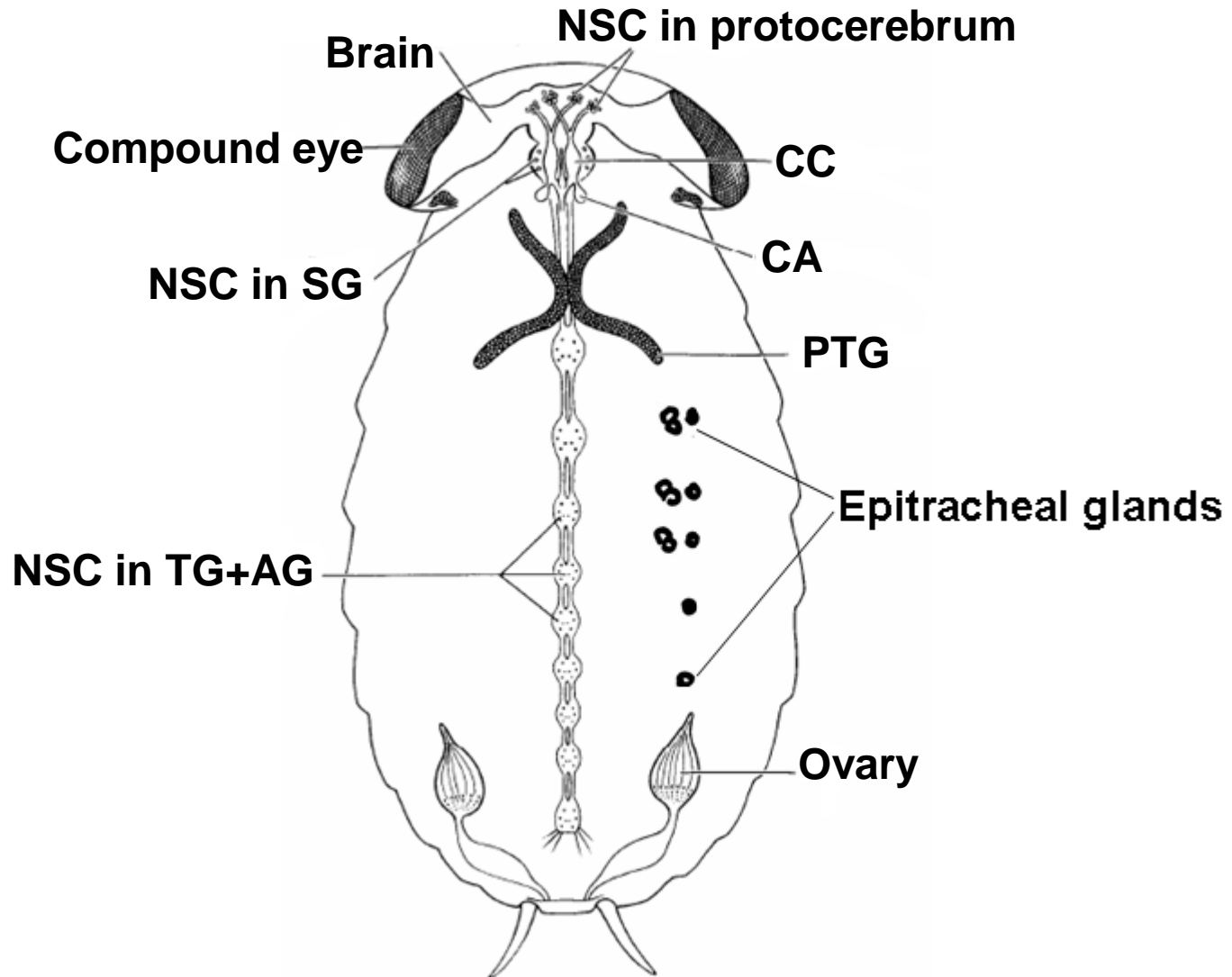


Lecture 15. Endocrine system I



Animals have two systems for communication and coordination

- **Nerve system**

1. **Fast** means of communication and coordination of **short-term** events, such as behavioral response to environmental stimuli
2. **Electrochemical** information is directly sent to target tissues (muscles and secretory glands) **by NS**
3. **Fast** response and the effects are usually **transient** except for long-term memory

- **Endocrine system**

1. **Slow** means of communication and coordination of **long-term** events, such as growth, differentiation and development
2. Endocrine glands secrete chemicals called **hormones** (=1st messengers) into **bloodstream**. Hormones circulate inside the body **by blood** and serves messengers between internal tissues and organs .
3. **Slow** response and the effects are usually **long-term or permanent**

Overview

- Anatomy
- Hormones
- Functions

Anatomy: diversity of locations

- Endocrine cells located in nerves system
- Pure endocrine structures
 - Prothoracic glands (PTG)
 - Epitracheal glands
- Endocrine cells located in other systems
 - Reproduction system (female and male reproduction tracts)
 - midgut

Anatomy: NS and endocrine system are related

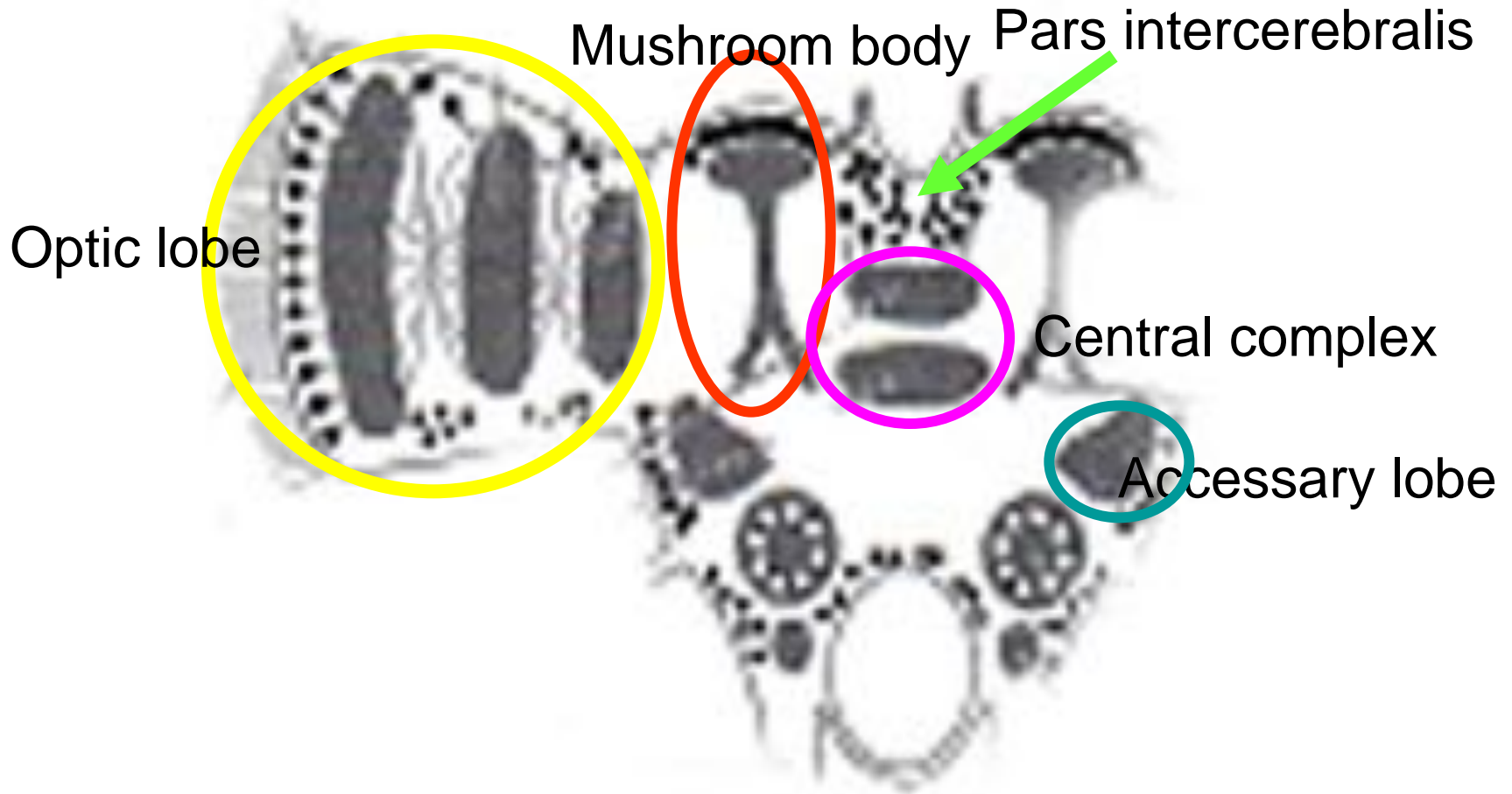
- **Anatomy**

- **Neurosecretory cells (NSC):** specialized nerve cells that secrete hormones
 - NSC in pars intercerebralis of protocerebrum
 - NSC in other parts of brain
 - NSC in ganglia of ventral nerve cord
- **Ganglion:** a whole ganglion become a hormone synthesis / release organ
 - CC: Corpora cardiaca
 - CA: Corpora allata

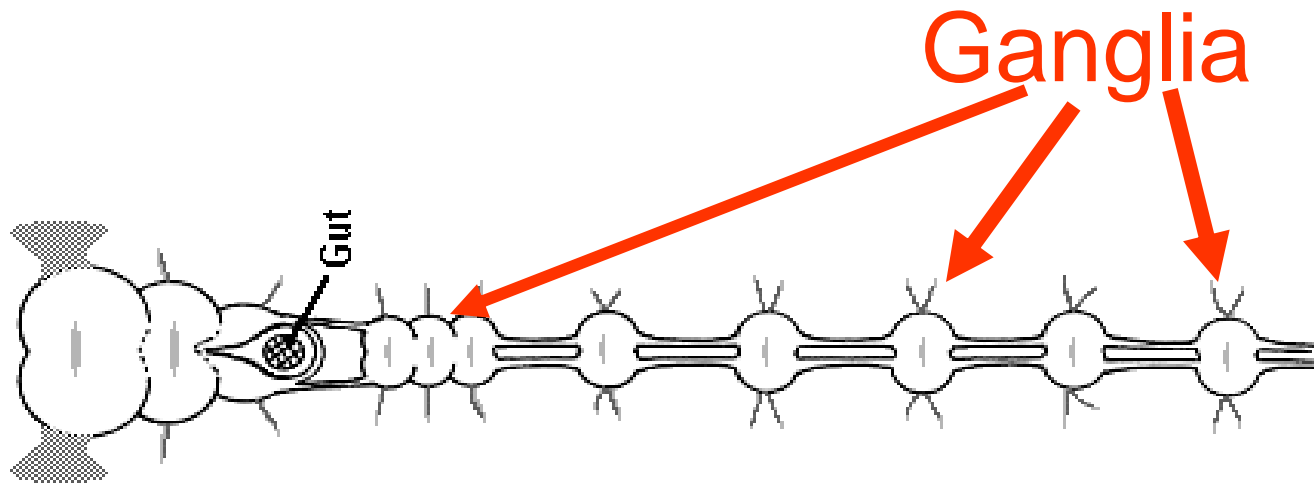
- **Function:**

Feedback: positively or negatively regulate each other

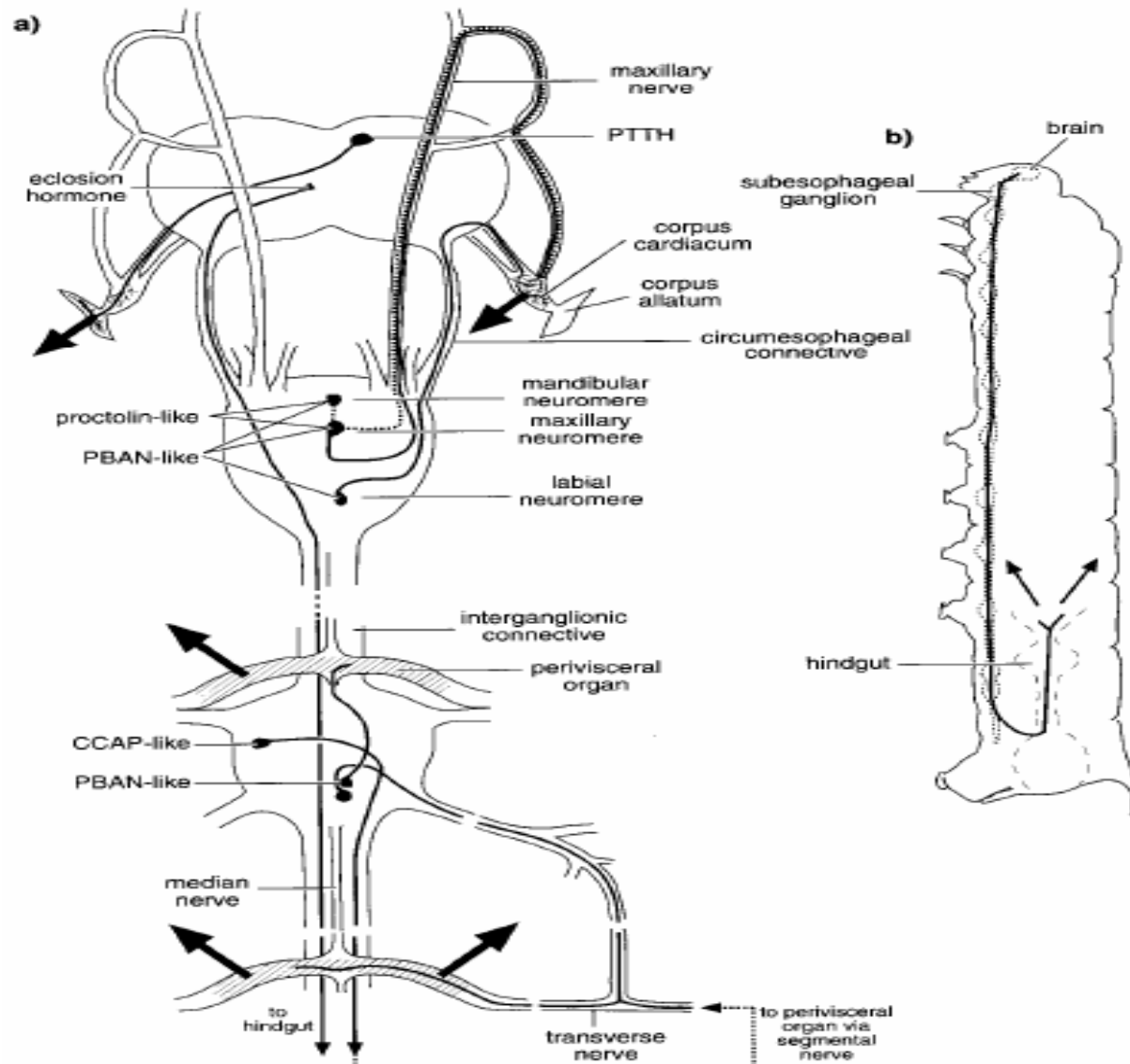
Anatomy: NSC in pars intercerebralis



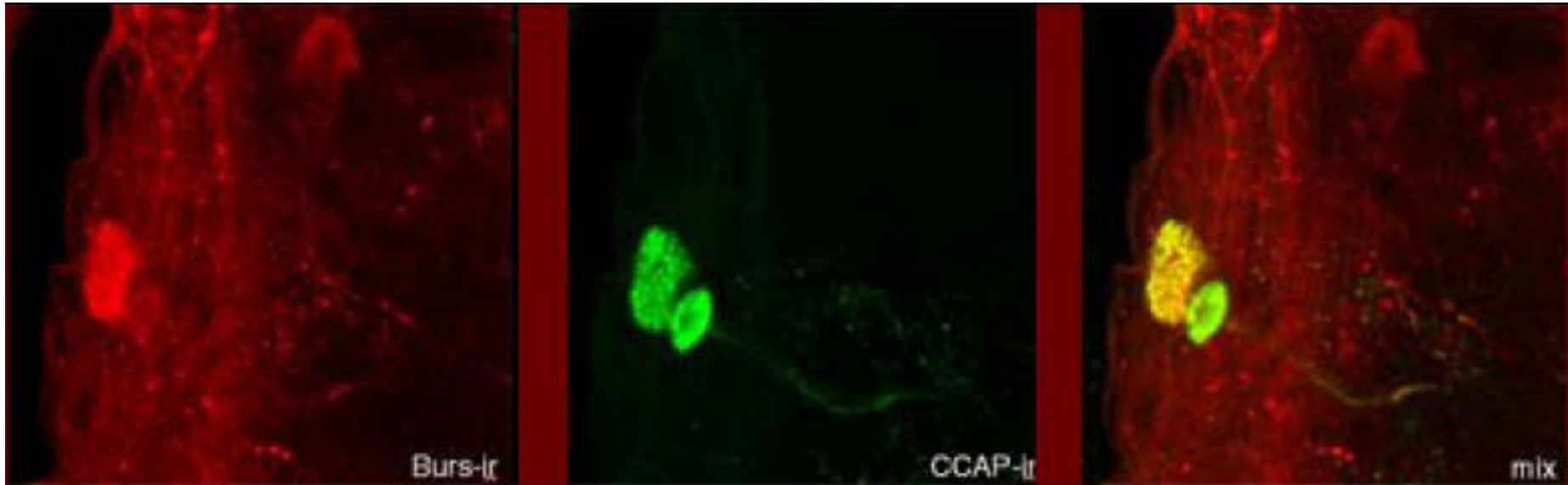
Anatomy: NSC in Ganglia



Anatomy: NSC in Ganglia



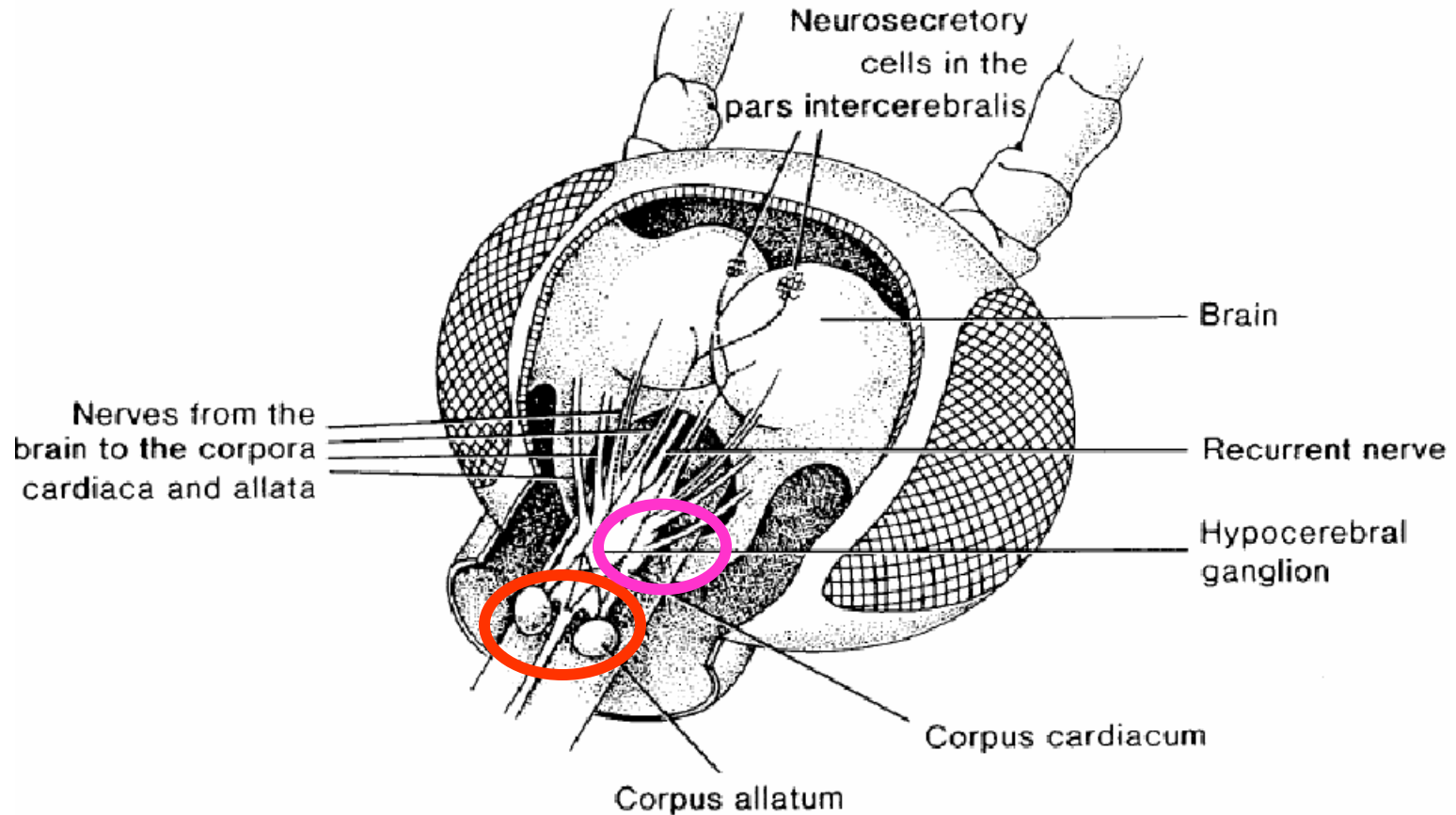
Anatomy: NSC in ganglia



The cockroach abdominal ganglion

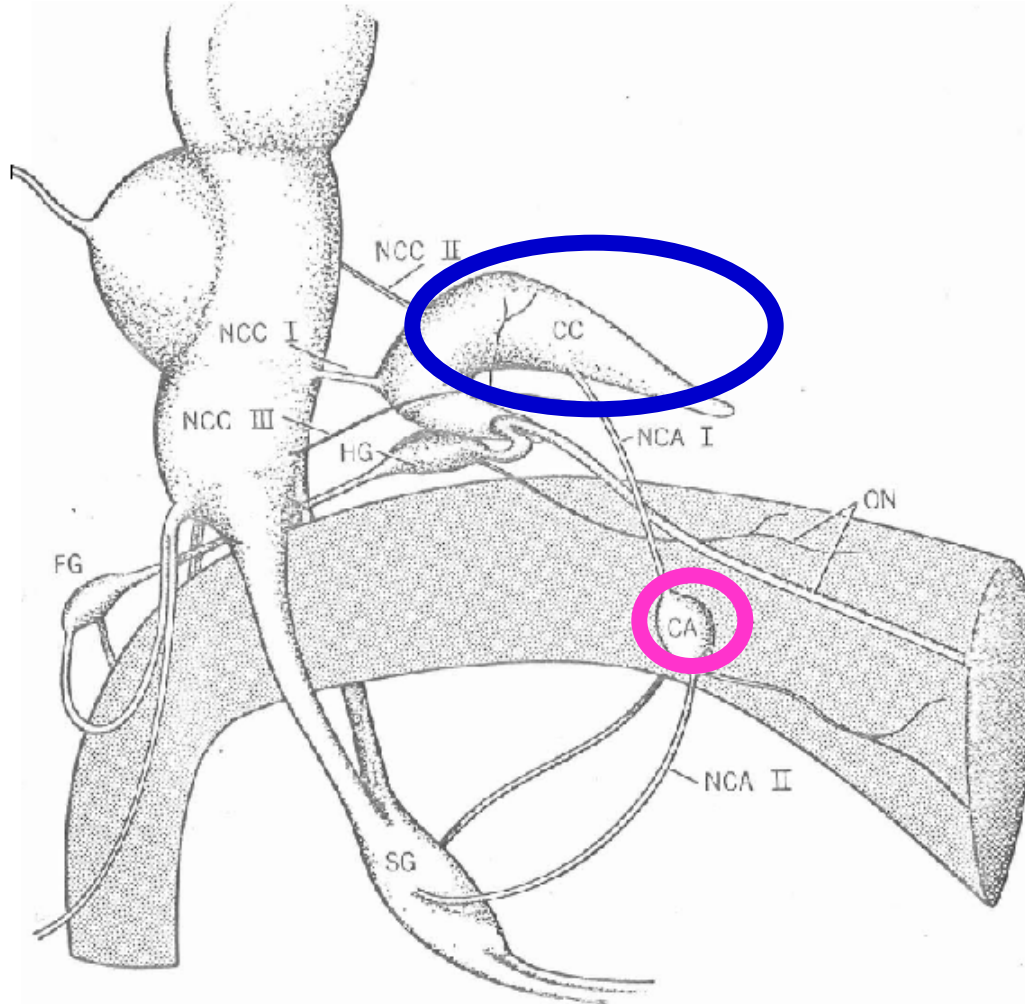
- CCAP= crustacean cardioactive peptide, is involved in triggering the motor activity that allows the animal to crawl out of its old cuticle.
- Bursicon and CCAP produced by the same neurons

Anatomy: CC and CA

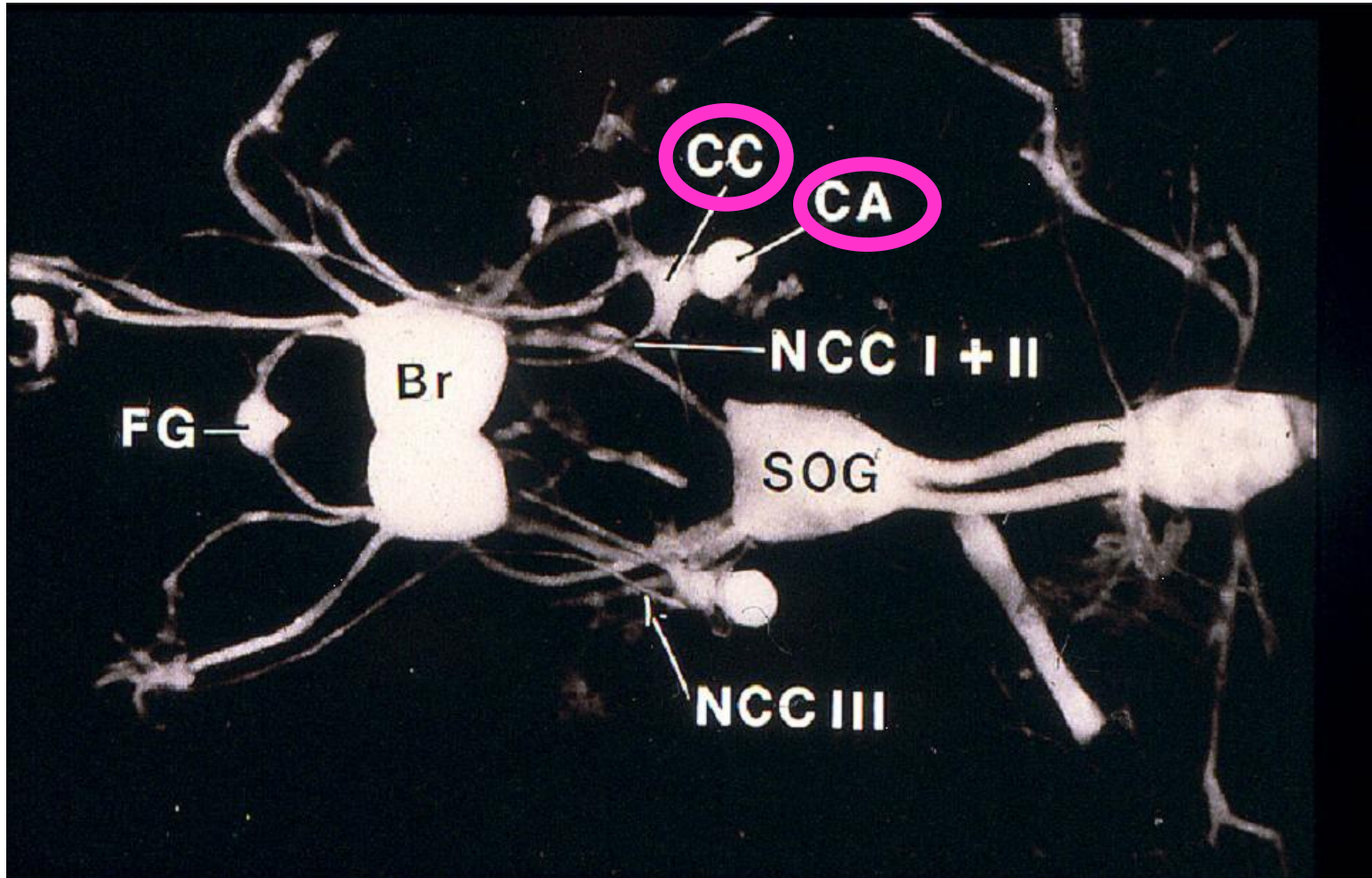


CC = Corpora cardica, CA = corpora allata

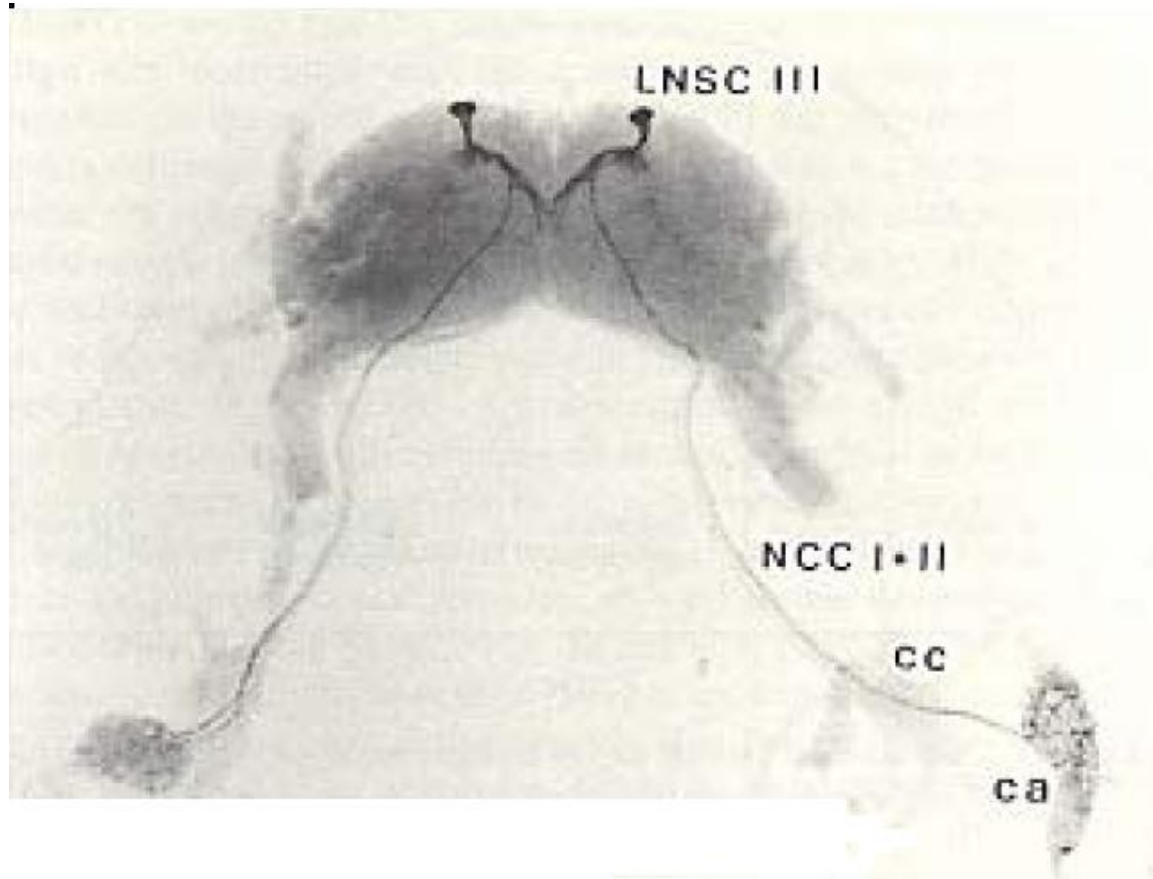
Anatomy: CC and CA



Anatomy: CC and CA



Anatomy: NSC in brain is linked to CC, CA and or NSC in ganalia



- In most insects, CC is the release site for prothoracictropic hormone (PTTH)
- In *Manduca sexta*, the PTTH release site is CA

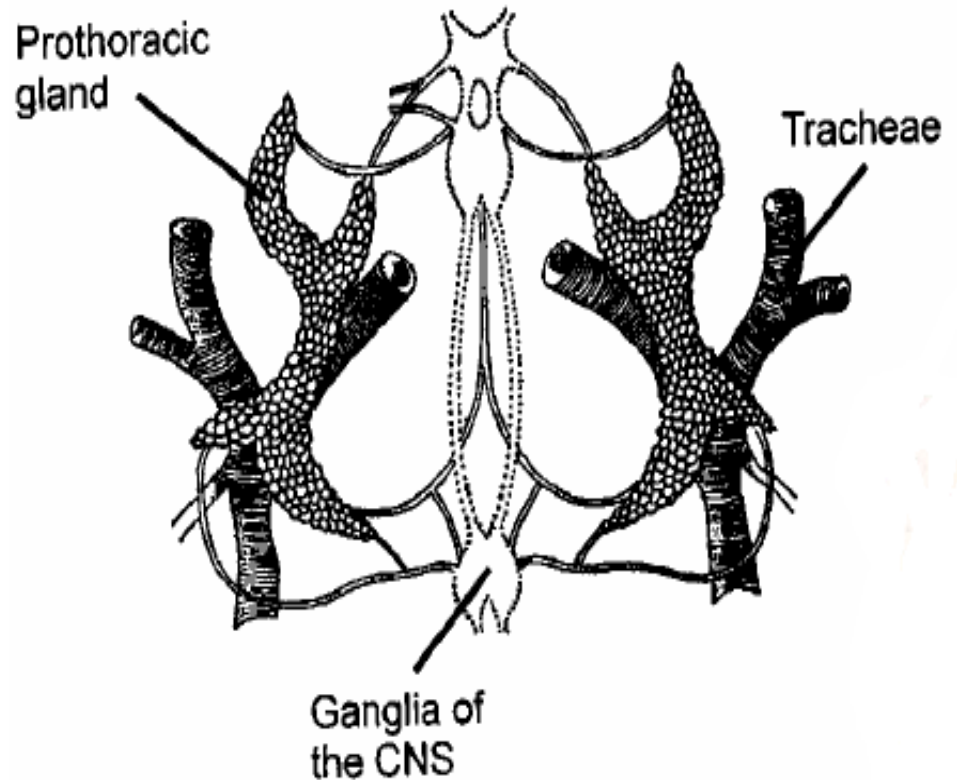
Anatomy: outside CNS

- Pure endocrine glands
 1. PTG: Prothoracic glands
 2. Epitracheal glands: known to exist in Lepidoptera. Not sure if it exists in other orders
- Secretory cells in non-nerve systems
 1. Ovary or other parts of female reproductive tract
 2. Male reproductive tract
 3. Midgut

Pure endocrine glands: prothoracic gland (PTG)

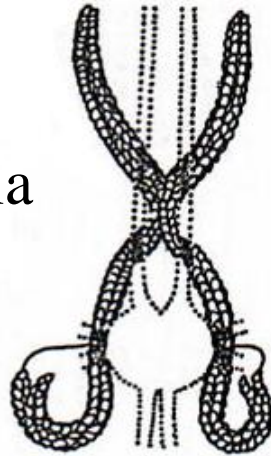
REMEMBER

- PTG is **destroyed** in adults of most insects
- EXCEPTION: **Apterygota** (especially thysanura) which keep on molting during adulthood
- Signal for destruction: absence of **juvenile hormone**



Pure endocrine glands: Diversity of PTG

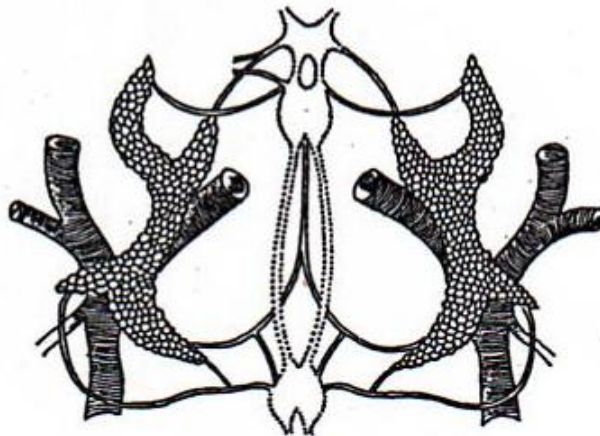
Blattaria



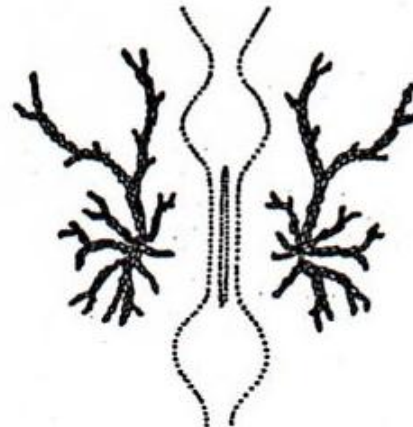
Hemiptera



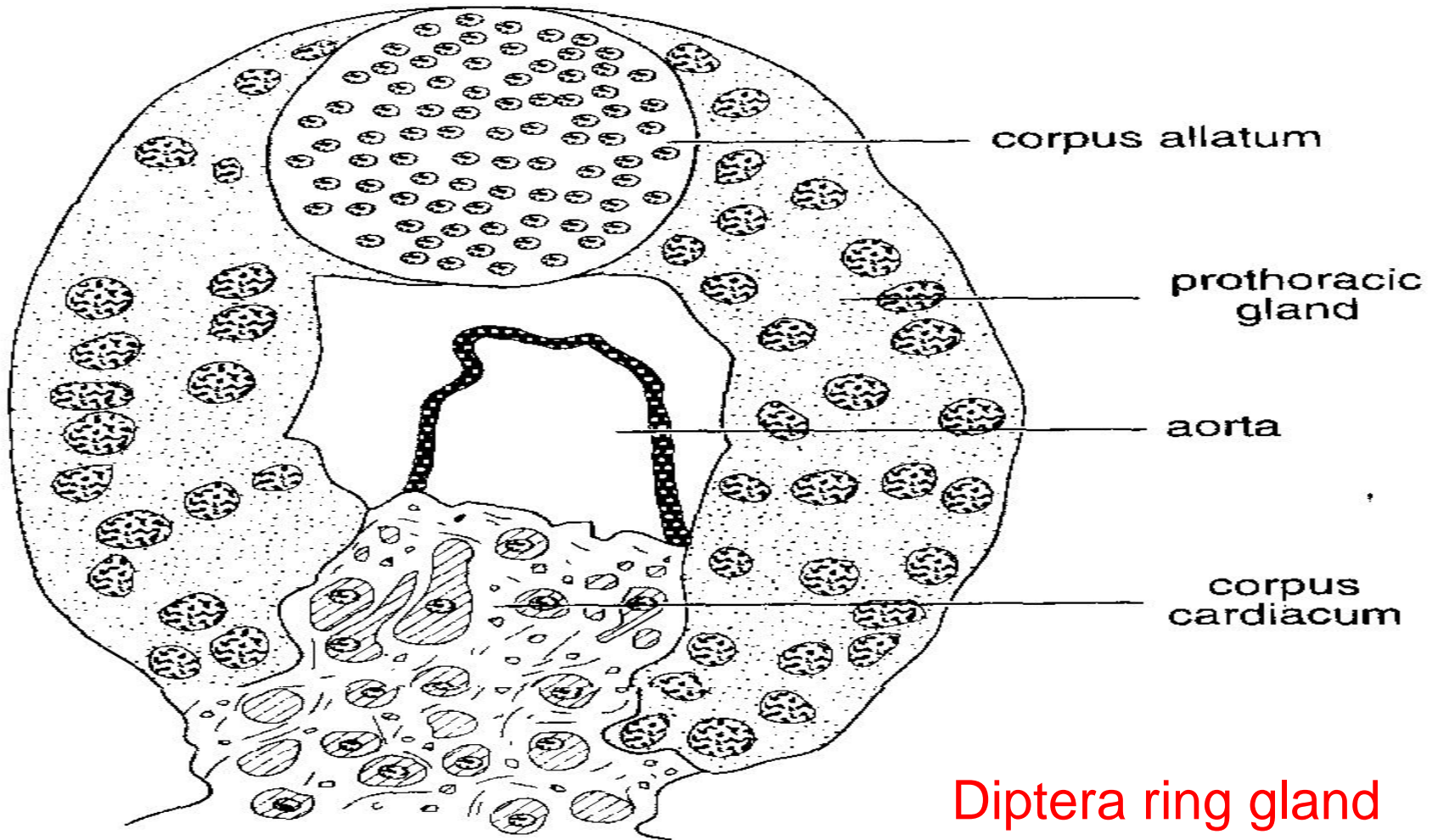
Lepidoptera



Hymenoptera



Ring gland: Fusion of CC, CA, and PTG

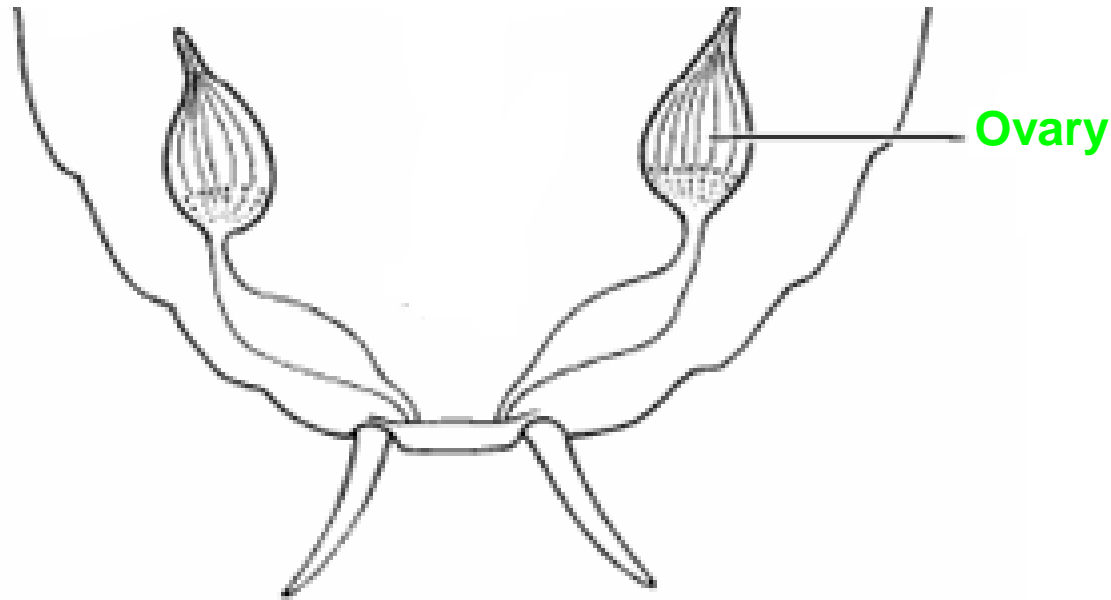


Pure endocrine glands: epitracheal gland (EG)

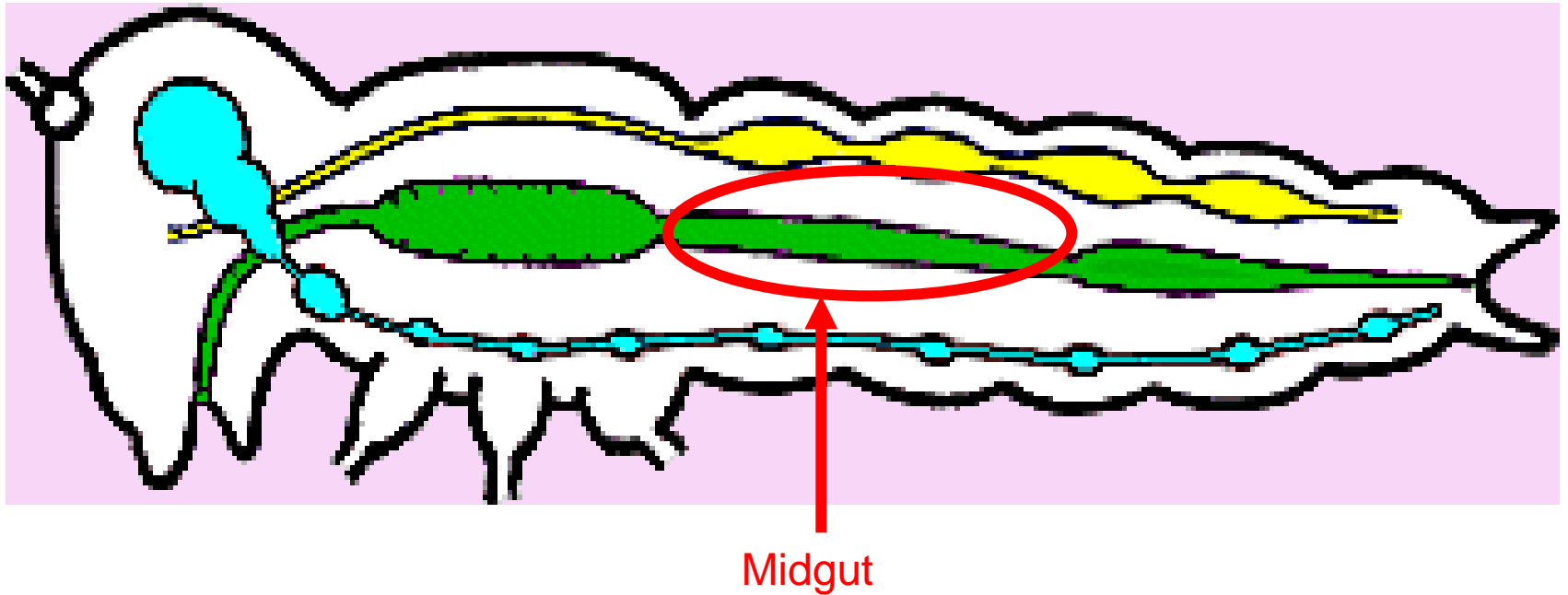
- **EG**: a three-cell gland complex found near each of the the larval and pupal spiracles
- Only in lepidopterans



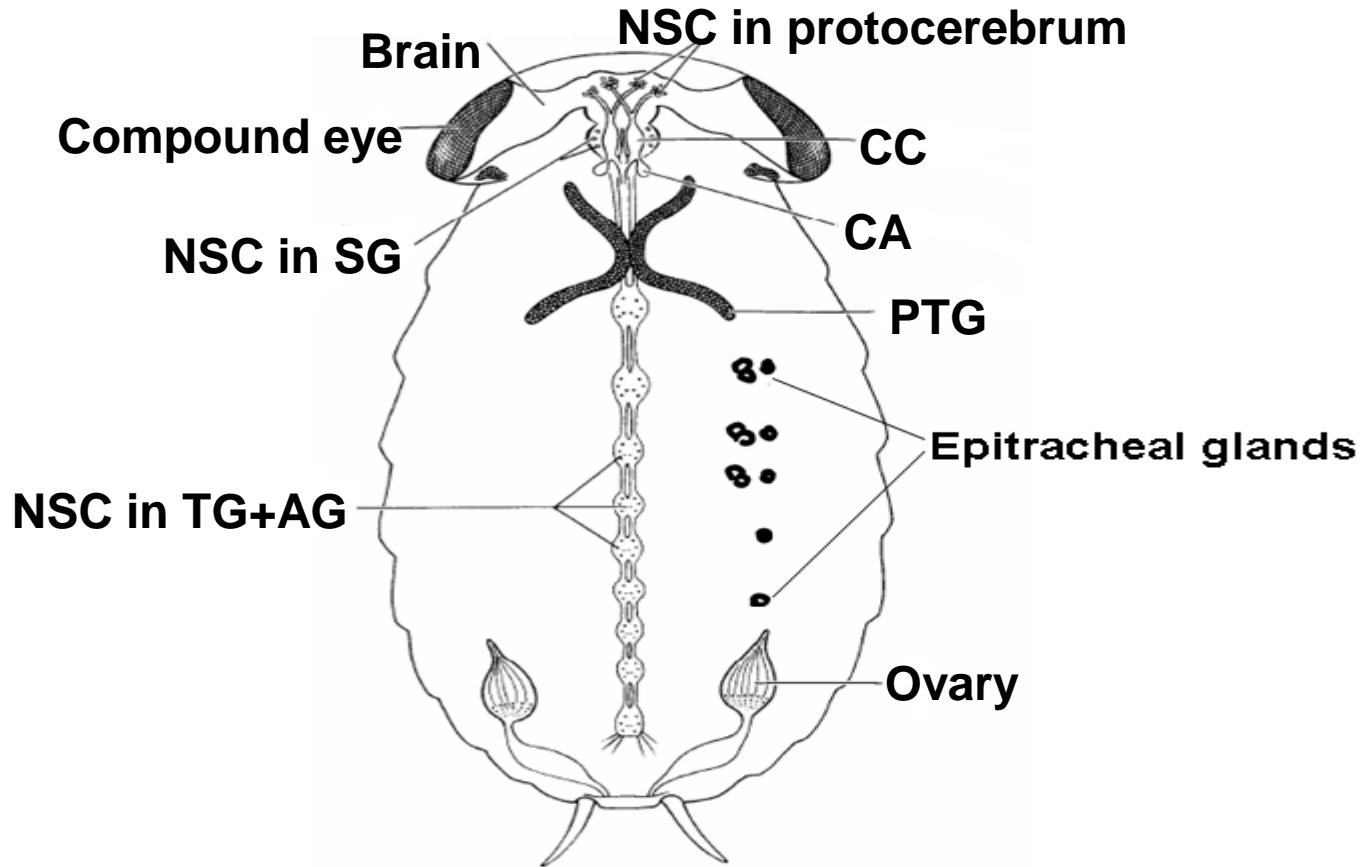
Secretory cells (SC) in non-nerve systems: reproduction tracts



Secretory cells (SC) in non-nerve systems: midgut



Anatomy: summary



- Endocrine cells in nerve system: NSC cells in pars intercerebralis of protocerebrum and other ganglia, CC, CA
- Pure endocrine organs: PTG and epitracheal glands
- Endocrine cells in Non-nerve system: ovary, midgut, male reproductive tract

Hormones: produced by NSC in pars intercerebralis

- Prothoracicotropic hormone (PTTH): peptide; stimulate PTG to produce Molting Hormone (MH, i.e. ecdysteroids)
- Ovarian ecdysteroidogenic hormone (OEH): peptide; stimulate adult ovary to produce MH
- Allatostatin: peptide; inhibition of Juvenile Hormone (JH) production by CA
- Allatotropin: peptide; stimulation of juvenile hormone production by CA
- Brain hormone: all hormones produced by brain.

Hormones: produced by NSC in other parts of brain

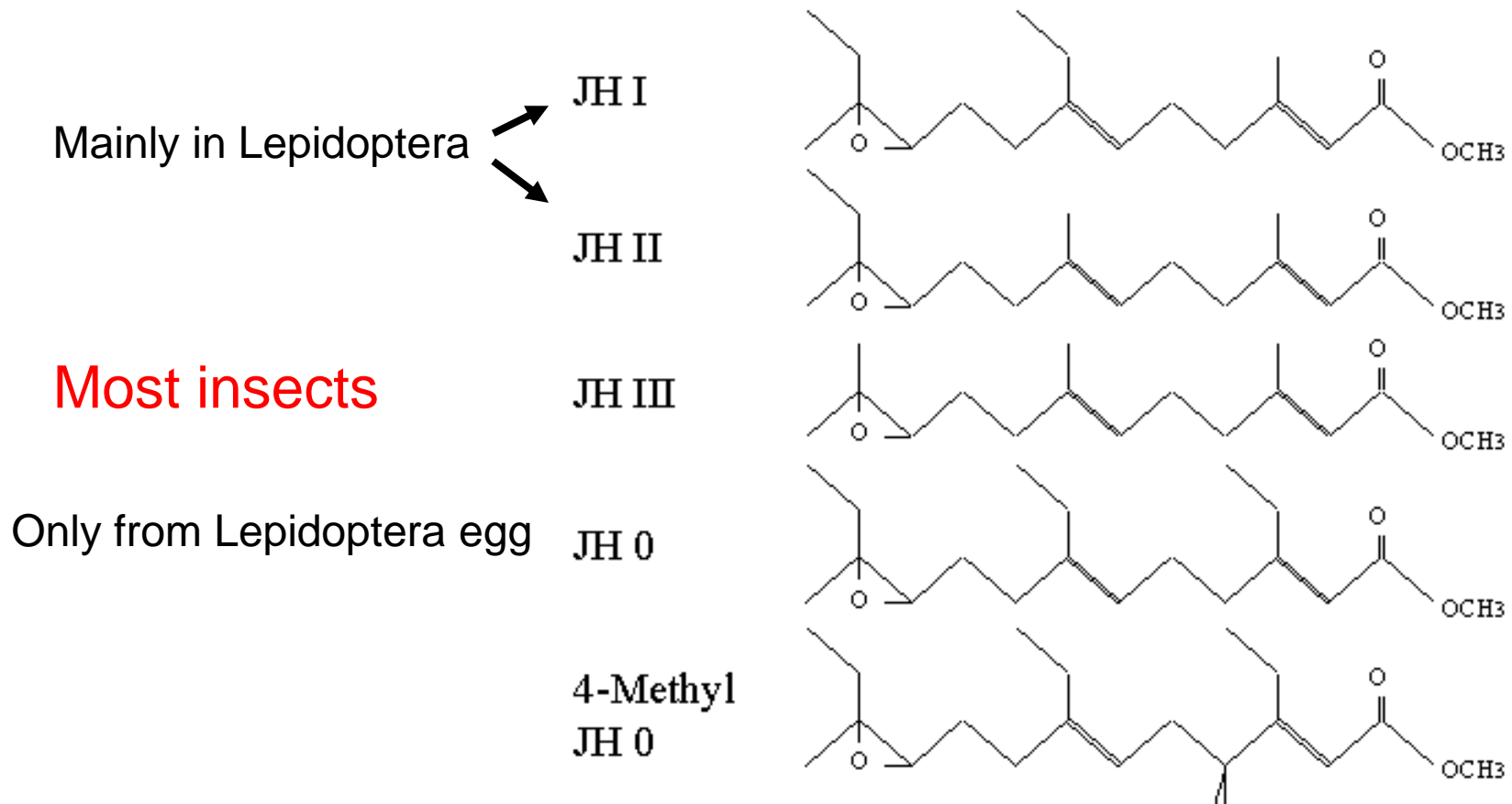
- Ecdosion hormone (EH): peptide; control ecdysis behavior
- Diapause hormone: also produced by NSC in suboesophageal ganglion; peptide; Initiation of diapause in embryos

Hormones: produced by corpora cardiaca (CC)

- CC stores and releases brain hormones
- Produce its own peptide hormones
 - Adipokinetic hormone (AKH): Fat (energy) metabolism
 - Hypertrehalosemic hormone (HTH): Control of sugar metabolism, resulting high concentration of trehalose in blood
 - Diuretic hormone (DH): also produced by NSC in brain and ventral ganglia; Water balance and urine production

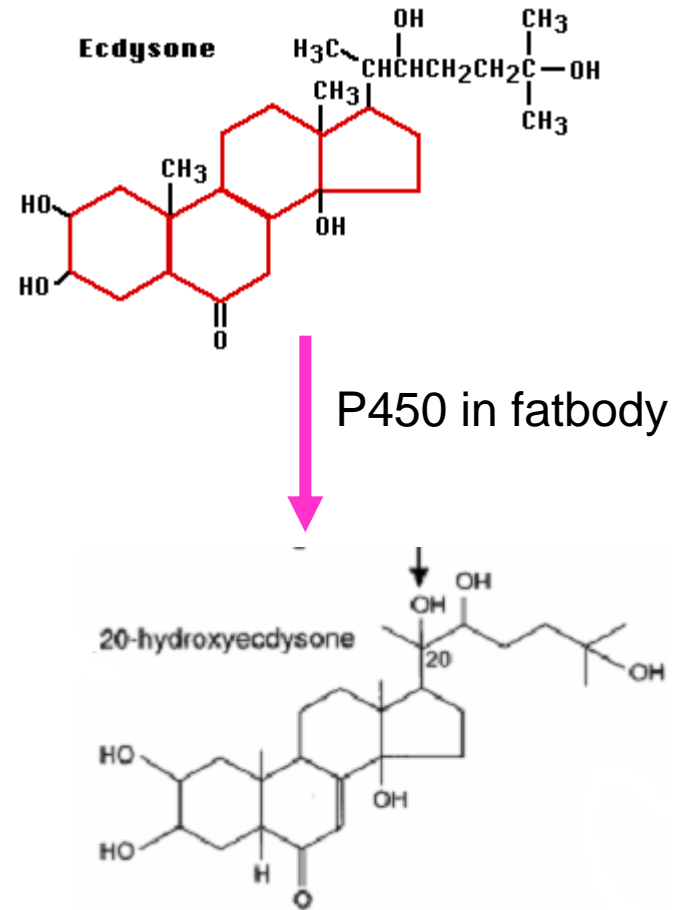
Hormones: produced by corpora allata (CA)

- **Juvenile hormone (JH): Sesquiterpenoids;** regulation of molting, metamorphosis and reproduction



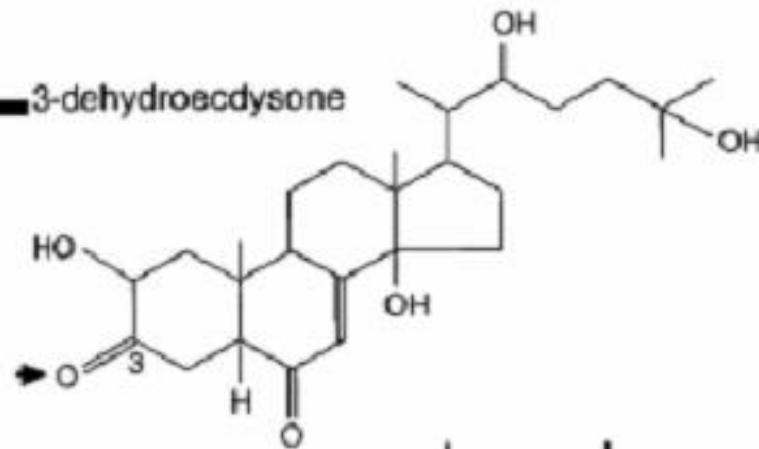
Hormones: produced by PTG and ovary

- **Molting hormone (MH):** Ecdysteroids, Initiation of molting (larvae) or egg maturation (adults)
- **Insect must obtain sterols** (cholesterol or phytosterol), the precursor of ecdysteroids
- **Ecdysone** is converted to active 20-hydroxyecdysone by P450 in fatbody
- **In larvae**, PTG synthesize and release MH which targets epidermis. Synthesis of MH is stimulated by **PTTH**.
- **In diptera adult**, ovary produce MH that stimulates the fat body to produce vitellogenin and egg maturation. Synthesis is regulated by ovary ecdysteroidogenic hormone (**OEH**)

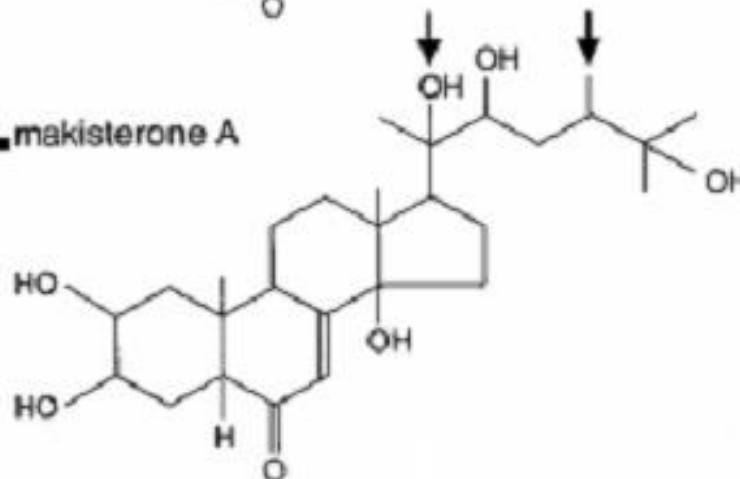


The ecdysteroid hormone

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



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



Hormones: produced by NSC in ganglia of ventral nerve cord

- Crustacean cardioactive peptide (CCAP): peptide; ecdysis behavior and heart rate modulation
- Bursicon: peptide; tanning of cuticle
- Pheromone biosynthesis activating neuropeptide (PBAN): peptide; stimulation of pheromone biosynthesis

Hormones: produced by Epitracheal glands

- Ecdysis triggering hormone (ETH):
peptide, only in Lepidoptera, control
ecdysis behavior

Hormones: produced by midguts

- Various peptides
- Function unknown

The peptide hormones

Name of peptide	Code name	Primary sequence
Trypsin modulating oostatic factor	Aedae-TMOF	YDPAPPPPPP
	Neobu-TMOF	NPTNLH
Adipokinetic hormone	Locmi-AKH-I	pELNFTPWNWGTamide
	Locmi-AKH-II	pELNFTSAGWamide
	Locmi-AKH-III	pELNFTPWWamide
Diuretic hormone, CRF-like	Manse-DH	RMPSLSIDLPMSVLRQKLSLEKERKVHA- LRAAARNFLNDamide
	Manse-DP-II	SFSVNPVAVDILQHRVMEKVAQNRRNFLN- RVamide
	Locmi-DH	MGMGPSLSIVNPMVDVLRQRLLEIARRR- LRDAEEQIKANKDFLQQamide
Locustakinin	Locmi-K	AFSSWGamide
Locustasulfakinin	Locmi-SK	pELASDDY(SO ₃ H)GHMRamide
Pheromone biosynthesis activating neuropeptide	Helze-PBAN	LSDDMPATPADQEMYRQDPEQIDSRTKY- FSPRLamide
Pyrokinin/myotropin	Leuma-PK	pETSFTPRLamide
Diapause hormone	Bommo-DH	TDMKDEDRGAHSERGALCFGPRLamide
'Cockroach' allatostatin, A-type	Dippu-AST-1	LYDFGLamide
'Cricket' allatostatin, B-type	Grybi-AST-B1	GWQDLNGGWamide
'Moth' allatostatin, C-type	Manse-AST	pEVRFRCYFNPISCF

Gade & Goldsworthy, 2003. *Pest Manag Sci*

Table 1. Some of the known insect hormones^a, their function(s) and chemical nature

Hormone	Source	Function	Chemical Type
Ecdysteroids	prothoracic gland	Initiation of molting and egg maturation	Steroid
Prothoracicotropic hormone (PTTH)	brain	Control of ecdysteroid production	Peptide
Bombyxin	brain	Ecdysteroid production, ?Carbohydrate metabolism	Peptide (insulinlike)
Ecdysis triggering hormone (ETH)	epitracheal gland	Ecdysis behavior	Peptide
Eclosion hormone (EH)	brain	Ecdysis behavior	Peptide
crustacean cardioactive peptide (CCAP)	ventral nerve ganglia	Ecdysis behavior; heart rate modulation	Peptide
Bursicon	brain and ventral nerve ganglia	Tanning of cuticle	Peptide
Juvenile hormone (JH)	corpora allata	Regulation of metamorphosis and reproduction	Terpenoid
Allatostatin	brain	Inhibition of juvenile hormone production	Peptide
Allatotropin	brain	Stimulation of juvenile hormone production	Peptide
Adipokinetic hormone (AKH)	corpora cardiaca	Fat (energy) metabolism	Peptide
Hypertrehalosemic hormone	corpora cardiaca	Control of sugar metabolism	Peptide
Diuretic hormone (DH)	brain, corpora cardiaca, ventral ganglia	Water balance and urine production	Peptide
FMRFamides	central nervous system	Neuromodulators; myosuppression	Peptide
Diapause hormone	brain, suboesophageal ganglion	Initiation of diapause in embryos	Peptide
Pheromone biosynthesis activating neuropeptide	suboesophageal ganglion	Initiates pheromone production	Peptide

^aThis is not intended to be a comprehensive list of all insect hormones.