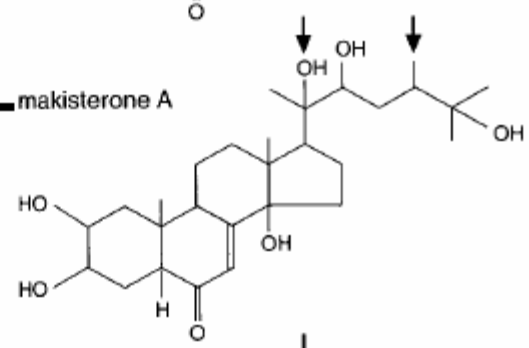
Ecdysone is the most common ecdysteroid produced in insects



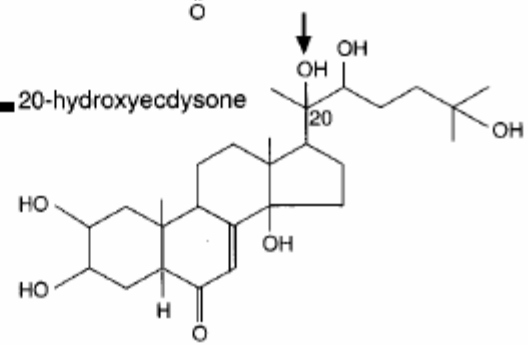
Some larval leps. Use 3-dehydroecdysone that is coverted to ecdysone by enzymes in the hemolymph



In the honeybee and Heteroptera, makisterone is the main ecdysteroid produced and used



In the Diptera is release from the ovaries and stimulates the fat body to produce vitellogenin. Ecdysone converted to 20-hydroxyecdysone in fat body.



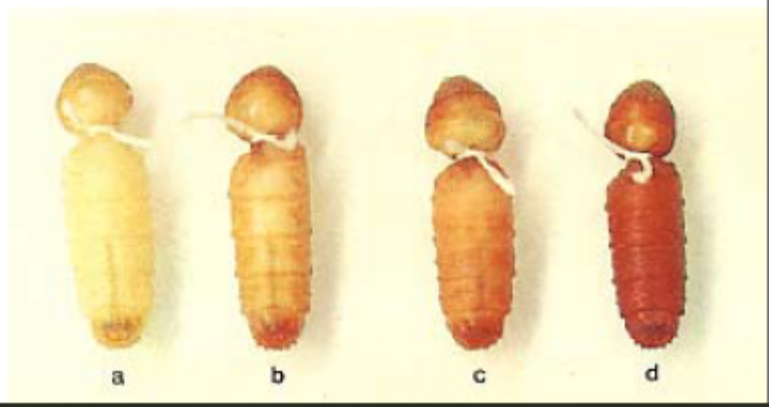
JUVENILE HORMONES

Are sesquiterpenes produced by the corpora allata. Several different forms have now been discovered (see next slide).

Analogues of JH, especially methoprene have been successfully used in insect control. Used against mosquito larvae and fleas (Siphotrol).

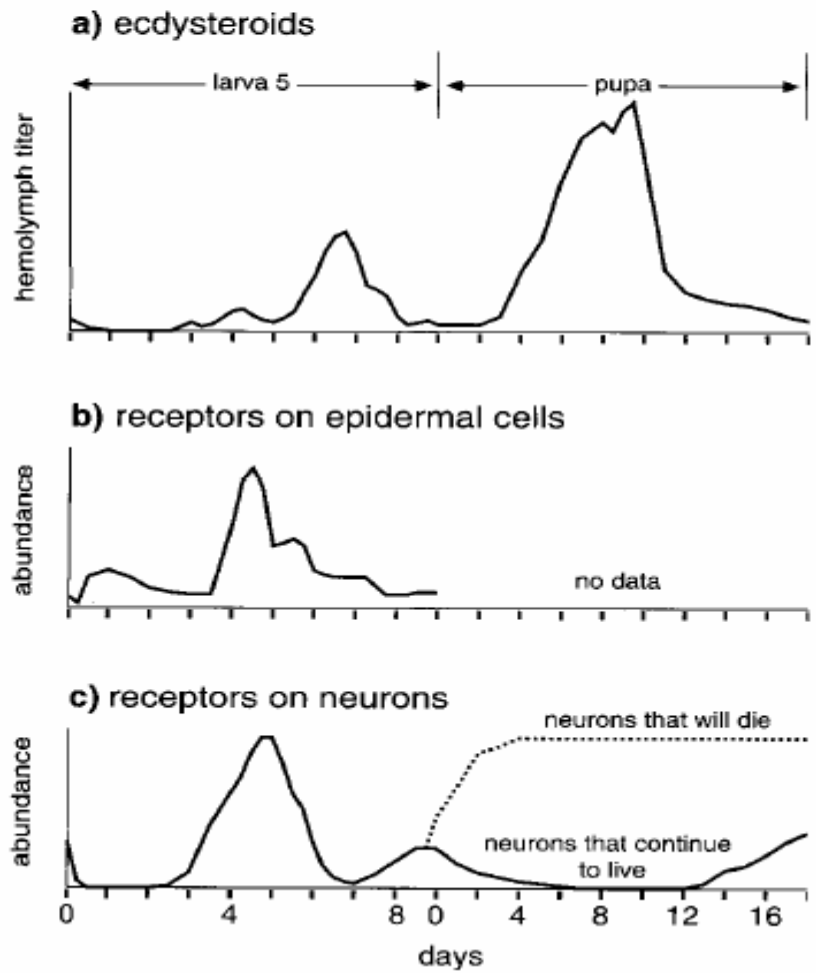
BURSICON-Neurosecretory hormone that controls tanning (sclerotization) and mechanical properties of the cuticle during and after a molt. Found in most ganglia of the CNS.

1. Cuticle of newly emerged adult fly is soft and plasticized.
2. Soon, however, it becomes smooth and rigid due to the tanning process and also it becomes darkened due to the melanization process.
3. Ecdysone or eclosion hormone causes the release of bursicon, which is the neurohormone that causes both plasticization and melanization.



Mode of action of hormones-

1. Activity within a cell depends on specific receptors for that hormone
2. The response of different tissues depends on the presence + number of receptors. This varies with development. Thus, different tissues will respond at different times
3. Receptors are in the cell membrane or within the cell
4. Both Ecdy. + JH are lipophilic so they pass through the cell membrane and have their effect within the cell
5. Cause inactive genes to become active or can inactivate other genes
6. In immature insects, JH has no effect by itself but it modifies the responses to ecdysteroids. In adult insects JH can produce an effect by itself.



Mode of action of hormones-

7. Peptide hormones and biogenic amines are lipophobic, thus they will not pass through the cell membrane. Specific receptor proteins for these substances are present in the cell membranes. Activation of these receptors activates secondary messengers (e.g., cAMP + cGMP) with the cells


Thank You
Any questions?