Hormonální systém

Vývoj hmyzu a řízení tvorby kutikuly – klasický modelový objekt pro studium látkové signalizace

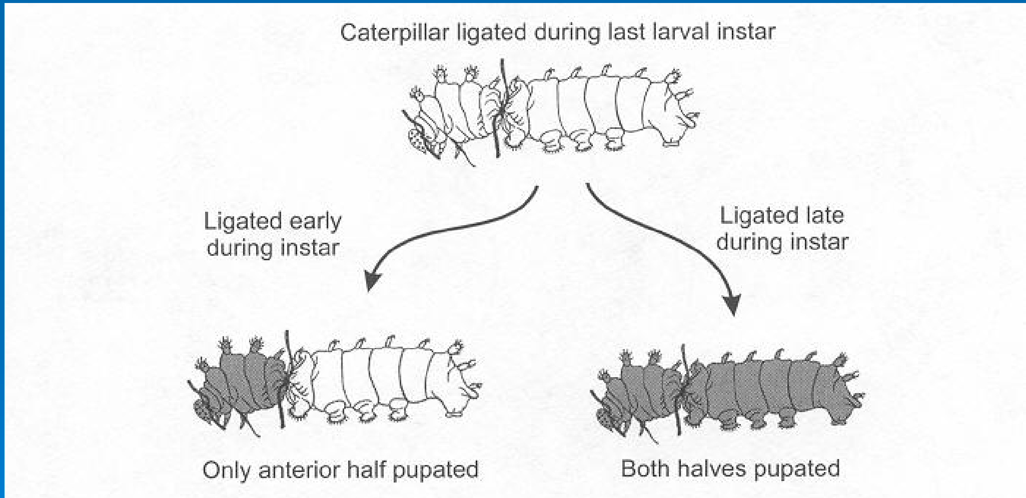
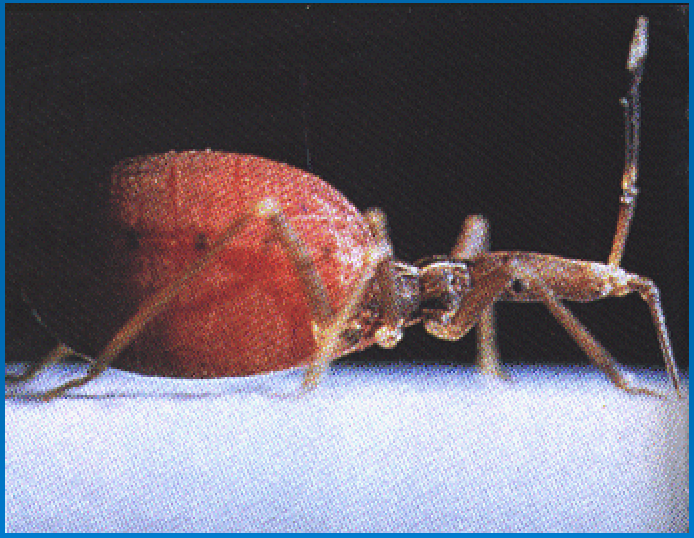


FIGURE 1.2 An experiment performed by Kopeć. When a caterpillar was ligated early during the last larval instar, only the anterior half later pupated. However, when ligated late during the last larval instar, both halves pupated. Adapted from Cymborowski (1992). Reprinted with permission.

Manduca sexta

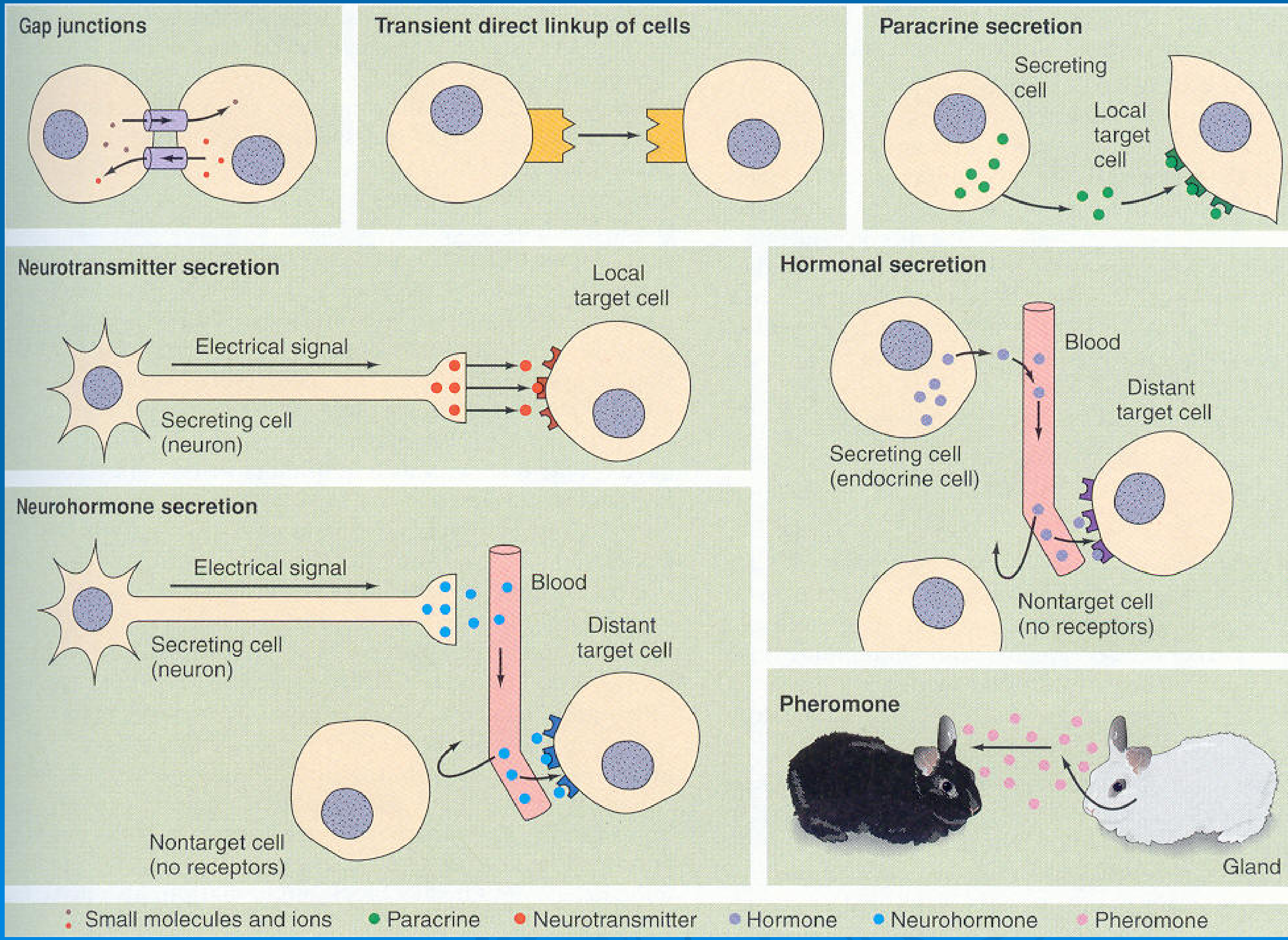
Hyalophora cecropia

Rhodnius



Calliphora vicina

Hormonální řízení v kontextu všech látkových signalizací



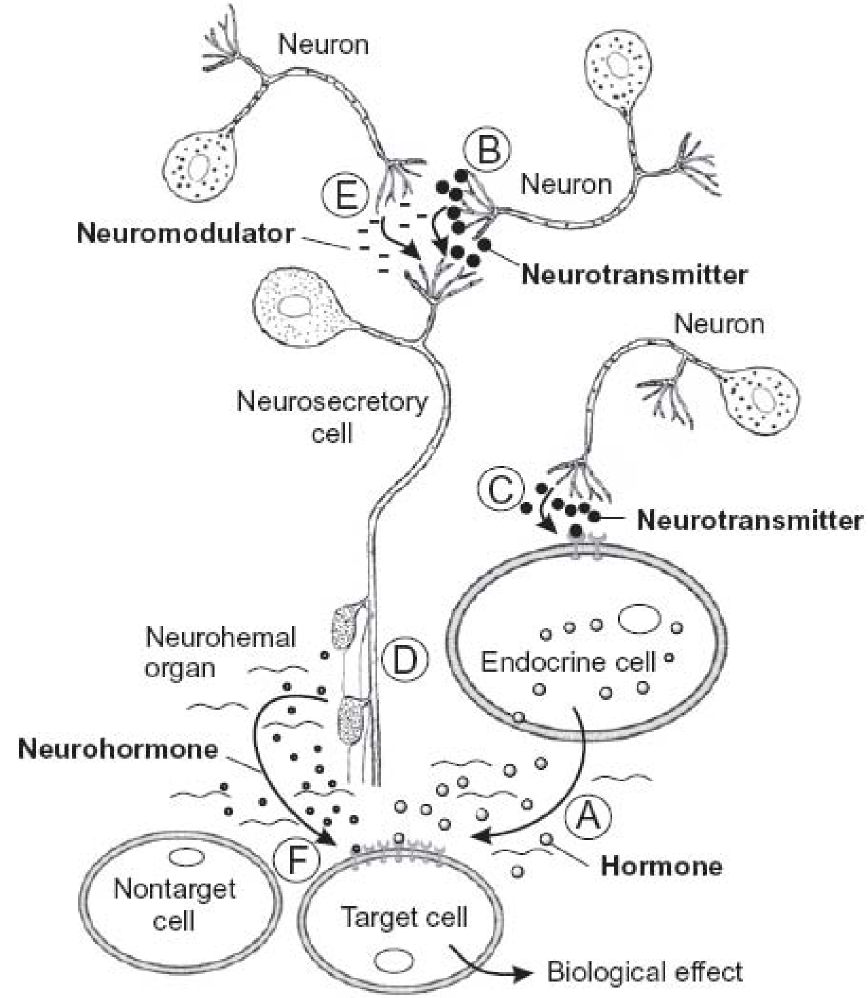
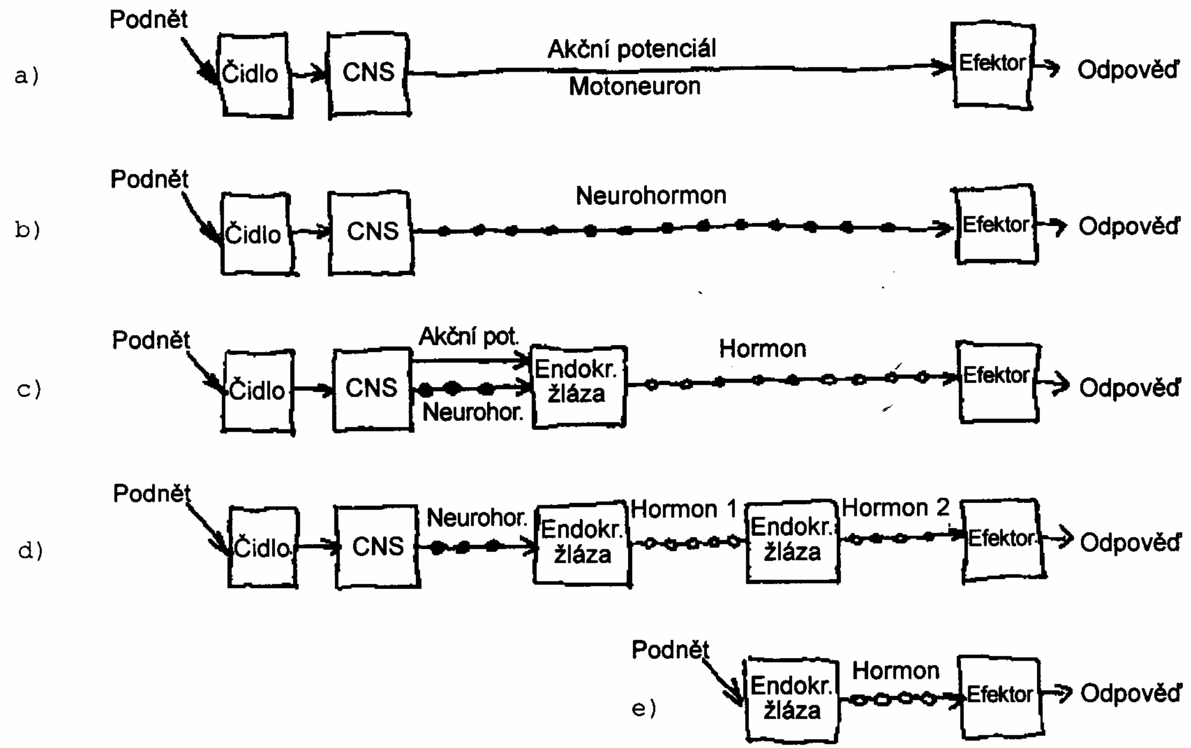


FIGURE 1.1. Some examples of neurotransmitter release. A. An endocrine cell releasing a hormone into the circulatory system. B. A neuron synapsing with a neurosecretory cell, releasing a neurotransmitter at the synapse. C. A neuron synapsing with an endocrine cell, releasing a neurotransmitter. D. A neurosecretory cell releasing a neurohormone into the circulatory system at a neurohemal organ. E. An inhibitory neuron synapsing with a neurosecretory cell, releasing a neuromodulator at the synapse. F. Receptors on target cells recognize specific neurohormones in circulation, resulting in a biological effect. The absence of receptors on nontarget cells results in the cell not being able to respond to the circulating chemical messages, and any molecules taken up nonspecifically are degraded.

Spolupráce nervové a hormonální kontroly:

Bezobratlí: Neurosekrece převažuje

Jednodušší osy řízení než obratlovci



Obr. 14.3. Kaskády řídících soustav. Nervový systém obecně (a) nebo neuroendokrinní systém bezobratlých (b) využívají řídící smyčku 1. řádu – přímý účinek na cílový orgán (efektor). Smyčky 1. řádu jsou u obratlovců vzácné. Neurosekrece obratlovců zpravidla neovlivňuje přímo cílový orgán, ale sekreci klasické endokrinní žlázy. To je smyčka 2. řádu, jaké jsou běžné u obratlovců i bezobratlých (c). Smyčky 3. řádu nalézáme spíše jen u obratlovců (d). Poslední případ je přímé ovlivnění endokrinní žlázy bez účasti neurohormonu (e).

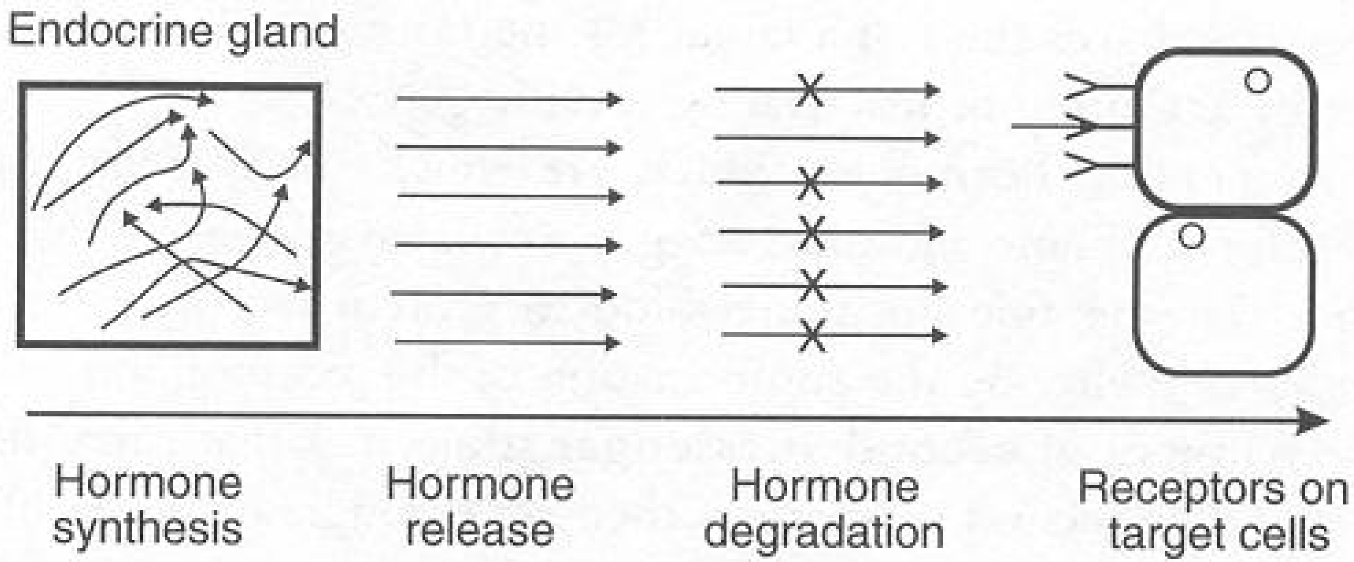


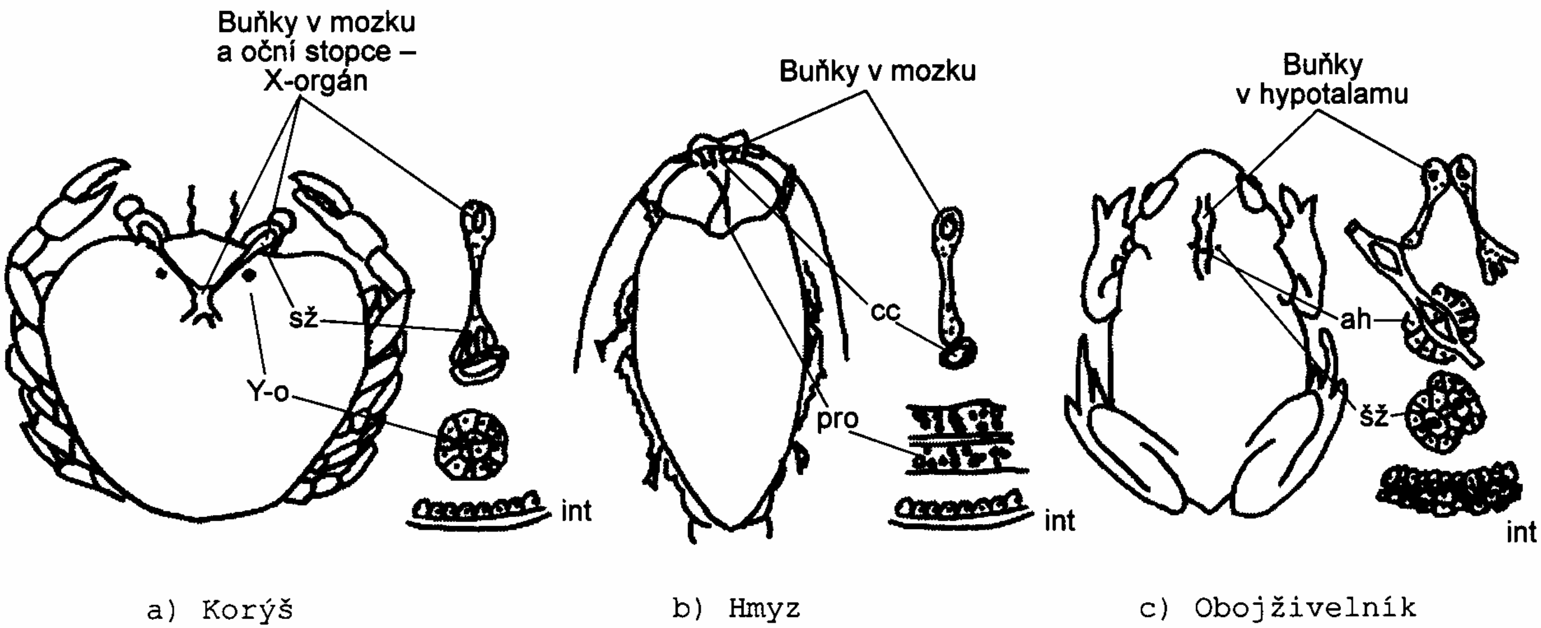
FIGURE 1.4 Factors that affect the activity of hormones. Hormonal activity in the circulatory system is regulated by its rate of synthesis by the endocrine glands, the rate of release into the blood, its degradation in the blood, and the development of hormone receptors on target cells.

Jednodušší bezobratlí
Morfogenetické procesy: vývoj, růst, regenarce, funkce gonád

Pokročilejší bezobratlí
Vývoj vajíček, osmoregulace, srdeční výkon, metabolismus, barvozměna

Nejprobádanější u korýšů a hmyzu: růst a tvorba kutikuly

Neurosekretorické buňky - spojovací článek mezi NS a HS



Obr. 14.2. Srovnání úlohy neurosekrece v hormonálním řízení svlékání nebo pigmentace pokožky. Neurohormony z mozku jsou vylévány v neurohemálních orgánech – sinusové žláze korýšů (sž), kardiálních tělíscích hmyzu (cc), adenohypofýze obojživelníků (ah). Řídí pak aktivitu periferní endokrinní žlázy – Y-orgán korýšů (Y-o), prothorakální žlázu hmyzu (pro), adenohypofýzu (ah) a štítnou žlázu (šž) obojživelníků. Cílovou tkání je integument (int).

Neurosekretorický systém hmyzu

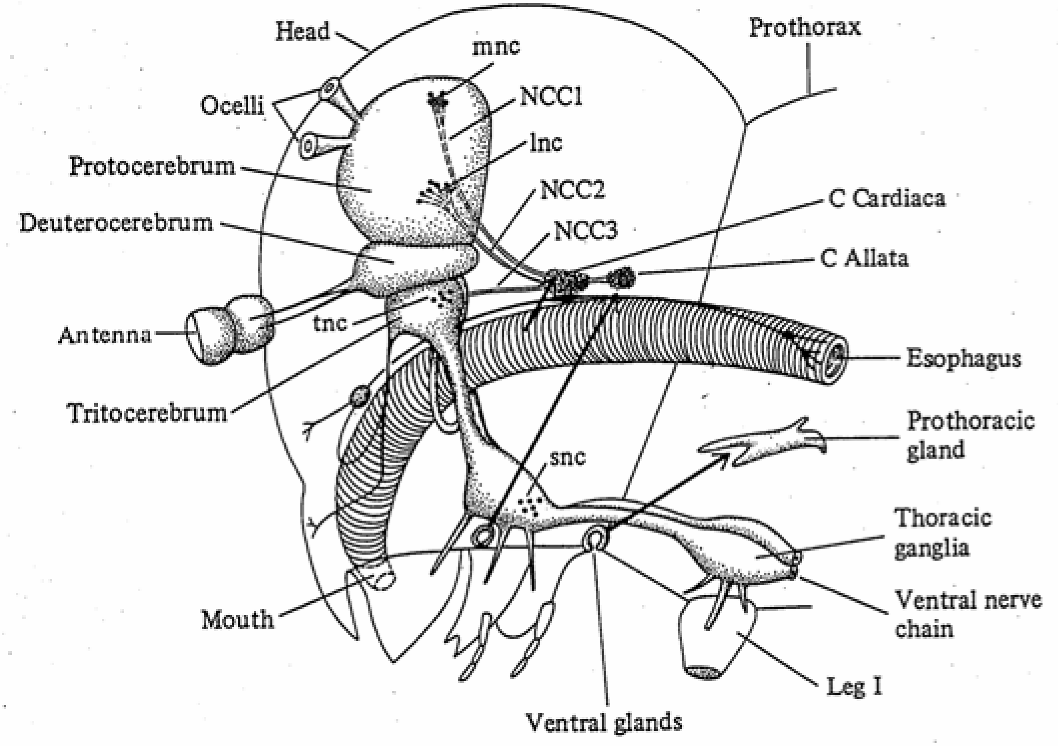


FIGURE 11–19 Generalized central nervous system and endocrine systems of an insect. The nervous system contains three major groups of neurosecretory cells: the median (mnc), lateral (lnc), and subesophageal (snc), which are connected with the corpora cardiaca via NCCI and NCCII nerves; phasmid insects have additional neurosecretory cells in the tritocerebrum (tnc) connected to the corpora cardiaca via NCCIII nerves. The corpora cardiaca are a neurohemal organ for the release of neurosecretions; they arise from stomodeal ectoderm (shown by black arrows). The corpora allata are classical endocrine glands that arise from ectodermal invaginations near the maxillae (black arrows). The prothoracic gland is another important classical endocrine gland; it arises (black arrow) from ventral glands (which are present in primitive insects). *(Modified from Jenkin 1962; after*

Endokrinní systém hmyzu
Hormony a řízení svlékání.

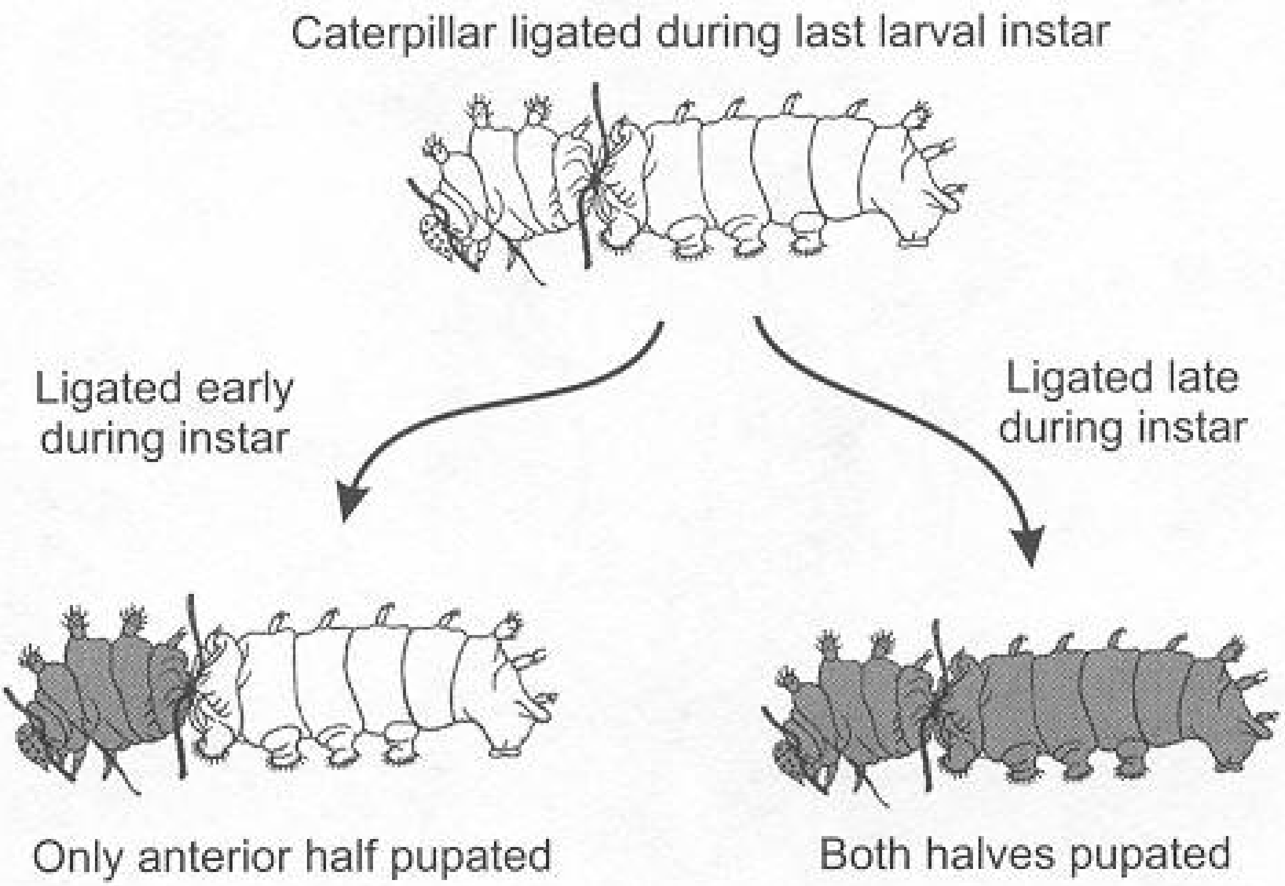
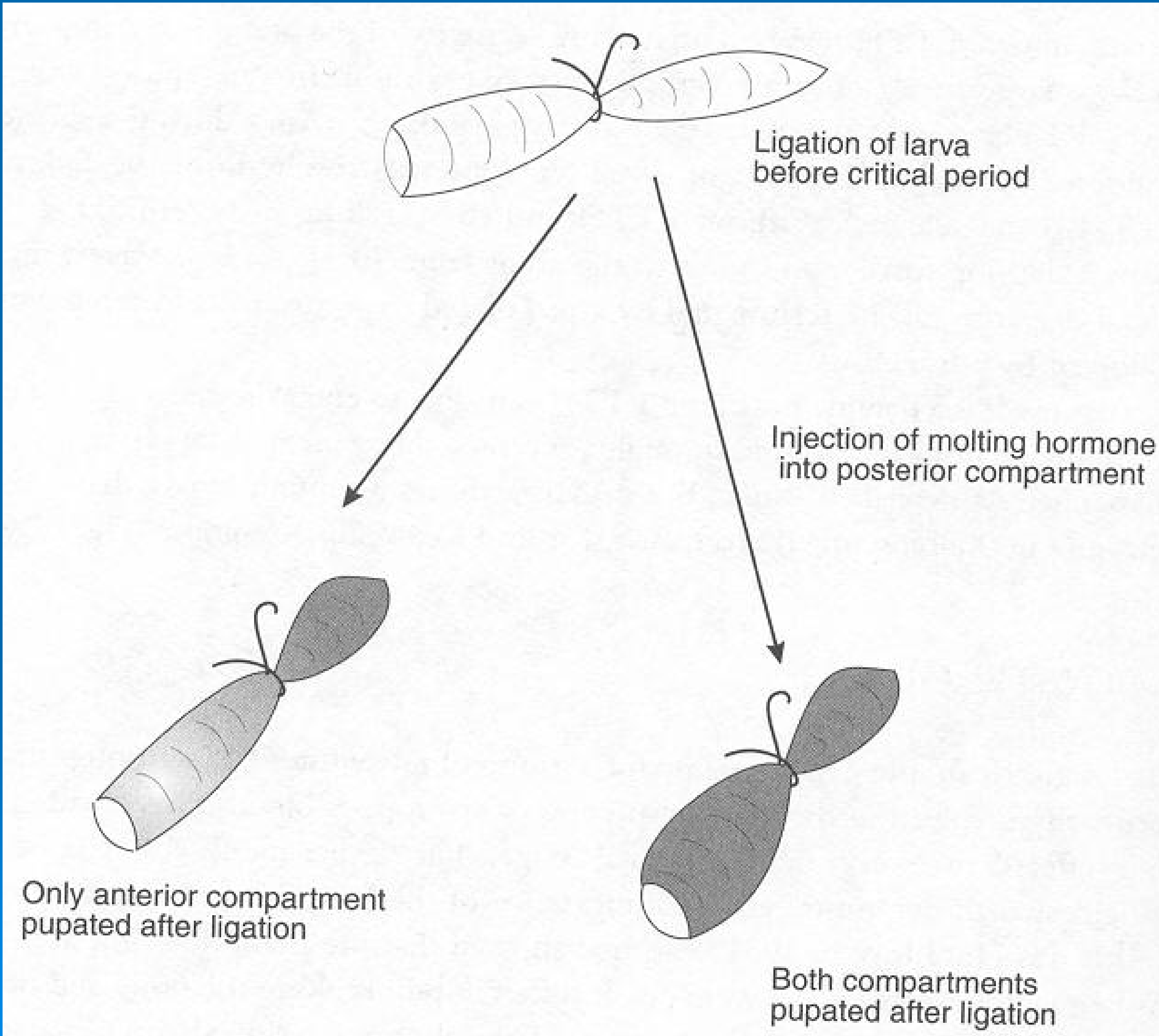


FIGURE 1.2 An experiment performed by Kopeć. When a caterpillar was ligated early during the last larval instar, only the anterior half later pupated. However, when ligated late during the last larval instar, both halves pupated. Adapted from Cymborowski (1992). Reprinted with permission.


Ligation of larva
before critical period
Injection of molting hormone
into posterior compartment
Only anterior compartment
pupated after ligation
Both compartments
pupated after ligation

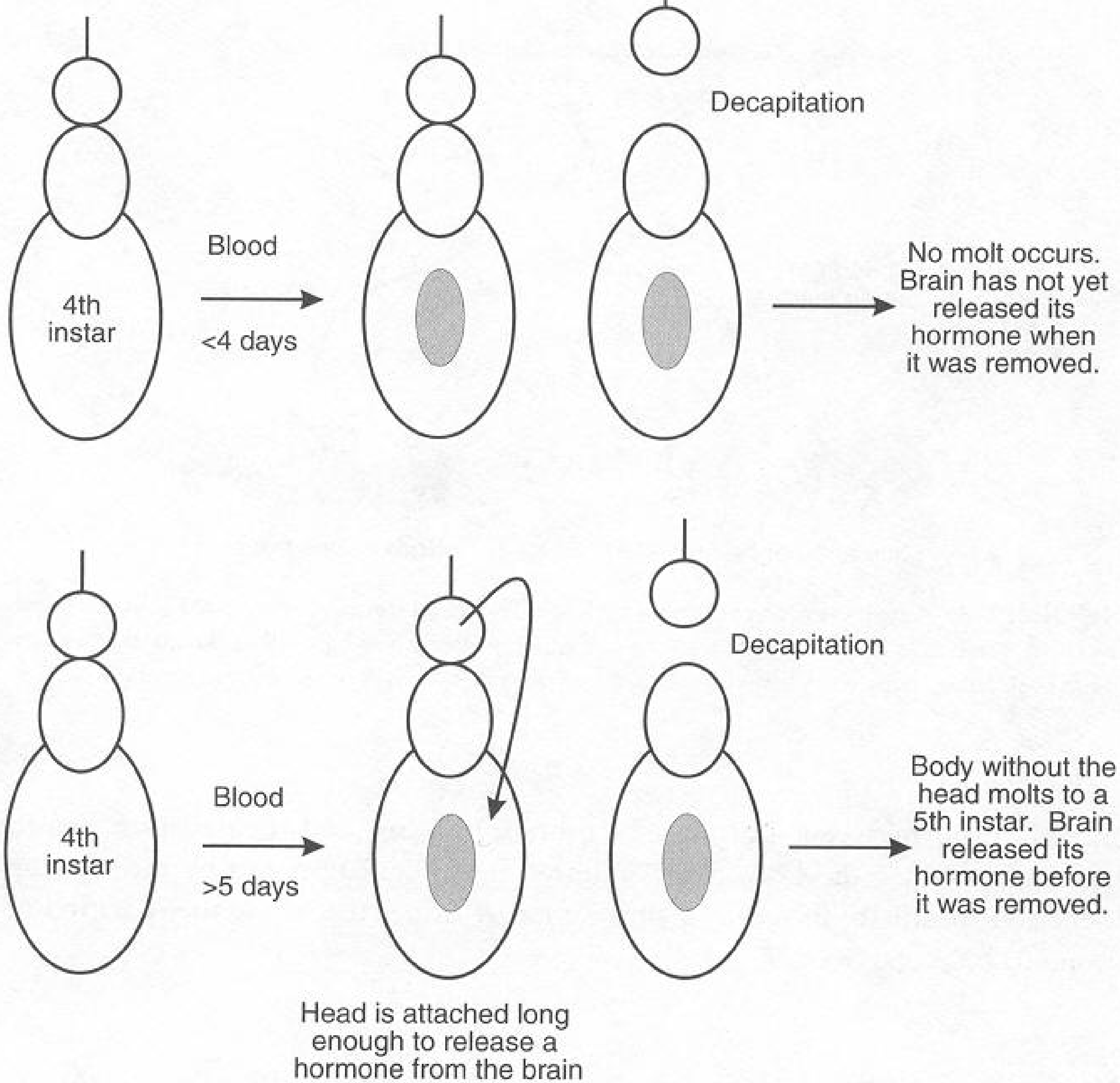
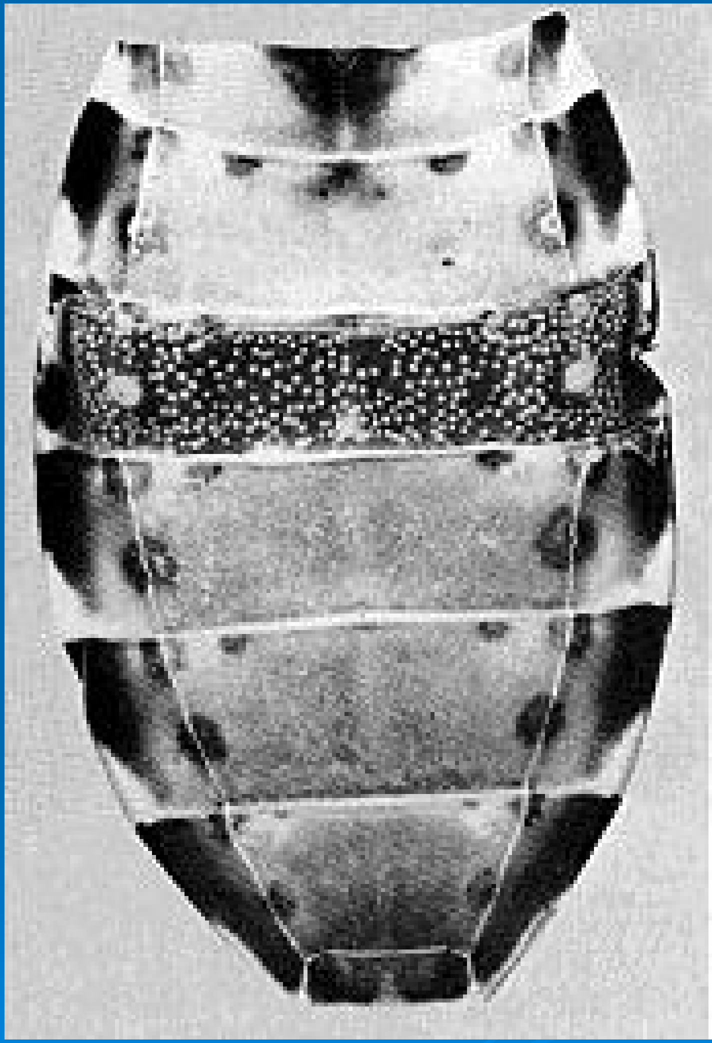
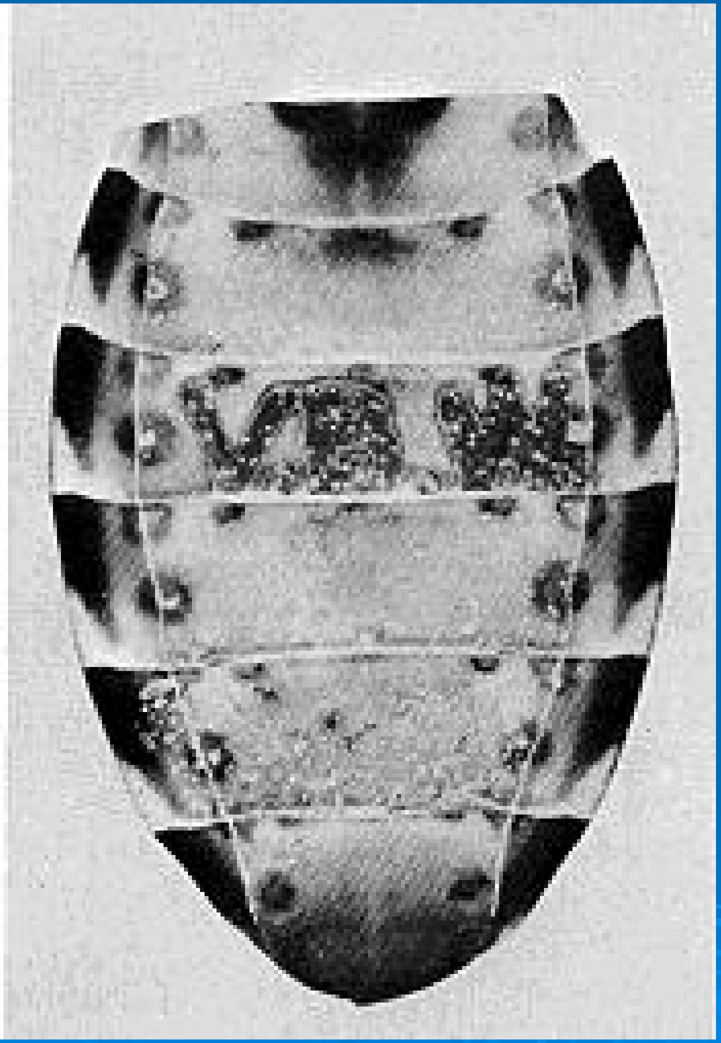


FIGURE 1.3 Wigglesworth's decapitation experiments using *Rhodnius* larvae. When fourth instar larvae were blood fed and decapitated within 4 days, they failed to molt. When they were decapitated after 5 days, the body still molted even though the head was not attached at the time.

Dav přístupy k metamorfóze

A) Změna v sekreci

B) Imaginální disky

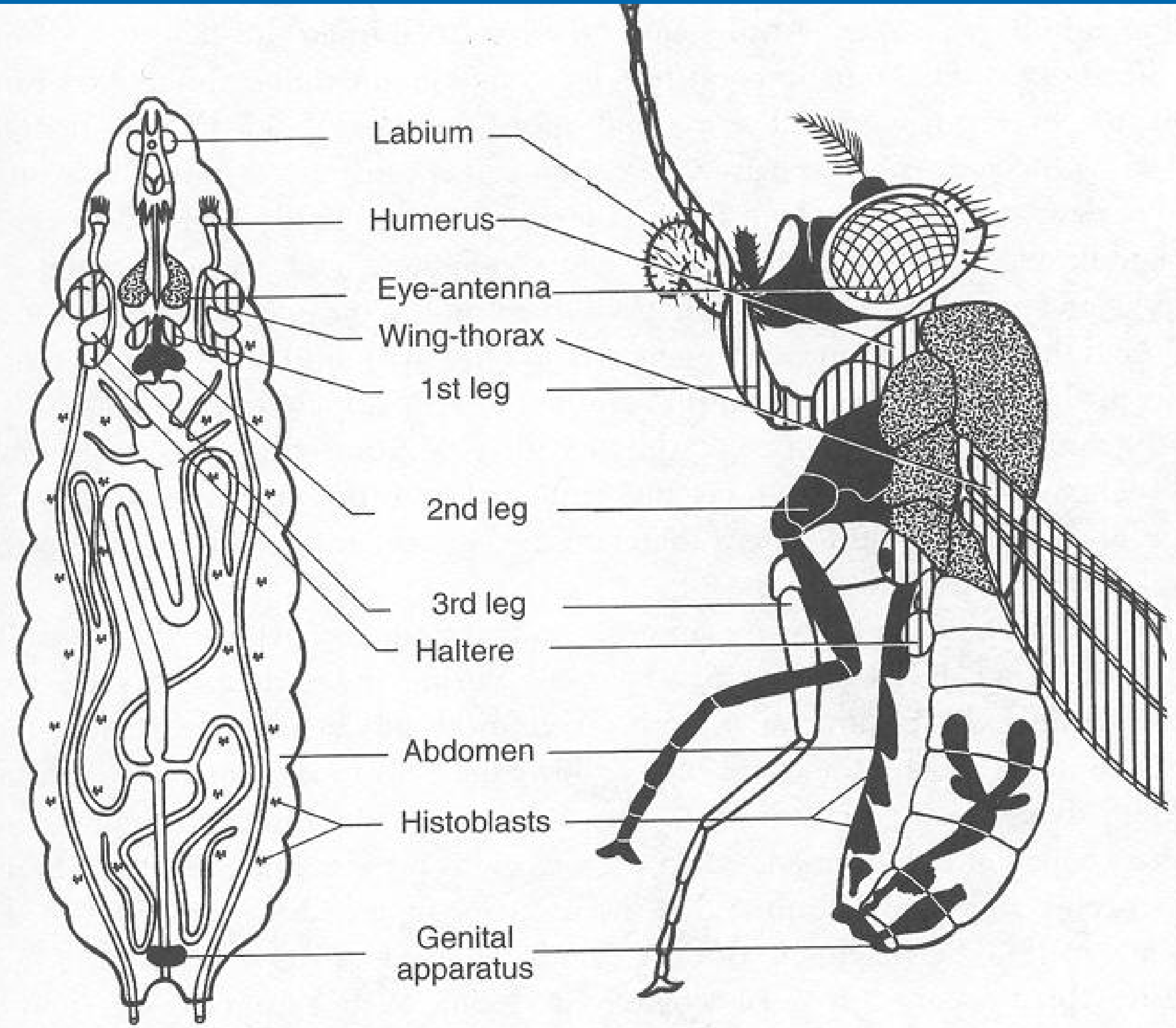
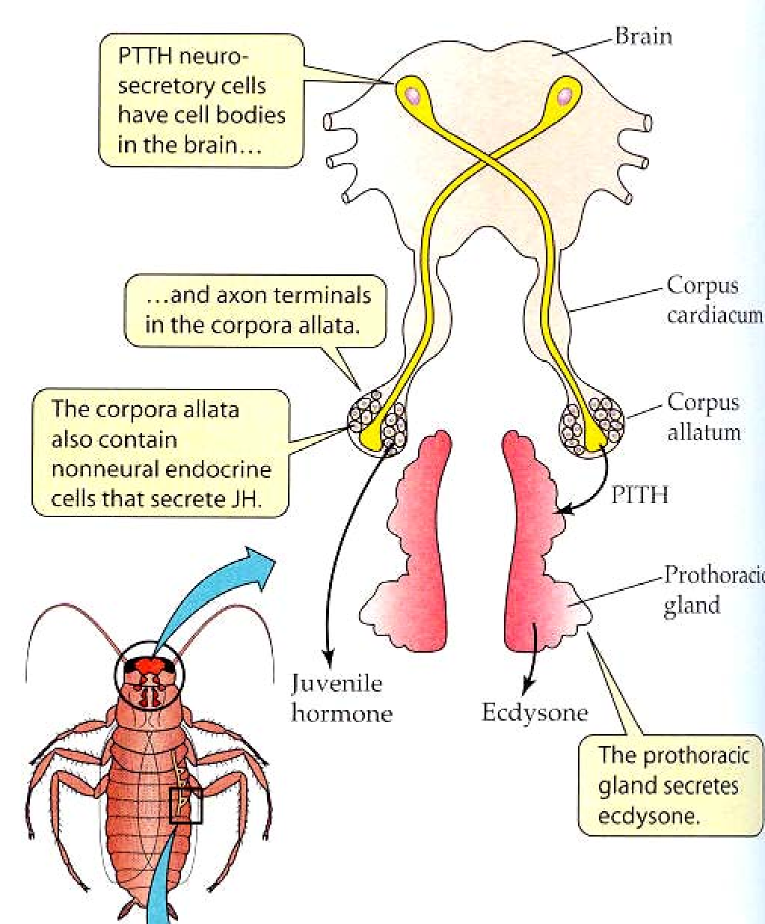
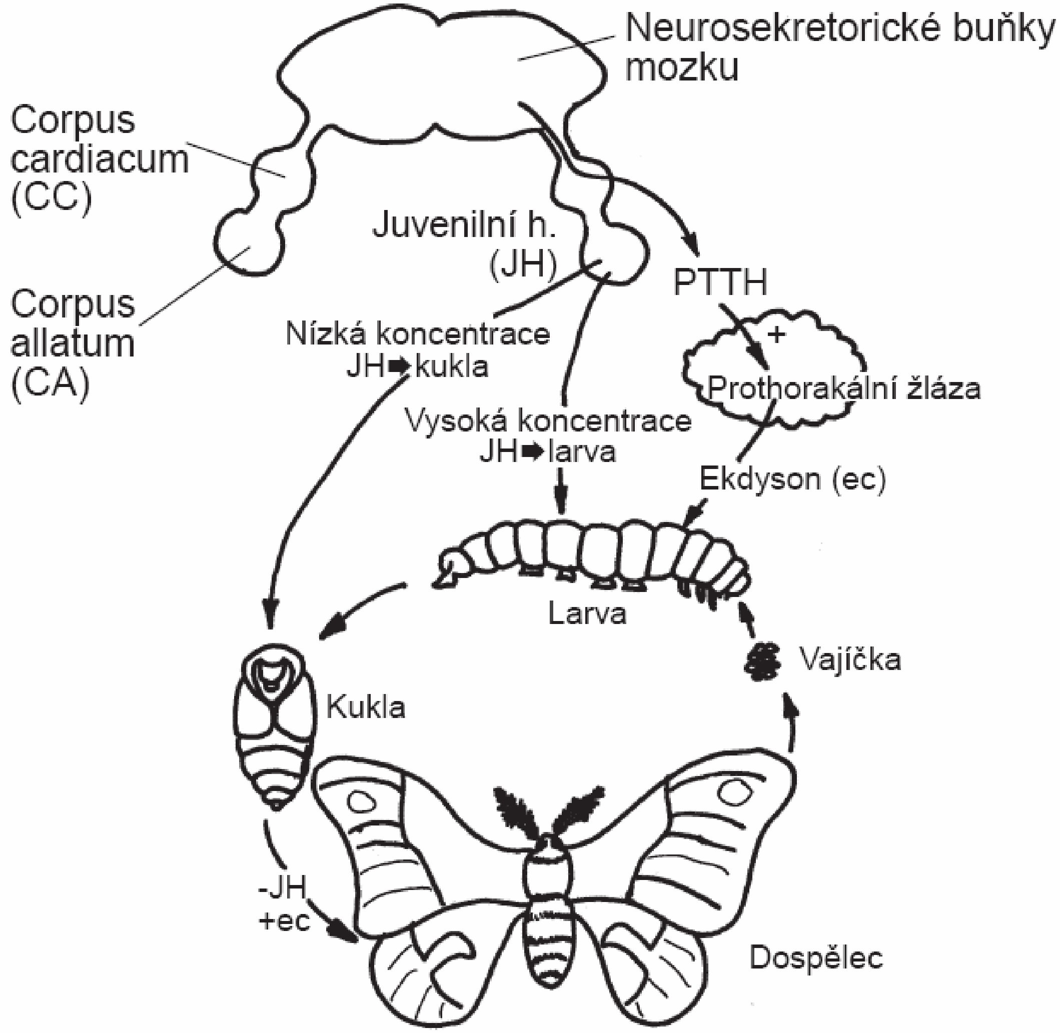


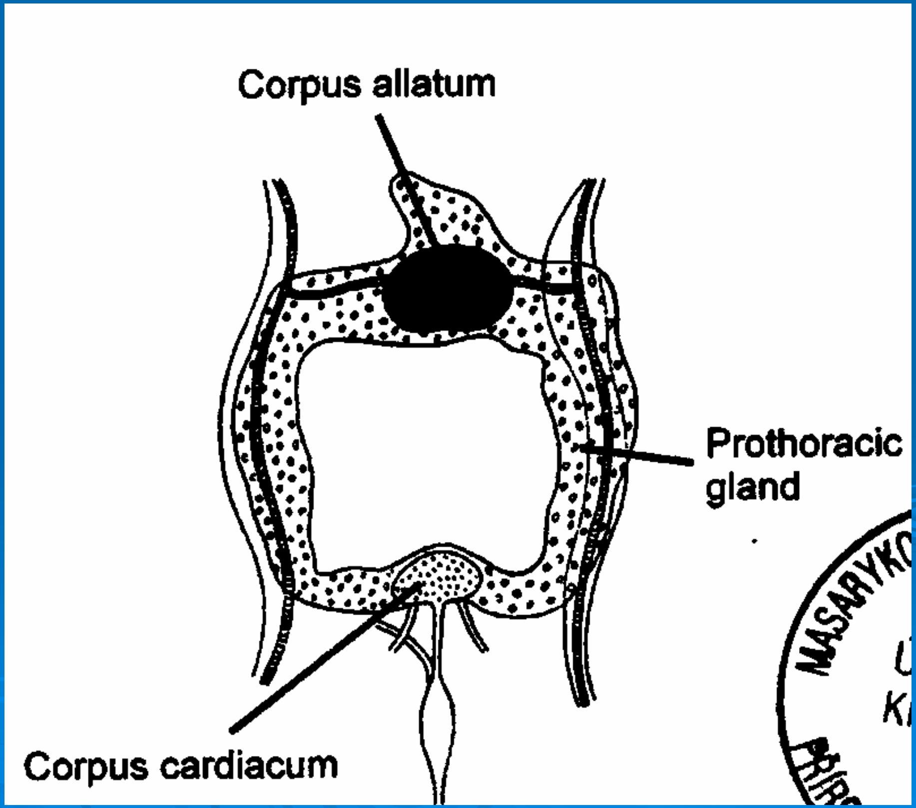
FIGURE 2.22 The imaginal discs of a larval *Drosophila* (left) and the corresponding structures in the adult (right) to which they give rise. From Nothiger (1972). Reprinted with permission.





Obr. 15.5. Hormonální řízení svlékání hmyzu. Produkce ekdysonu z prothorakálních žláz je stimulována protoracikotropním hormonem (PTTH) syntetizovaného v mozku a vylévaného z kardiálních tělísek (CC). Ekdyson iniciuje svlékací děje. Zda se vytvoří kutikula kuklová nebo opět larvální, rozhodne koncentrace juvenilního hormonu (JH). Ten je produkován v tělískách přilehlých (CA).

Prstencovitá žláza u vyšších dipter spojující prothorakální žlázu CC a CA.



PTTH

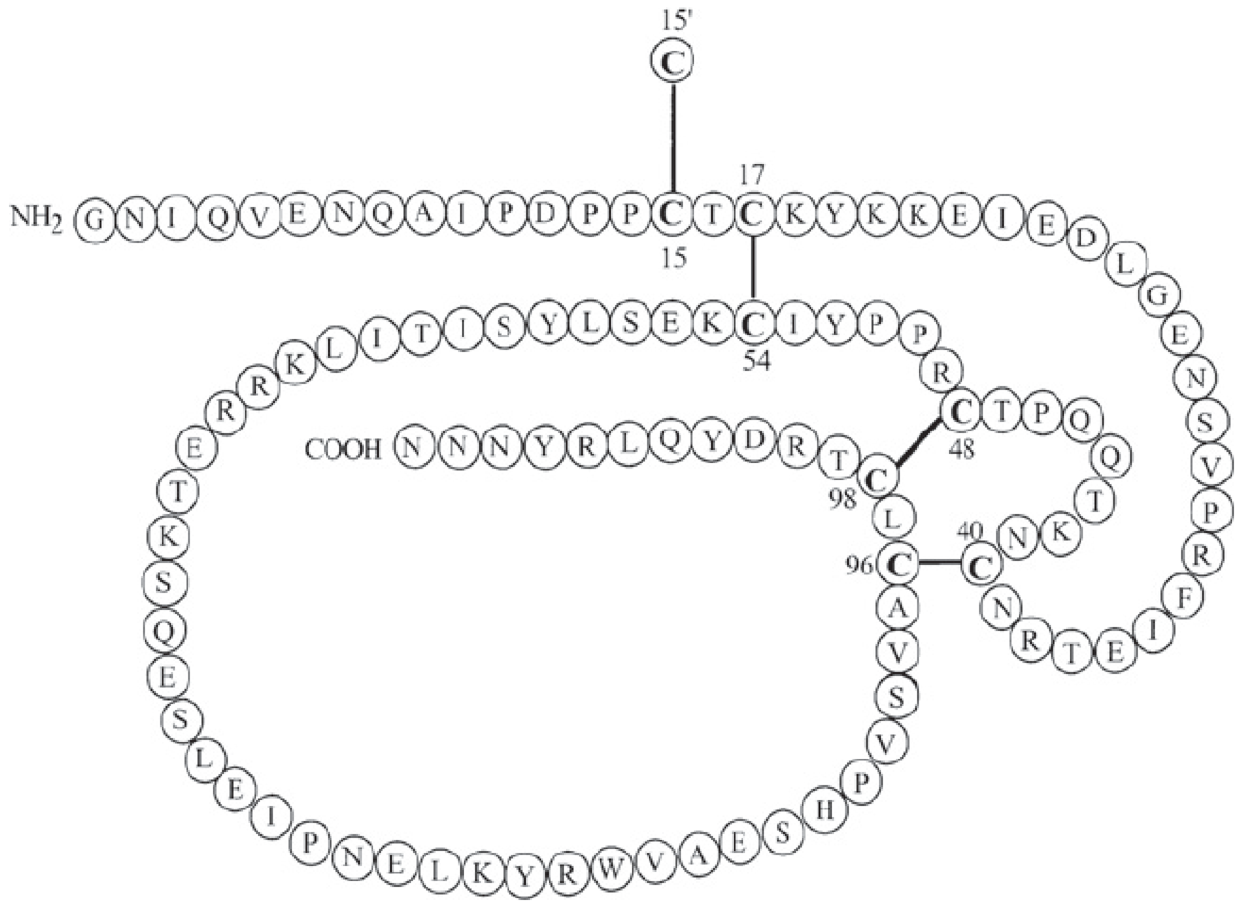


FIGURE 1.14. The amino acid structure of PTTH. Only one of the two identical chains in the homodimer is shown. From Nagata et al. (2005). Reprinted with permission.

http://www.cals.ncsu.edu/course/ent425/tutorial/endocrine.html

TABLE 14.6 Major hormones and neurohormones that control insect metamorphosis

Hormone	Type of molecule	Type of signal	Site of secretion	Major target tissue	Action
Prothoracicotropic hormone (PTTH)	Protein (~5000 molecular weight)	Neuroendocrine	Brain, with axon terminals extending to corpora allata	Prothoracic glands	Initiates molting (ecdysis) by stimulating release of ecdysone from prothoracic glands
Ecdysone (molting hormone)	Steroid	Endocrine	Prothoracic glands in larva/nymph; ovary in adult	Epidermis in larva/nymph; fat body in adult	When activated to 20-hydroxyecdysone, promotes cellular mechanisms to digest old cuticle and synthesize new one; stimulates production of yolk proteins in adult
Juvenile hormone (JH)	Terpene (fatty-acid derivative)	Endocrine	Corpora allata	Epidermis in larva/nymph; ovary in adult	Opposes formation of adult structures and promotes formation of larval/nymphal structures; functions as a gonadotropin in the adult
Eclosion hormone (EH)	Peptide	Neuroendocrine	Brain	Inka cells, possibly others	Promotes PETH and ETH secretion from Inka cells
Pre-ecdysis triggering hormone (PETH)	Peptide	Endocrine	Inka cells of tracheae	Neuronal circuits in brain	Coordinates motor programs to prepare for shedding the cuticle
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Bursicon	Large protein (~35,000 molecular weight)	Neuroendocrine	Brain and nerve cord	Cuticle and epidermis	Tans and hardens new cuticle

Sources: After Randall, Burggren, and French 2002; and Žitňan et al. 2003.

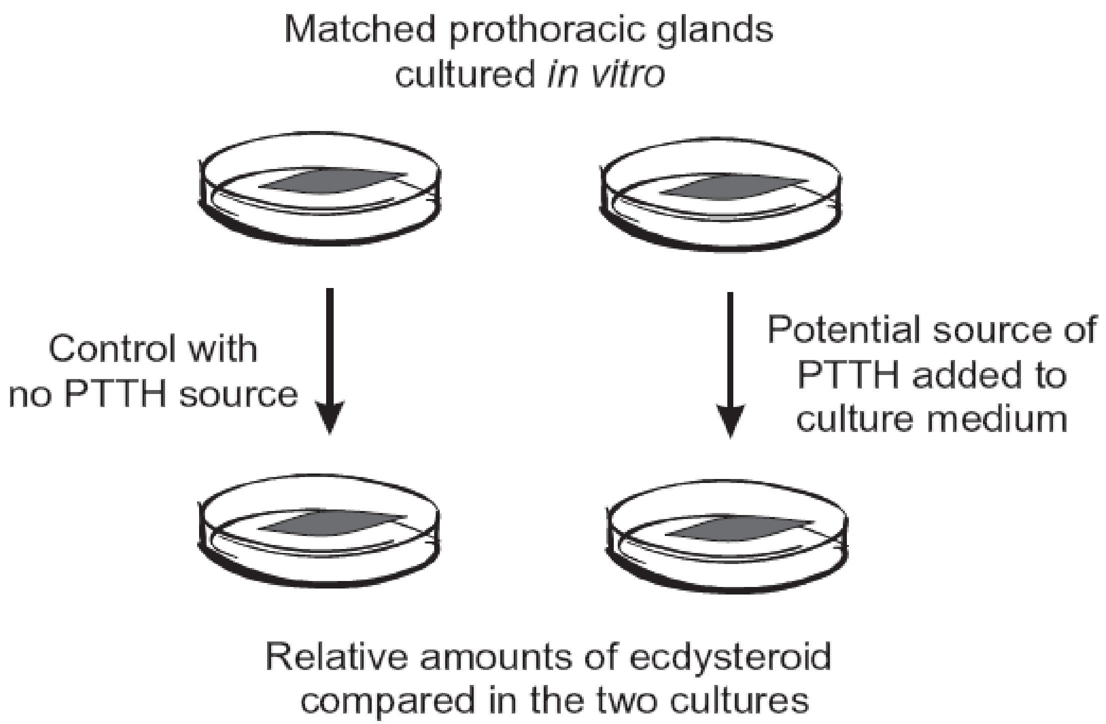
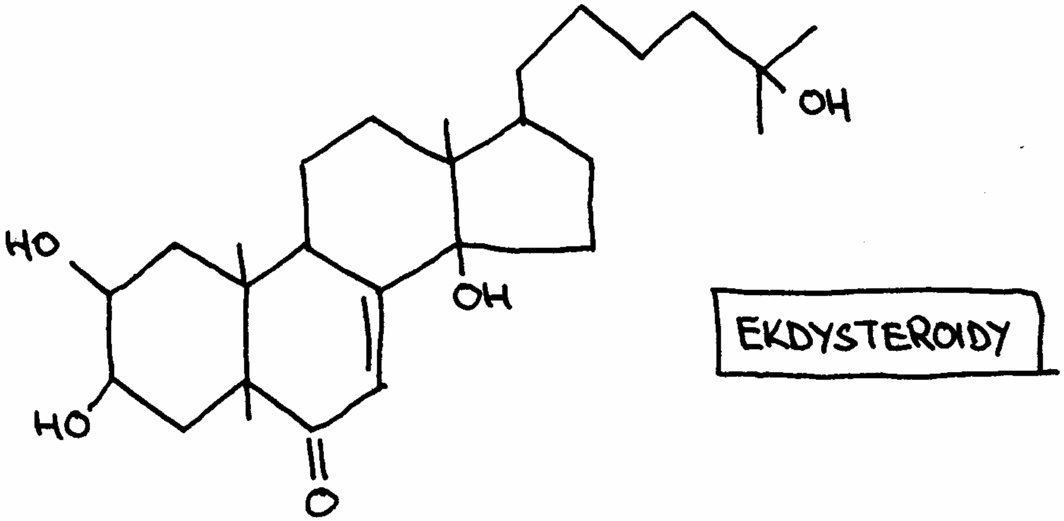


FIGURE 1.13. An assay for PTTH developed by Bollenbacher et al. (1979). A pair of matched prothoracic glands are removed from the insect and placed in culture. If PTTH is added to the culture, the glands produce increased amounts of ecdysteroids into the medium.

Transformace cholesterolu na ekdyson. Ten je v periferních tkáních konvertován na 20-hydroxyekdyson

Ecdysteroidy



Ecdysone = Molting hormone

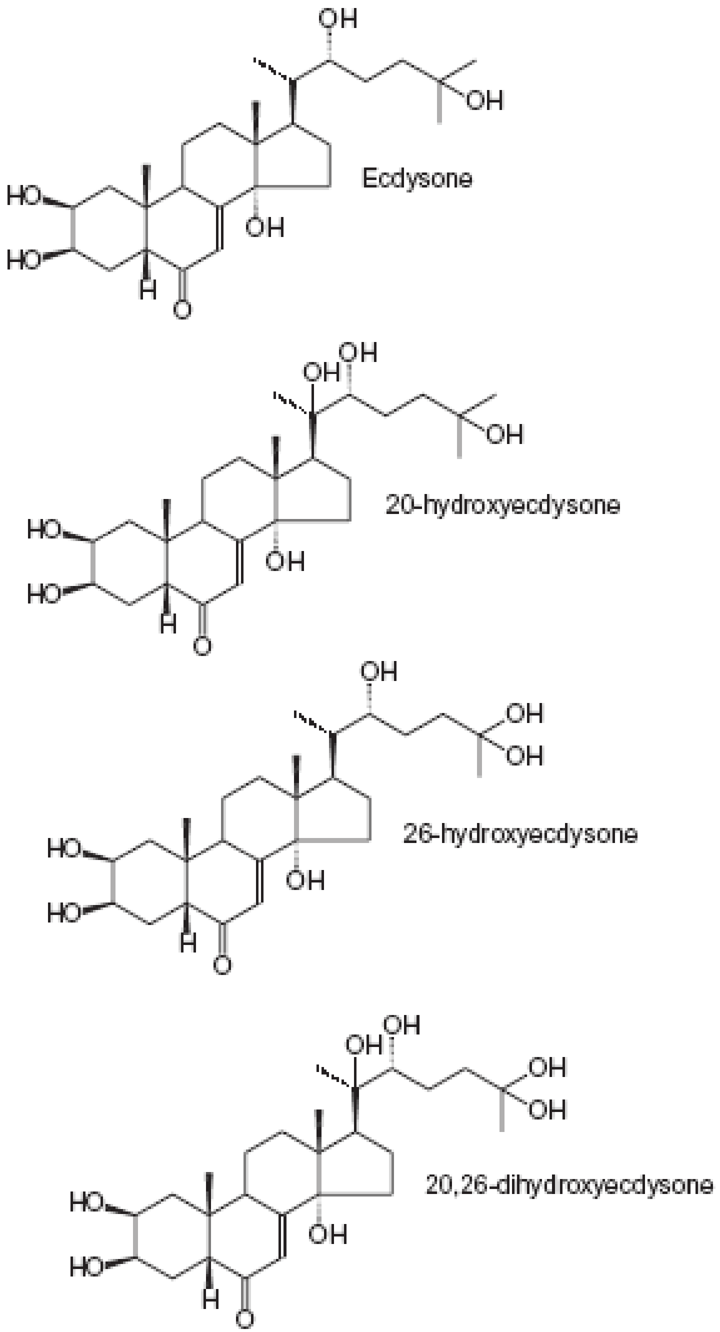


FIGURE 1.17. Some common ecdysteroids.

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Sources: After Randall, Burggren, and French 2002; and Žitňan et al. 2003.

Aktivace genů pod vlivem ecdysteroidů.
In vivo, polyténní chromozómy slinných žlaz

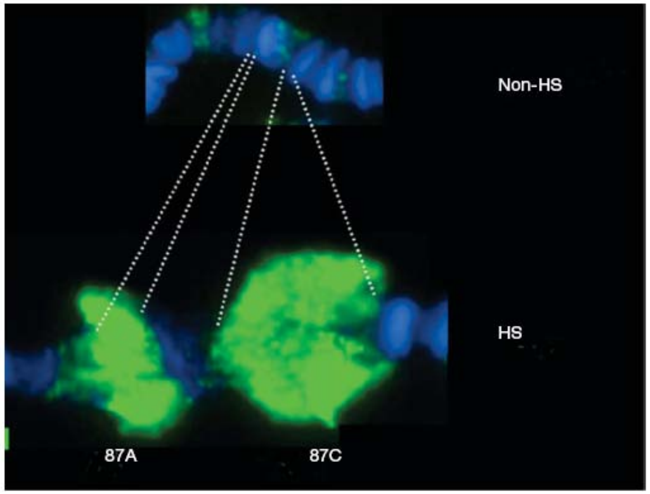
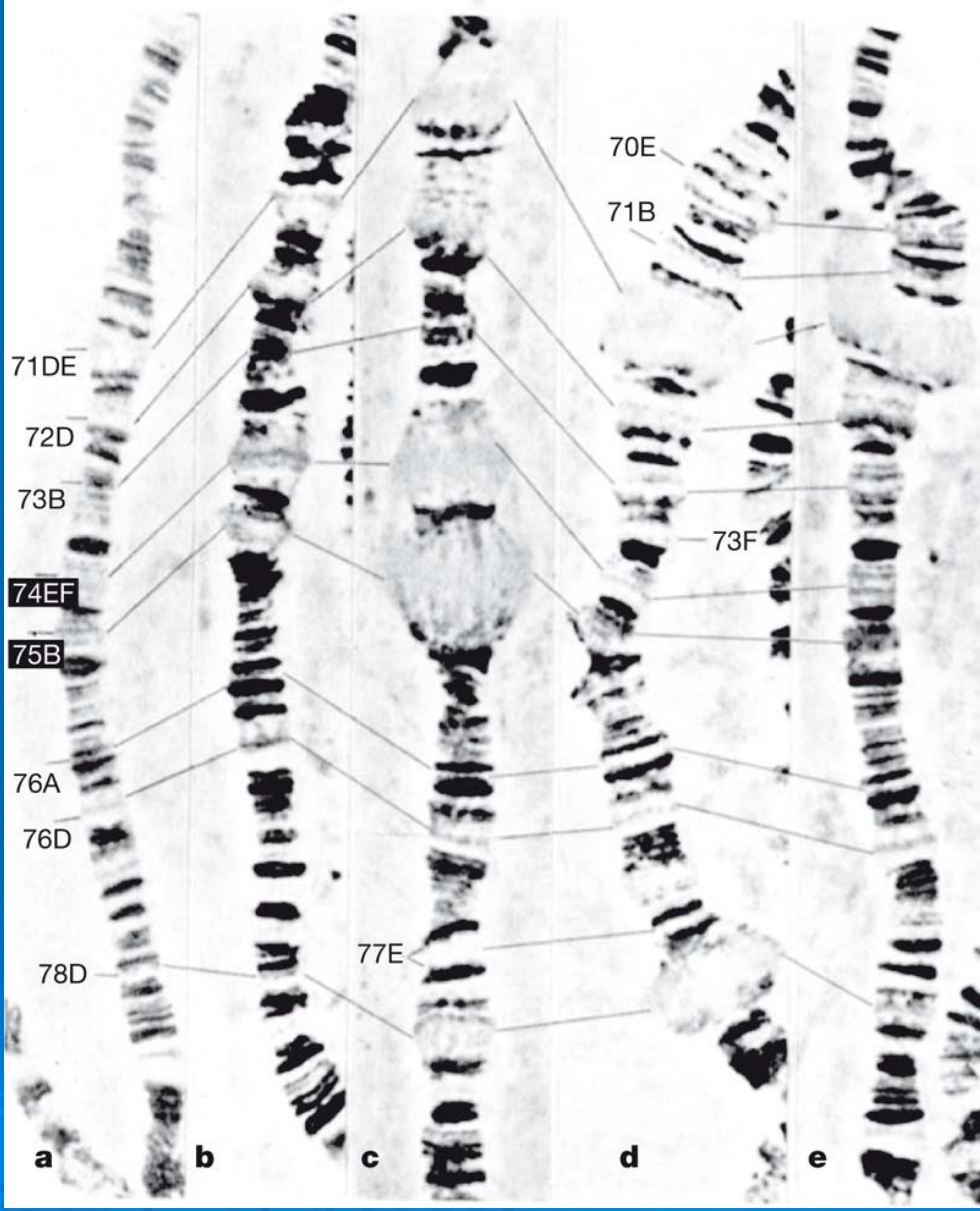


Figure 2 | Heat-shock-induced puffing at major heat shock loci 87A and C. Displayed is a small segment of fixed chromosome 3 before (top) and after (bottom) heat shock. Chromosomes are stained for DNA (Hoeschst dye; blue) and for Pol II (green)[29]. HS, heat shock.



Puffing patterns on chromosome 3L during *Drosophila* larval development

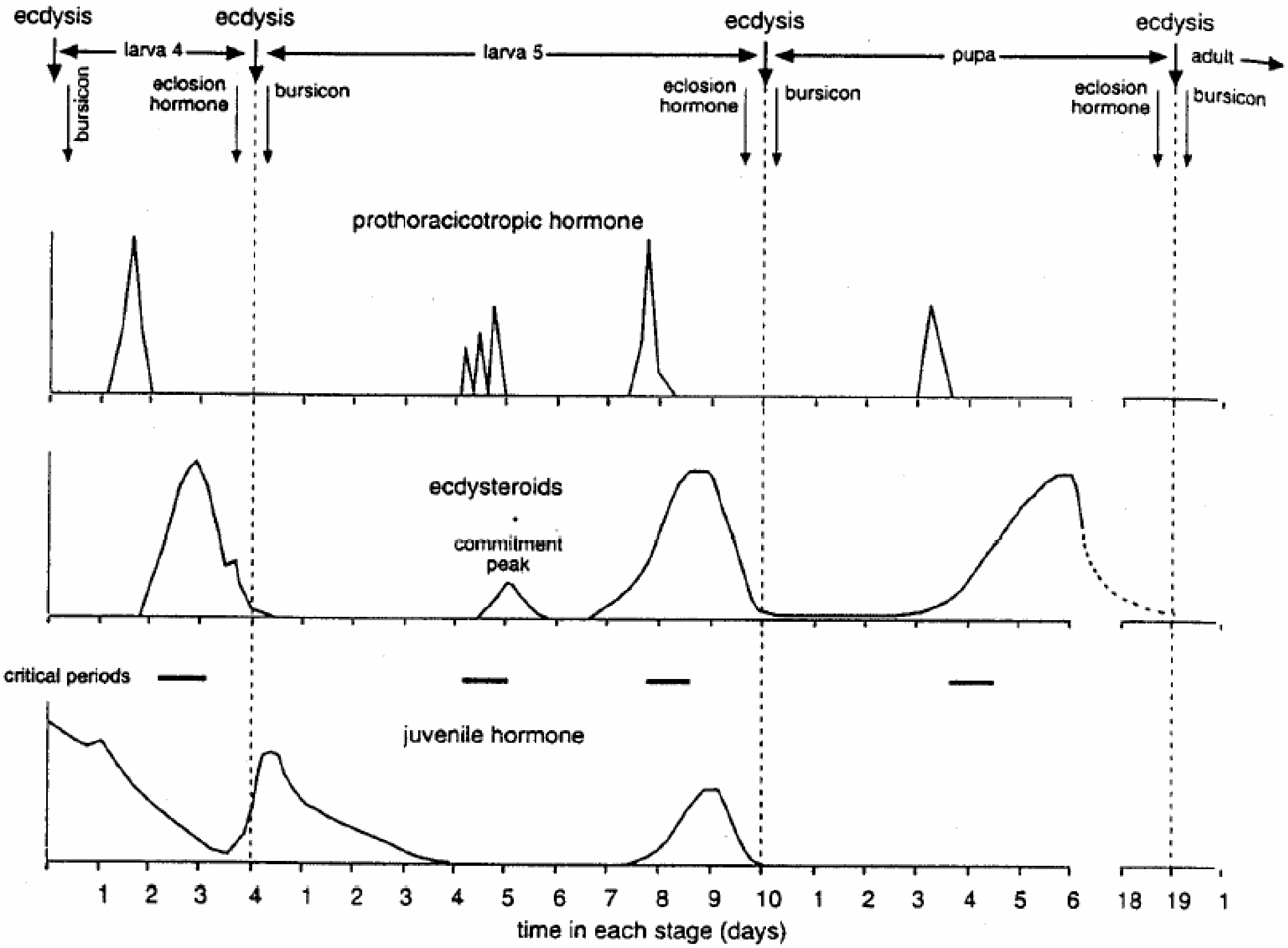
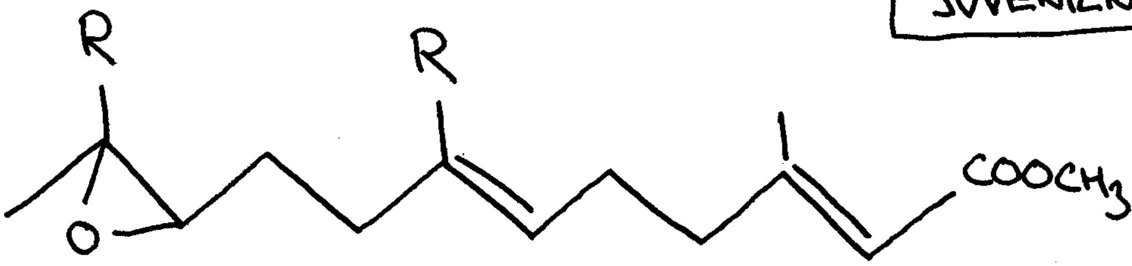
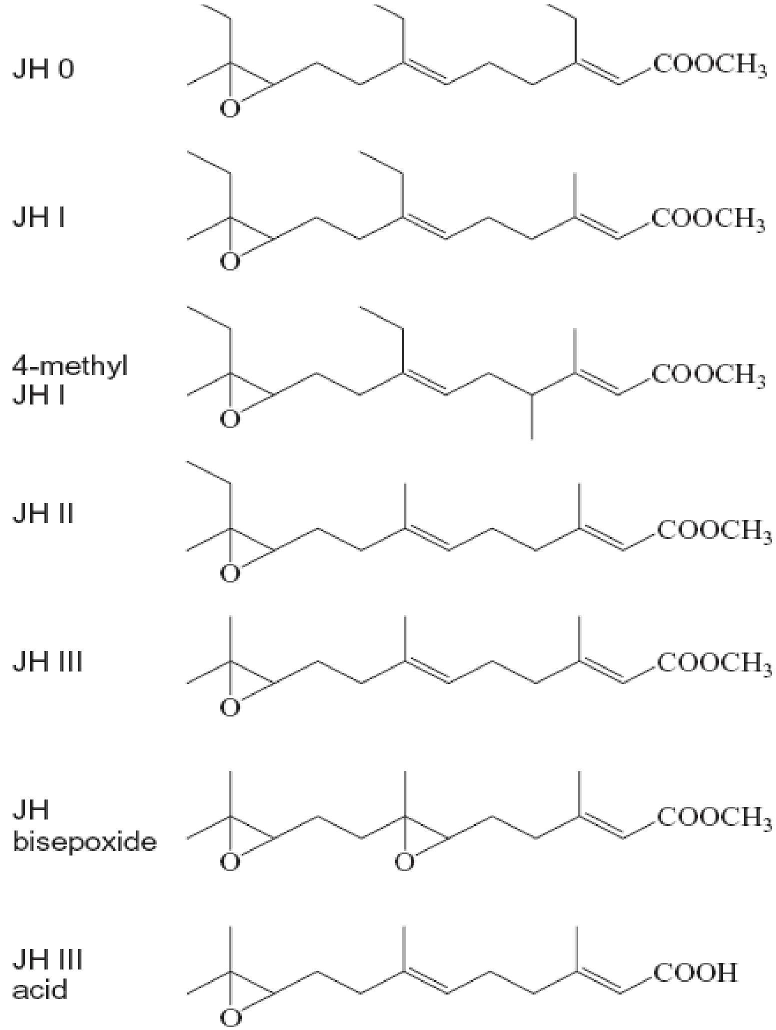


Fig. 15.30. Changes in hormone titers regulating molting and metamorphosis in a holometabolous insect. At the molt from larva to larva, juvenile hormone is present during the critical period; at the molt from larva to pupa, no juvenile hormone is present at the first critical period. The second critical period of sensitivity to juvenile hormone in the fifth stage larva regulates development of the imaginal discs. Eclosion hormone and bursicon are produced for a brief period before and after each ecdysis (based on data for *Manduca*, Lepidoptera).

JUVENILNÍ HORMON



Juvenoidy



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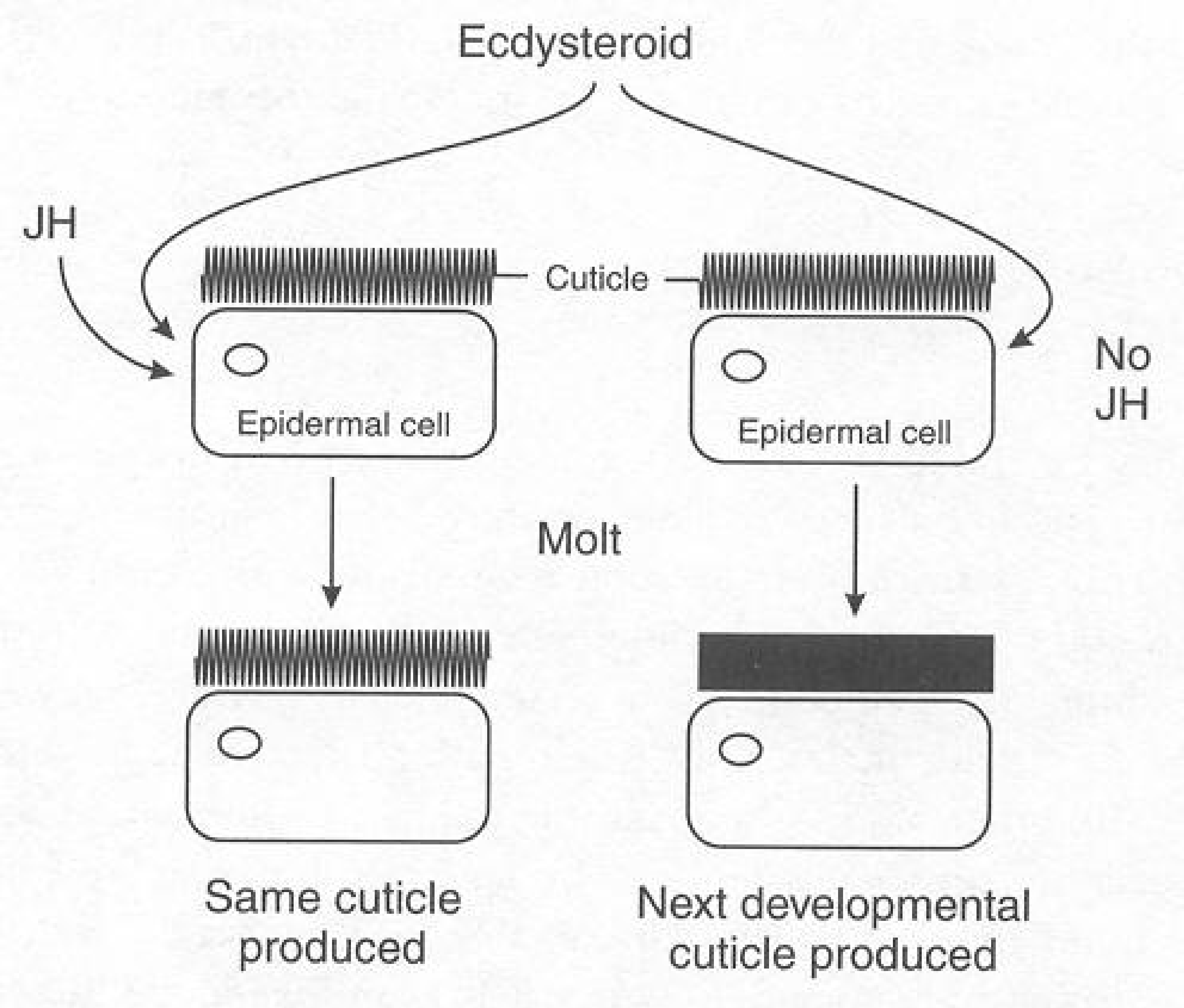

Ecdysteroid
JH
Cuticle
No
JH
Epidermal cell
Epidermal cell
Molt
Same cuticle
produced
Next developmental
cuticle produced

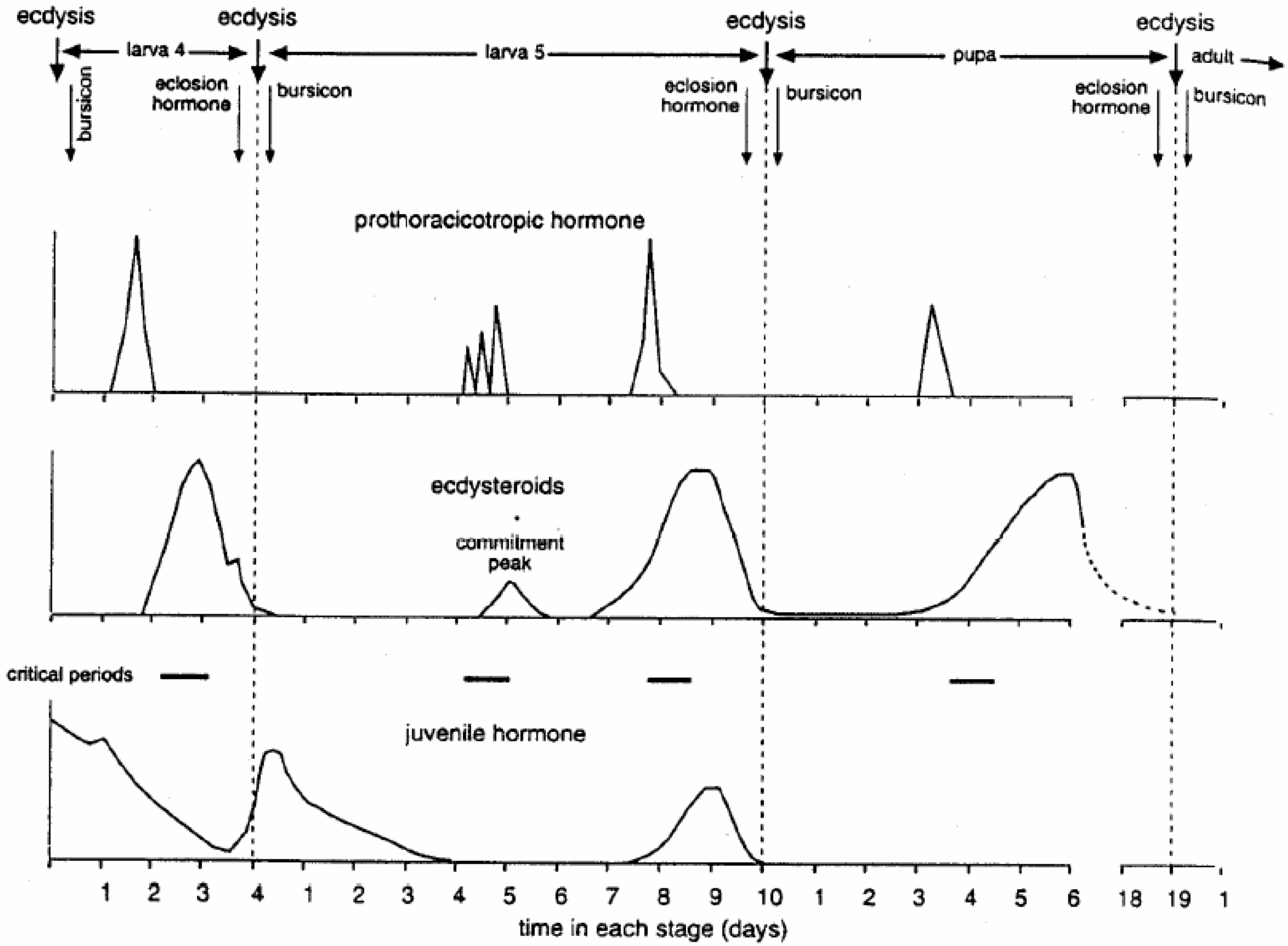


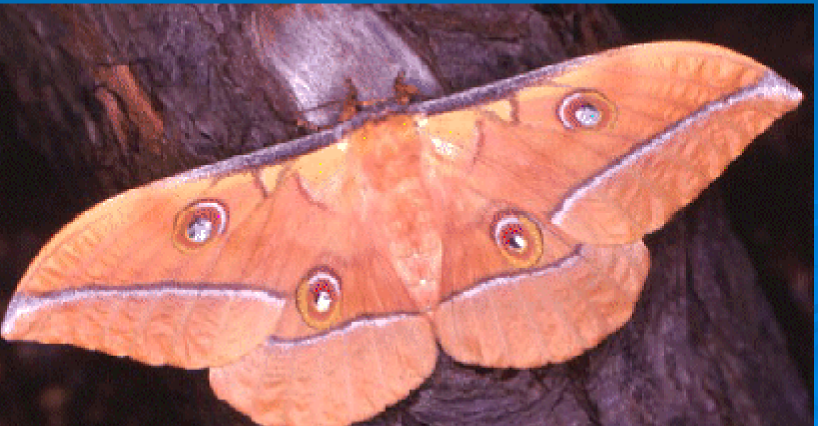
Fig. 15.30. Changes in hormone titers regulating molting and metamorphosis in a holometabolous insect. At the molt from larva to larva, juvenile hormone is present during the critical period; at the molt from larva to pupa, no juvenile hormone is present at the first critical period. The second critical period of sensitivity to juvenile hormone in the fifth stage larva regulates development of the imaginal discs. Eclosion hormone and bursicon are produced for a brief period before and after each ecdysis (based on data for *Manduca*, Lepidoptera).

Eklozní hormon

Nastavení času líhnutí.

Hyalophora cecropia
Ekloze ráno

Antherea pernyi
Ekloze večer



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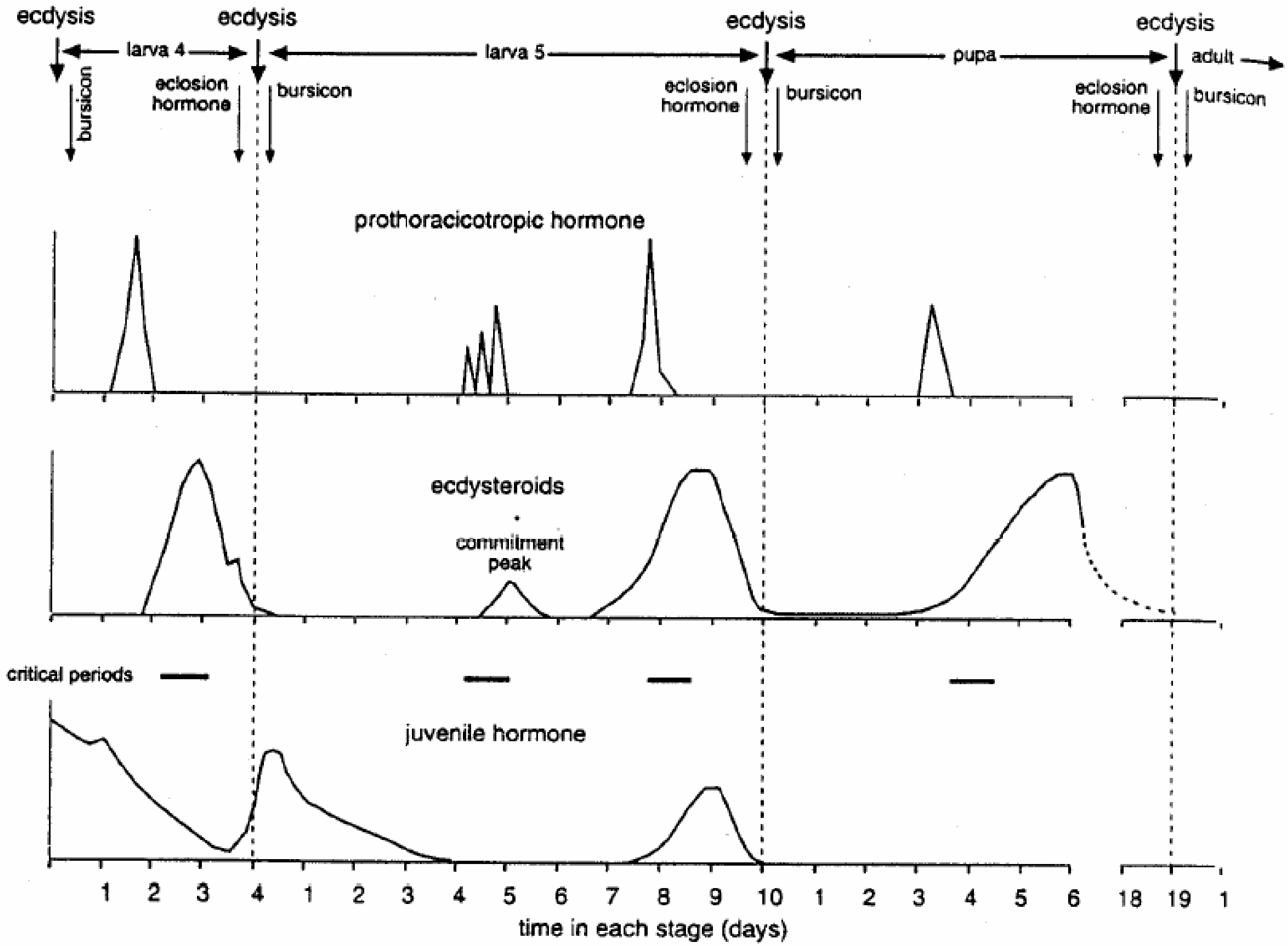

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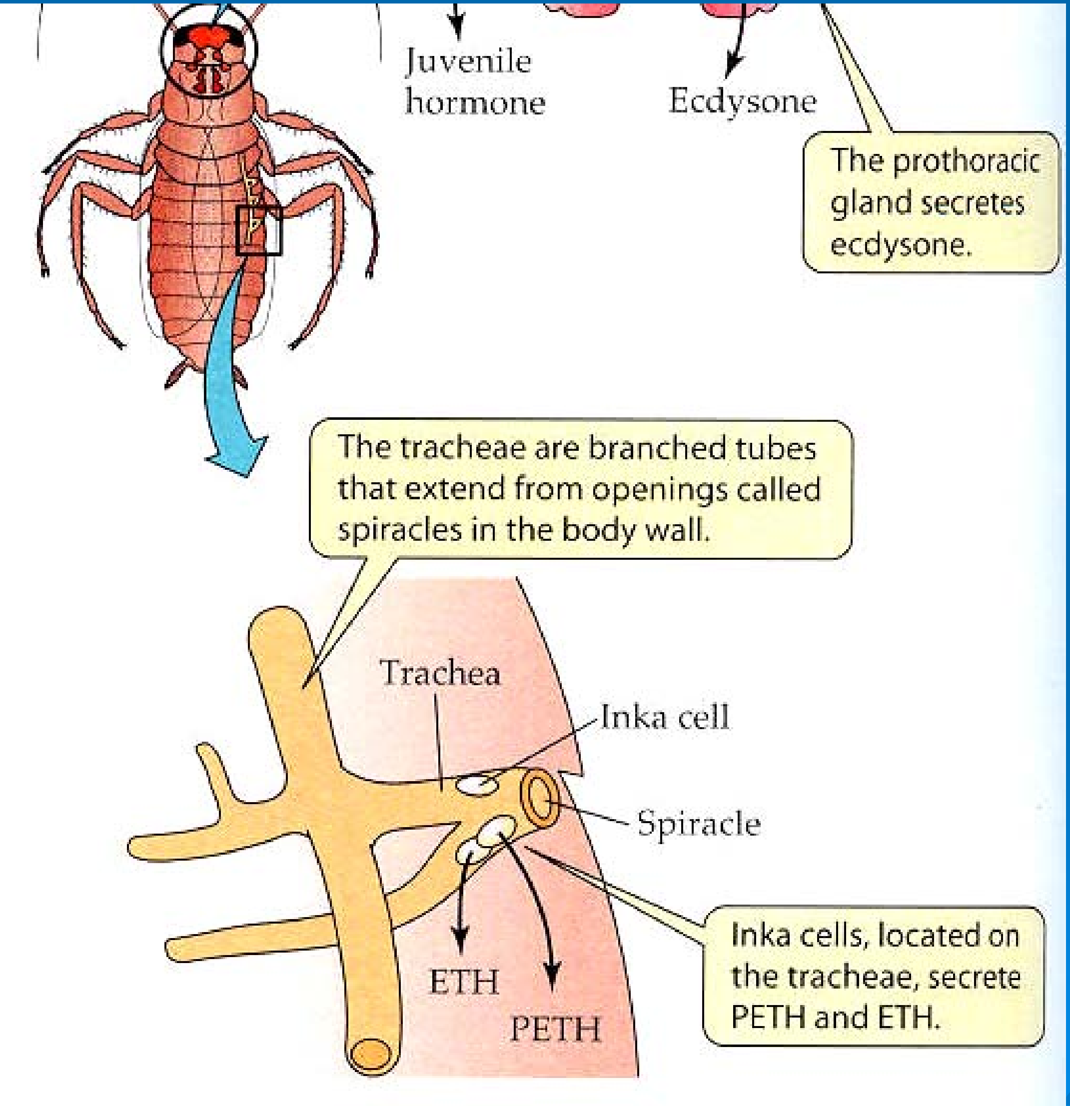
Epitracheální žlázy



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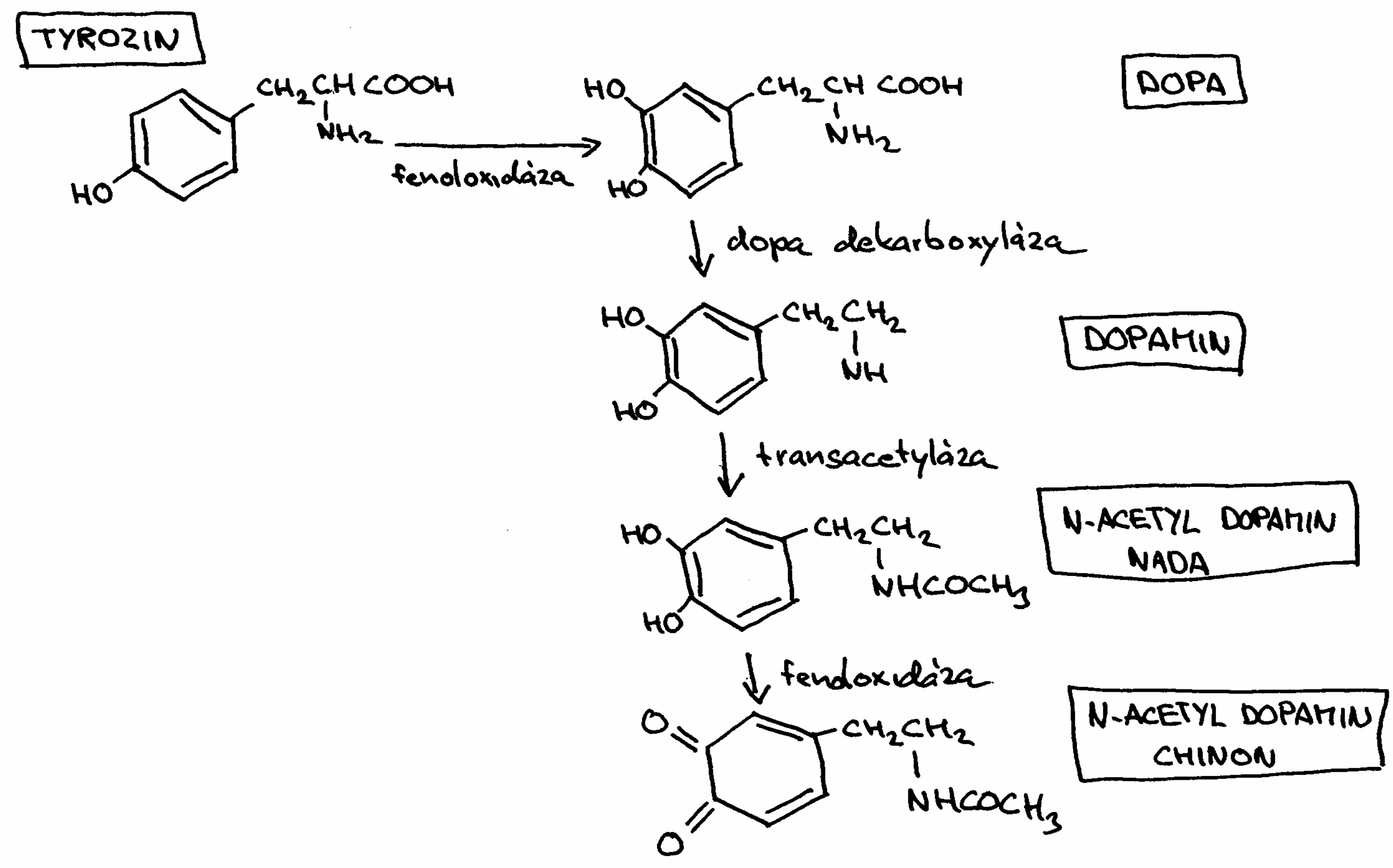
Ecdysis triggering hormone (ETH)	Peptide	Endocrine	Inka cells of tracheae	Neuronal circuits in brain	Coordinates final motor programs for escaping from old cuticle
Bursicon	Large protein (~35,000 molecular weight)	Neuroendocrine	Brain and nerve cord	Cuticle and epidermis	Tans and hardens new cuticle

Sources: After Randall, Burggren, and French 2002; and Žitňan et al. 2003.

Bursicon, vytvrzovací hormon

Reguluje syntézu fenoloxydázových enzymů.
Fenoloxidázová kaskáda



Ptilinum mouchy Tsetse (*Glossina morsitans morsitans)*

TABLE 14.6 Major hormones and neurohormones that control insect metamorphosis

Hormone	Type of molecule	Type of signal	Site of secretion	Major target tissue	Action
Prothoracicotropic hormone (PTTH)	Protein (~5000 molecular weight)	Neuroendocrine	Brain, with axon terminals extending to corpora allata	Prothoracic glands	Initiates molting (ecdysis) by stimulating release of ecdysone from prothoracic glands
Ecdysone (molting hormone)	Steroid	Endocrine	Prothoracic glands in larva/nymph; ovary in adult	Epidermis in larva/nymph; fat body in adult	When activated to 20-hydroxyecdysone, promotes cellular mechanisms to digest old cuticle and synthesize new one; stimulates production of yolk proteins in adult
Juvenile hormone (JH)	Terpene (fatty-acid derivative)	Endocrine	Corpora allata	Epidermis in larva/nymph; ovary in adult	Opposes formation of adult structures and promotes formation of larval/nymphal structures; functions as a gonadotropin in the adult
Eclosion hormone (EH)	Peptide	Neuroendocrine	Brain	Inka cells, possibly others	Promotes PETH and ETH secretion from Inka cells
Pre-ecdysis triggering hormone (PETH)	Peptide	Endocrine	Inka cells of tracheae	Neuronal circuits in brain	Coordinates motor programs to prepare for shedding the cuticle
Ecdysis triggering hormone (ETH)	Peptide	Endocrine	Inka cells of tracheae	Neuronal circuits in brain	Coordinates final motor programs for escaping from old cuticle
Bursicon	Large protein (~35,000 molecular weight)	Neuroendocrine	Brain and nerve cord	Cuticle and epidermis	Tans and hardens new cuticle

Sources: After Randall, Burggren, and French 2002; and Žitňan et al. 2003.

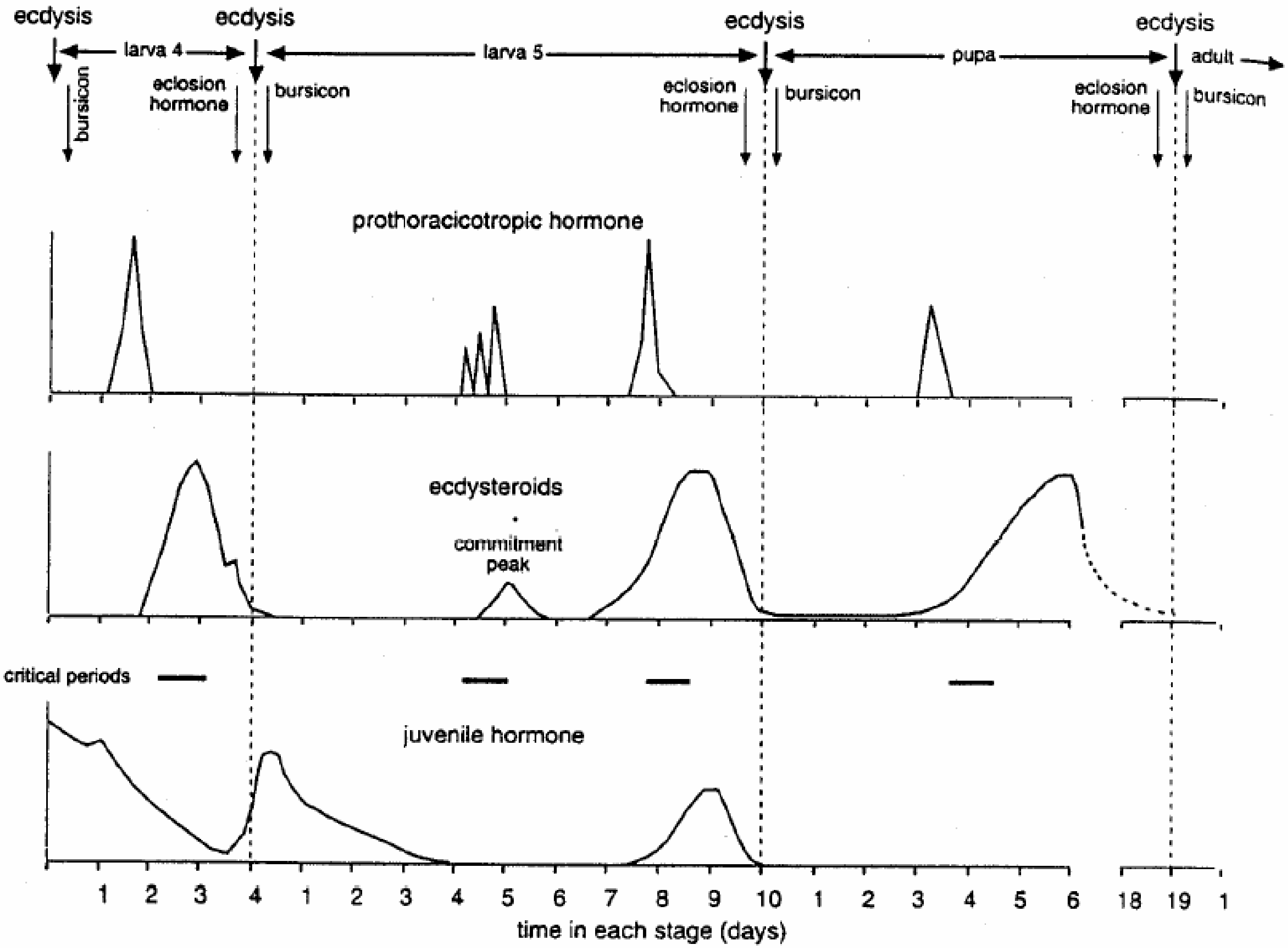


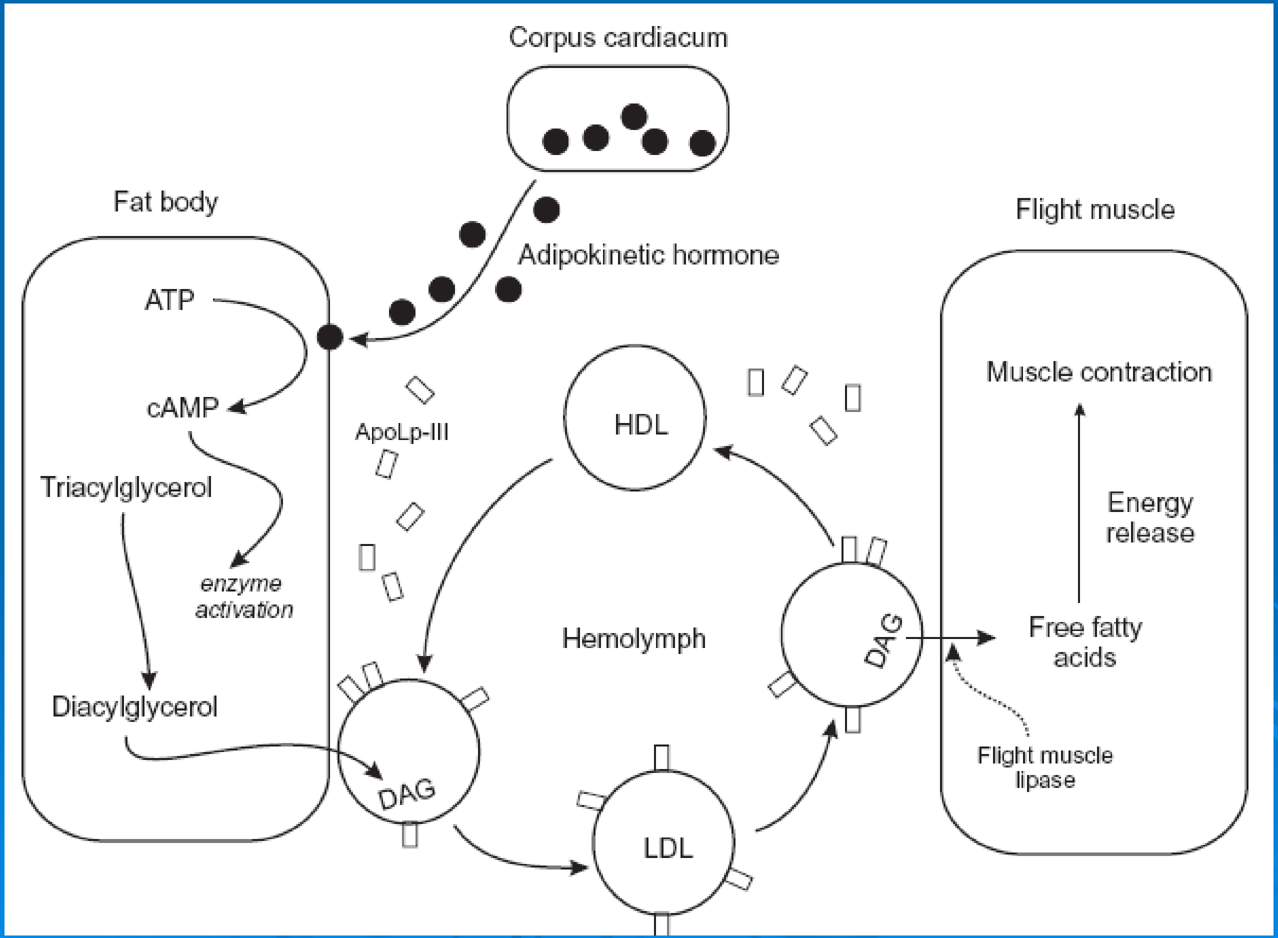
Fig. 15.30. Changes in hormone titers regulating molting and metamorphosis in a holometabolous insect. At the molt from larva to larva, juvenile hormone is present during the critical period; at the molt from larva to pupa, no juvenile hormone is present at the first critical period. The second critical period of sensitivity to juvenile hormone in the fifth stage larva regulates development of the imaginal discs. Eclosion hormone and bursicon are produced for a brief period before and after each ecdysis (based on data for *Manduca*, Lepidoptera).

Hormony a metabolismus

Přehled hmyzích hormonů
1. Ekdysteroidy - ekdyson, 20-hydroxyekdyson (20-E), makisteron A (=24-metyl-20E), 2-deoxyekdyson, 26-hydroxyekdyson a další
2. Juvenilní hormony JH-I, JH-II, JH-III, JH-0, 4-metyl-JH-I, kyselina juvenilního hormonu
3. Peptidické neurohormony **I. Hormony řídící metabolismus a homeostázu** 1. Adipokinetické hormony (AKH) a hypertrehalosemické hormony 2. Diuretické hormony 3. Antidiuretické hormony 4. Chloride transport stimulating hormone a ion transport peptide **II. Hormony řídící metamorfózu, vývoj a růst** 1. Prothoracikotropní hormon (PTTH) a bombyxin 2. prothoracikostatický hormon (PTSH) 3. Allatostatiny a allatotropin 4. PBAN I, II, III (pheromone biosynthesis activating neuropeptide) 5. Eklozní hormon a *ecdysis triggering hormone (ETH)* 6. Burzikon 7. Faktory regulující puparizaci much 8. Diapauzní hormon **III. Hormony řídící pohlavní funkce** 1. stimulační gonádotropní neurohormony (gonadotropiny): - ovary maturing parsin (OMP) - egg development neurohormone (EDNH) (=ovarian ecdysteroidogenic factor) 2. inhibiční neurohormony (antigonadotropiny, folikulostatiny): - neuroparsin - oostatické hormony a TMOF (trypsin-modulating oostatic factor) **VI. Hormony modifikující svalovou kontrakci (myotropní peptidy)** 1. Proctolin 2. Kardiostimulační hormony - crustacean cardioactive peptide (CCAP) 3. Skupiny myotropních neurohormonů - myokininy, sulfakininy, pyrokininy, tachykininy, myoinhibiční peptidy, periviscerokininy, FMRF-amid **V. Hormony řídící barvoměnu (chromatotropiny)** 1. PDF - pigment dispersing factor 2. MRCH - melanization and reddish coloratig hormone (identický s PBAN)

AKH - adipokinetický hormon

Mobilizace lipidů pro dlouhý let sarančе.

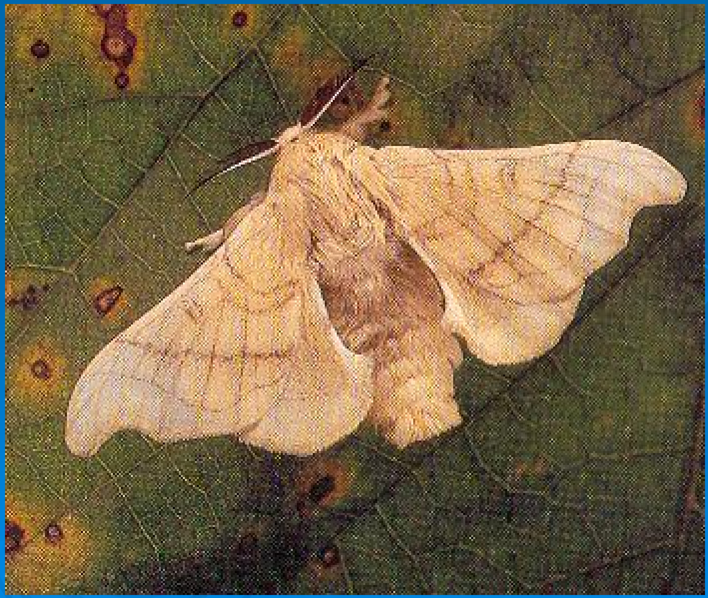


Další hormony řídí funkce ovárií, vitelogenezi, embryogenezi,

Chování.

Řada hormonů známých od obratlovců ale v jiné funkci (inzulín, gastrin, somatostatin, glukagon, melatonin).

Diapauzní hormon



Feromony – exokrinní,

vábení opačného pohlaví a spuštění sexuálního chování	- sexuální feromony
vábení obou pohlaví dohromady	- agregační feromony
poplach	- poplachové feromony
rozptýlení po okolí	- disperzní feromony
tah	- migrační feromony

synchronizace vývoje (akcelerace nebo inhibice)	- maturační feromony
inhibice ovárií	- substance královny
určení kast (u larev termitů) nebo změny v chování včelích dělnic z úlových včel - kojiček-3, stavitelek-4, čističek-1, krmičky-2, strażkyně5 na létavky-6.	- modifikátory kast