Endocrine System

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Intercellular Information Flow

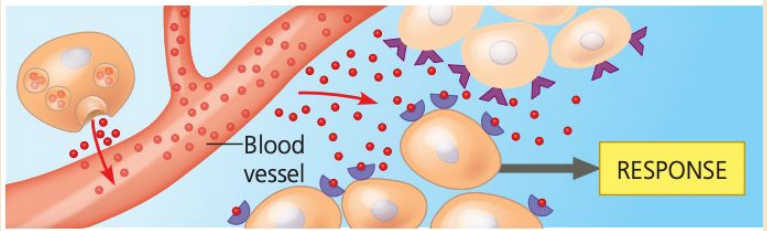
Endocrine Signaling

Type of secreting cell: endocrine cells

Reaches target by: blood or hemolymph

Function

- Maintain homeostasis
    - Blood pressure and volume, metabolism, solute concentrations
- Responses to environmental stimuli
- Growth and development
- Reproduction



(a) In **endocrine signaling**, secreted molecules diffuse into the bloodstream and trigger responses in target cells anywhere in the body.

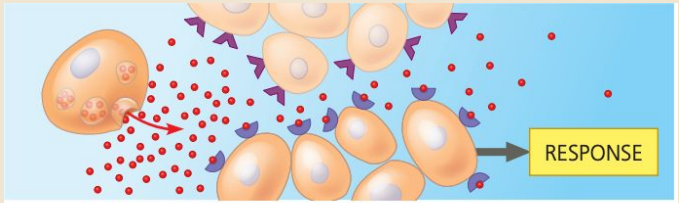
Paracrine & Autocrine Signaling

Type of secreting cell: those that make local regulators (that work for short distances)
Reaches target by: diffusion (really fast!)
Function

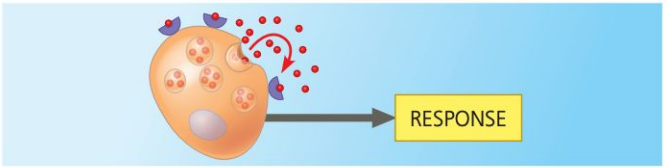
- Blood pressure regulation
- Nervous system function - synapse
- Reproduction

Paracrine – target cells nearby
Autocrine – target cell is self
Examples

- **Prostaglandins** (modified fatty acids)
  - Immune function – inflammation and pain in response to injury
  - Drugs like aspirin and ibuprofen block synthesis
- **Cytokines** (polypeptides)
  - Immune function – cell communication
- **Growth factors** – polypeptides
- **Nitric Oxide (NO)**
  - Made when oxygen level in blood falls
  - Causes vasodilation via an enzyme in smooth muscle cells to relax cells



(b) In **paracrine signaling**, secreted molecules diffuse locally and trigger a response in neighboring cells.



(c) In **autocrine signaling**, secreted molecules diffuse locally and trigger a response in the cells that secrete them.

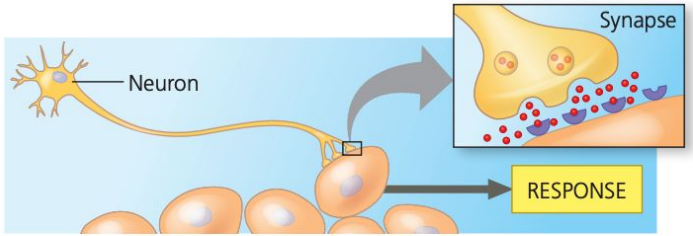
Synaptic & Neuroendocrine Signaling

Type of secreting cell: neurons and neurosecretory cells

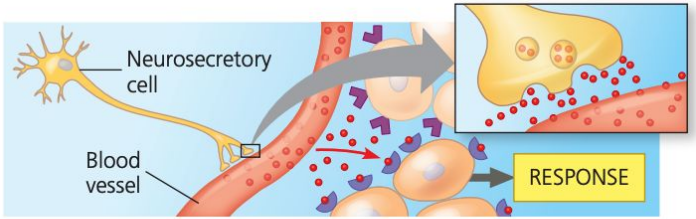
Reaches target by: diffusion – a super short distance

Function

- Neurotransmitters
  - Synaptic signaling
- Neuroendocrine signaling
  - Neurosecretory cells secrete neurohormones
    - ADH



(d) In **synaptic signaling**, neurotransmitters diffuse across synapses and trigger responses in target tissues (neurons, muscles, or glands).



(e) In **neuroendocrine signaling**, neurohormones diffuse into the bloodstream and trigger responses in target cells anywhere in the body.

Pheromones

Pheromone – chemical released into external environment

Examples

- Animal discovers new food source
- Ant colonies migrate to new location
- Define territories
- Warn predators
- Attract mate
    - Polyphemus moth pheromone – 4.5 km away

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Hormones

Chemical Classes

1. Polypeptides
    a. Insulin – 2 chains
2. Steroids – 4 fused carbon rings, form from cholesterol
3. Amines
    a. Tyrosine
        i. **Catecholamines**: epinephrine, norepinephrine, dopamine
        ii. Thyroid: T3, T4
    b. Tryptophan
        i. Melatonin
        ii. Serotonin

Cellular Hormone Response Pathways

Water soluble

- Exocytosis + travel freely in blood
- Cannot diffuse through plasma membrane of target cell, so binds to cell surface receptor
- Response Pathway Ex.
    - Epinephrine → GPCR → Adenylyl cyclase converts AMP to cAMP → Protein kinase A → Result
        - Signal amplification

Lipid soluble

- Diffuse out
- Bind to **transport proteins** to be soluble
- Diffuse into plasma membrane of target cell
- Bind receptor in cytoplasm/nucleus (usually gene expression)
    - Steroid hormones usually go to cytoplasm
    - Non-steroids usually go to nucleus
- Response Pathway Ex. (birds and frogs)
    - Estradiol → cytoplasmic receptor in liver cell → activates transcription of vitellogenin gene → vitellogenin proteins secreted and transported into blood → reproductive system makes egg yolk

Release

- Can be a part of other organ systems, though less common
  - Scattered cells in stomach secrete gastrin
- Commonly grouped in endocrine glands
- Exocrine glands use ducts
  - Pancreas
    - Ductless – hormones
    - Ducts – enzymes, bicarbonate

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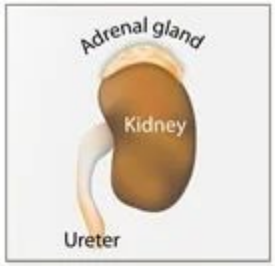
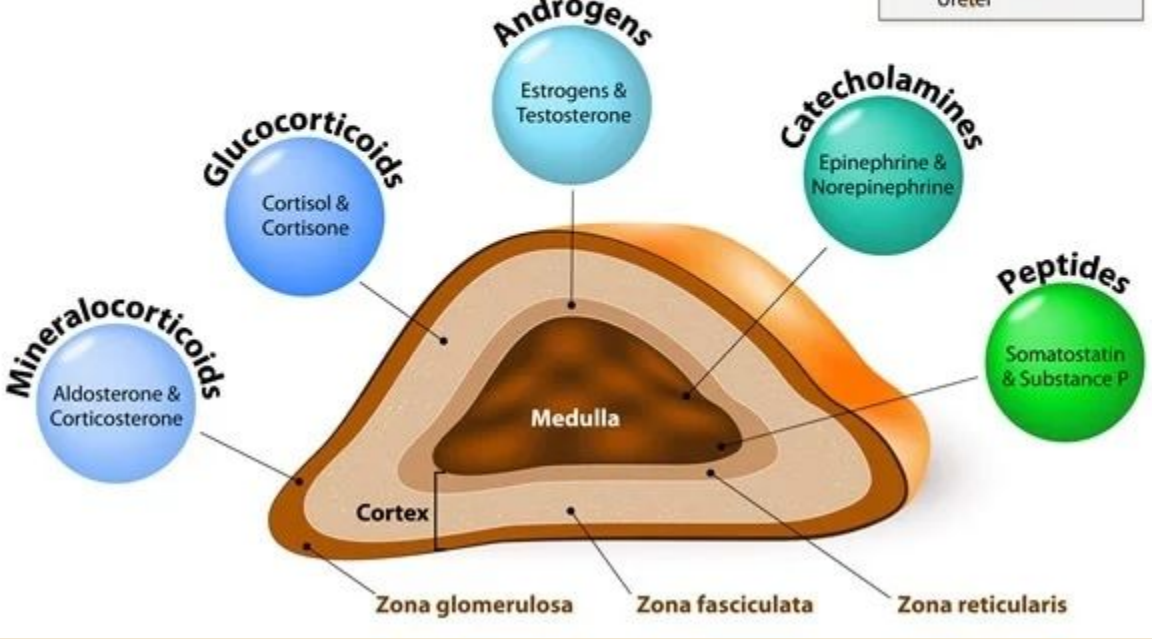
Adrenal Hormones

ADRENAL GLAND

(hormones)





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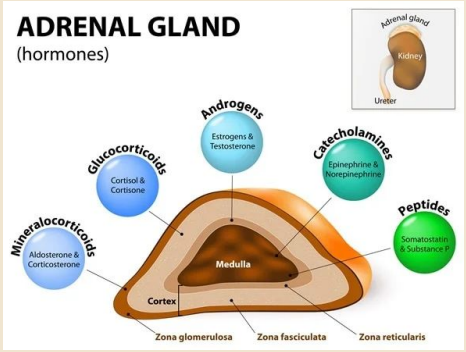
Medulla



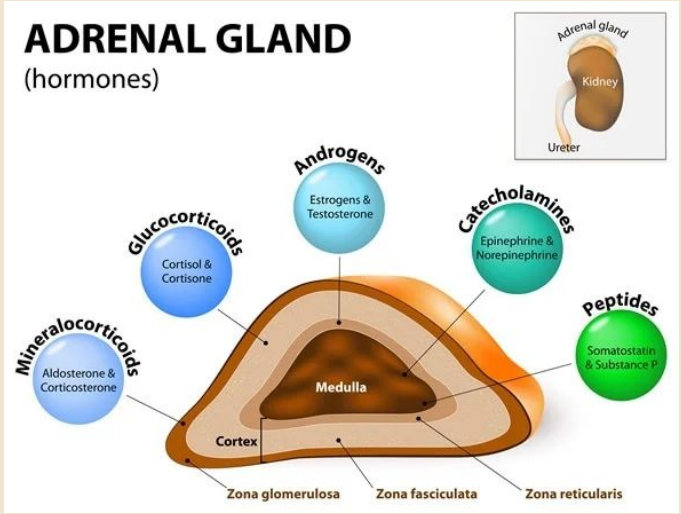
Adrenal medulla

- Modified sympathetic ganglion without axons

Catecholamines (all soluble)

- Norepinephrine
  - Affects blood vessels
- Epinephrine (4x more synthesized)
  - Affects heart
- Synthesis: Phenylalanine → tyrosine → dopa → dopamine → norepinephrine → epinephrine
- PNMT enzyme catalyzes conversion from norepinephrine to epinephrine
- Receptors
  - Liver - β-type
    - Activates protein kinase A → glycogen breakdown → glucose released
  - Smooth muscle in blood vessels - β-type
    - Relax → vasodilation → more blood to muscles
  - Smooth muscle in intestines - α-type
    - Contract → reduces blood flow

Cortex



Zona glomerulosa – mineralocorticoids
- Corticosterone (precursor to aldosterone)
- Aldosterone
    - Increases water retention and blood pressure

Zona fasciculata – primarily makes cortisol but makes some androgens
- Cortisol
    - Glucocorticoid (metabolism of glucose and organic nutrients)
    - Facilitates stress response – makes more glucose available and promotes gluconeogenesis
    - Regulates immune system (high levels may suppress)

Zona reticularis – primarily makes androgens but makes some cortisol
- DHEA and androstenedione

Addison's Disease – too little cortisol (and often, aldosterone) made

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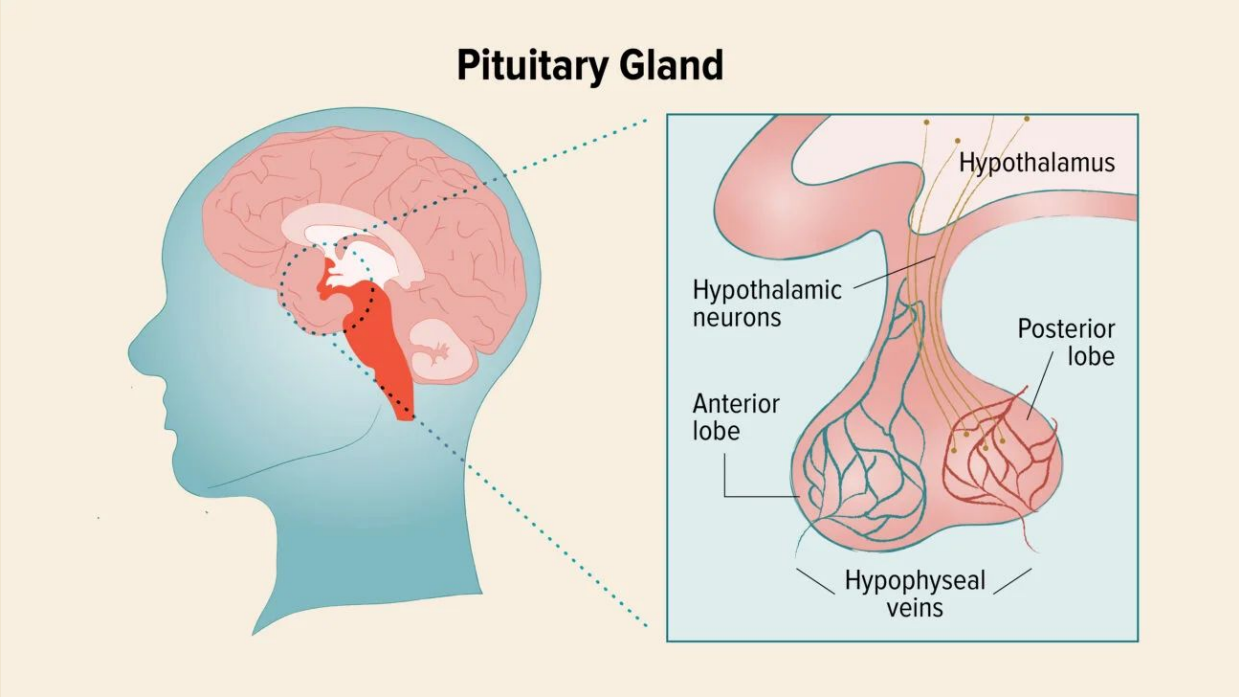
Pituitary Hormones



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Posterior Pituitary Hormones

Oxytocin
- Contraction of uterus and mammary gland cells for labor and lactation
- Modulates behavior

ADH/Vasopressin
- Constricts smooth muscle around blood vessels to raise blood pressure
- Decreases water excretion
    - Diabetes insipidus

Anterior Pituitary Hormones

Release controlled by hypophysiotropic hormones released by hypothalamus
Many are tropic hormones
Follicle-stimulating hormone (FSH) & luteinizing hormone (LH)

- Stimulate gonads to secrete sex hormones
- Regulate development of ova and sperm
- Release stimulated by: gonadotropin-releasing hormone (GnRH)

Growth Hormone (GH) (somatotropin)

- Stimulates liver to secrete IGF-1
- Affects bone and metabolism
    - Gigantism, acromegaly, dwarfism
- Release stimulated by growth hormone-releasing hormone (GHRH)
- Release inhibited by somatostatin (SST)

Thyroid-stimulating hormone (TSH) - thyrotropin

- Stimulates thyroid to secrete T3 and T4
- Release stimulated by thyrotropin-releasing hormone (TRH)

Prolactin

- No effects on other glands
- Stimulates lactation
- Delays metamorphosis in amphibians, regulates salt and water balance in freshwater fishes
- Release stimulated by prolactin-releasing hormone (PRH)

Adrenocorticotropic hormone (ACTH) – corticotropin

- Stimulates adrenal cortex to secrete cortisol
- Release stimulated by corticotropin-releasing hormone (CRH)

Melanocyte-stimulating hormone (MSH)

- Regulates skin color, hunger, and metabolism

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Thyroid Hormones

Thyroid (not Thymus) Hormones

T3 and T4 (thyroxine)

- Stimulate and maintain metabolic processes
- TRH secreted by hypothalamus → TSH secreted by anterior pituitary → T3 and T4 secreted by thyroid
- Disorders
    - Iodine deficiency
    - Hyperthyroidism → Graves' disease
        - Sweating, arrhythmia, weight loss, protruding eyes, nervousness, goiter
    - Hypothyroidism
        - Fatigue, weight gain, abnormal bone development
    - Hashimoto's Thyroiditis (autoimmune inflammation, may cause goiter)
- Stimulates reabsorption of tadpole tails during metamorphosis

Calcitonin

- Lowers blood calcium
- TONE it down

2.4

Other Hormones

Other Hormones

Melatonin (Pineal gland)

- Circadian rhythms
- Release controlled by suprachiasmatic nucleus (SCM)

Pancreatic hormones

- Insulin
- Glucagon

Parathyroid hormone (PTH)

- Raises blood calcium
  - Breaks down bone matrix
  - Stimulates reabsorption and promotes making vitamin D in the kidneys
- Pfffft you need more

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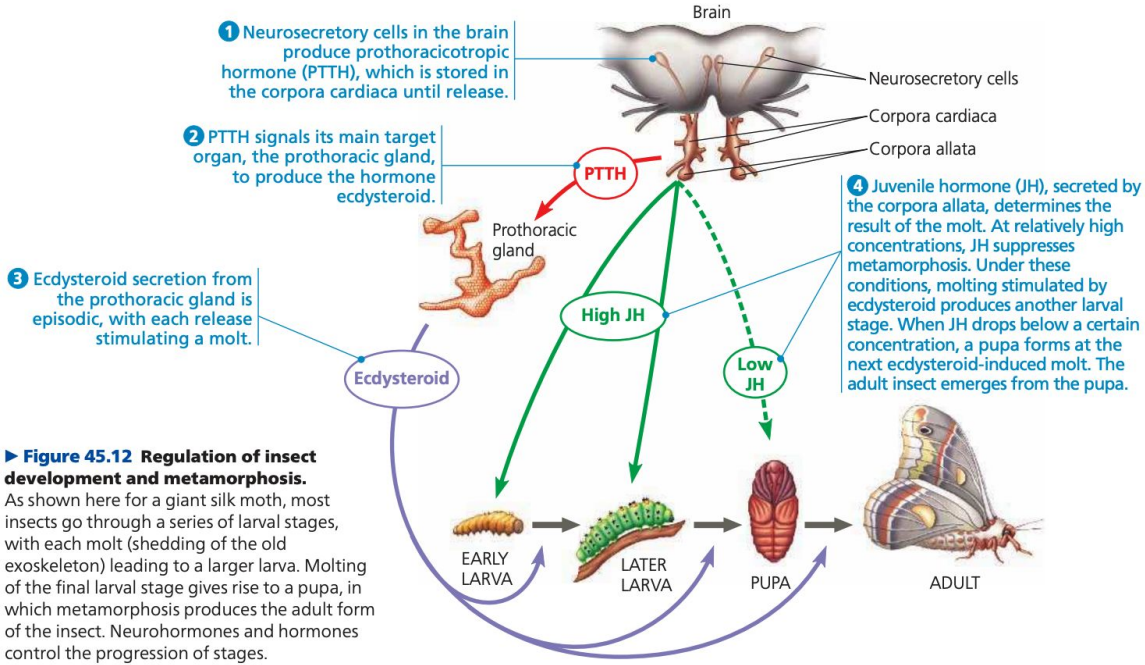
Invertebrate Development



► Figure 45.12 Regulation of insect development and metamorphosis. As shown here for a giant silk moth, most insects go through a series of larval stages, with each molt (shedding of the old exoskeleton) leading to a larger larva. Molting of the final larval stage gives rise to a pupa, in which metamorphosis produces the adult form of the insect. Neurohormones and hormones control the progression of stages.

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Practice

2017 Opens

20. One of your colleagues is attempting to isolate the receptor for testosterone. He decides to copy your protocol for isolating the receptor for epinephrine by radiolabeling the hormone, isolating the membrane fraction, and purifying radioactive protein complexes. Realizing that your colleague has probably not slept in days, you review the experimental procedure to ensure that it actually works. Which one of the following is a reason why your colleague's experiment would not work?

A. Radiolabels on testosterone do not last very long.
B. Testosterone is a steroid hormone and diffuses across the cell membrane.
C. Testosterone binds only briefly to its receptor and then rapidly dissociates.
D. Radiolabeling the hormone would result in cell death.
E. None of the above.

2017 Opens

21. In order to study the effects of certain hormone deficiencies, you inject a mouse with a tyrosine hydroxylase inhibitor. Since tyrosine hydroxylase is the rate-limiting step in the synthesis of catecholamines, which one of the following hormones do you expect to NOT be affected:

A. Serotonin.
B. Epinephrine.
C. Dopamine.
D. Norepinephrine.
E. None of the above.

2017 Opens

25. In Graves' disease, abnormal antibodies that activate the thyroid-stimulating hormone (TSH, or thyrotropin) receptor are made by the patient's plasma cells. TSH stimulates thyroid follicular cells to grow and produce hormones. Using this information and your knowledge of thyroid hormone regulation, which of the following statements would one expect an individual with advanced Grave's disease to possess (*Select ALL that apply*)?

A. The individual would have a high body temperature and substantial weight loss.
B. The individual would have an enlarged thyroid gland.
C. The individual would have high levels of thyrotropin-releasing hormone (TRH).
D. The individual would have high levels of TSH.
E. The individual would have high levels of thyroxine.

2016 Opens

2. Which of the following statements is FALSE regarding the secretion of hormones by the anterior pituitary? SELECT ALL THAT APPLY

Hormone	Target	Effect
A. Beta-endorphin	Adrenal gland	Secretion of glucocorticoid
B. Corticotropin	Adrenal gland	Secretion of androgens
C. Prolactin	Mammary glands	Promotes lactation
D. Growth Hormone	Liver	Promotes growth
E. Leptin	Corticotrophic cells	ACTH secretion

2014 Opens

19. You walk outside and are met with a blast of cold resulting from the polar vortex. Your body responds by setting into motion a hormone cascade pathway to activate your thyroid gland. Using the selections below, which of the following is the correct sequence of events for this pathway?

I. Thyroid Hormone
II. TRH
III. TSH

A. III, II, I
B. III, I, II
C. II, III, I
D. II, I, III
E. I, III, II

2013 Opens

22. Which of the following hormones is NOT secreted by the anterior pituitary gland?

A. Prolactin
B. Oxytocin
C. Luteinizing hormone
D. Thyroid-stimulating hormone
E. Adrenocorticotropic hormone

2013 Opens

23. Which gland is directly controlled by messages from nerves leading into it?

A. Adrenal cortex
B. Adrenal medulla
C. Anterior pituitary
D. Testes
E. Ovaries

Which of the following statements is true?
W) Prostaglandins [pros-tuh-GLAN-dins] are paracrine [PAR-uh-kruhn] regulators that act locally
X) Insulin is a paracrine regulator that acts over long distances
Y) Melatonin is an endocrine hormone that acts locally [EN-duh-krin]
Z) Prostaglandins are endocrine hormones that act over long distances

What specific part of the human brain has the most influence on heart rate, sleep, body temperature, and metabolism, and is a large part of the ventral portion of the
diencephalon (read as: die-en-SEFF-ah-lon):
W) hypothalamus (read as: hypo-THAL-ah-mus)
X) cerebellum
Y) pituitary
Z) sella turcica (read as: TURR-sik-ah)

If a person had low levels of corticosteroid, which of the following would be the BEST way to test whether the adrenal glands themselves are not functioning or if it is the fault of the pituitary gland:
W) monitor the kidney for sodium excretion
X) measure the blood plasma for high levels of potassium
Y) inject small amounts of corticotropin and find if the adrenals produce corticosteroids
Z) monitor the urine for high amounts of protein and sodium

Which of the following is NOT true regarding juvenile hormone
(JH) in the silkworm moth as it pertains to the hormonal control of insect metamorphosis?
W) JH is produced by the prothoracic gland
X) Levels of JH are higher in first instar larvae relative to levels in fifth instar larvae
Y) Pupae have little to no JH
Z) The interplay of ecdysone and JH is important to the molting process

You are surfing at the beach and see a shark nearby, activating your vertebrate stress response. Levels of which of the following would decrease during this response?
W) Cortisol
X) Glucagon
Y) Insulin
Z) Epinephrine

Which of the following would be the most likely explanation for hypothyroidism in a patient whose iodine level is normal?
W) Disproportionate production of T3 to T4
X) Hyposecretion of TSH
Y) Hypersecretion of TSH
Z) Hypersecretion of MSH

Thanks!

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