RUMORS PERSISTED THAT SAGE WAS USING SPIRITUAL GROWTH HORMONES

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• Chemical signals coordinate body functions

– Hormones are chemical signals that communicate regulatory messages throughout the body

• Secreted by endocrine glands that make up the endocrine system

• Travel in the circulatory system to target cells
Secretory vesicles

Endocrine cell

Blood vessel

Target cell

Hormone molecules
• Chemical signals coordinate body functions
  – Local regulators secreted into interstitial fluid affect nearby target cells.
  – Many processes are regulated by multiple hormones
Prostaglandins secreted from the placenta cause muscles of the uterus to contract. This is an example of a local hormone.
Pheromones carry messages between different individuals of a species

Aggregation pheromones in Bed Bugs

Pheromones in Animals

Female Deer

Male Deer

Benoit Guenard
Neurosecretory cell

Blood vessel

Target cell

Hormone molecules
Nerve cell

Nerve signals

Neurotransmitter molecules

Nerve cell
• Hormones affect target cells by two main signaling mechanisms
  – Hormones are made of proteins, amines, or steroids
  – Hormone signaling involves three key events
    • Reception of the signal
    • Signal transduction
    • Response: change in target cell's behavior
- Water-soluble hormone mechanism

1. Hormone binds to receptor protein on target cell's plasma membrane
2. Activation of protein initiates signal transduction pathway
3. Final relay molecule activates protein that carries out cell's response

One hormone may trigger a variety of responses
Water-soluble hormone (epinephrine)

1. Receptor protein

2. Target cell

3. Relay molecules

Plasma membrane

Signal transduction pathway

Glycogen

Glucose

Cellular response
(in this example, glycogen breakdown)
Steroid hormone mechanism

1. Hormone diffuses through plasma membrane of target cell

2. Binds to receptor protein in cytoplasm or nucleus, creating a complex that transduces the signal

3. Hormone-receptor complex attaches to specific site on cell's DNA

4. Binding to DNA stimulates transcription of genes into RNA, which is translated into proteins
Lipid-soluble hormone (testosterone)

1. Target cell

2. Receptor protein

3. Nucleus

4. DNA

Hormone-receptor complex

Transcription

mRNA

New protein

Cellular response: activation of a gene and synthesis of new protein
• The hypothalamus, closely tied to the pituitary, connects the nervous and endocrine systems
  – The hypothalamus exerts master control over the endocrine system
    • Receives information from nerves about internal and external conditions
    • Uses the pituitary gland to relay directives to other glands
  – Releasing and inhibiting hormones from the hypothalamus control the pituitary
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Brain

Posterior pituitary

Anterior pituitary

Bone

Hypothalamus
The posterior pituitary is an extension of the hypothalamus

- Stores and secretes hormones made in the hypothalamus
- Oxytocin and antidiuretic hormone (ADH)
Hypothalamus

Neurosecretory cell

Hormone

Posterior pituitary

Blood vessel

Anterior pituitary

Oxytocin

ADH

Uterine muscles
Mammary glands

Kidney tubules
The anterior pituitary is composed mostly of glandular tissue

- Synthesizes and secretes its own hormones
  - TSH, ACTH, FSH, LH, growth hormone, prolactin, and endorphins
Neurosecretory cell

Endocrine cells of the anterior pituitary

Blood vessel

Releasing hormones from hypothalamus

Endocrine cells of the anterior pituitary

Pituitary hormones

- TSH
- ACTH
- FSH and LH
- Growth hormone (GH)
- Prolactin (PRL)
- Endorphins

Thyroid
Adrenal cortex
Testes or ovaries
Entire body
Mammary glands (in mammals)
Pain receptors in the brain

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• The thyroid regulates development and metabolism
  – Thyroid hormones affect virtually all the tissues of vertebrates
  – Thyroid gland produces $T_4$ (thyroxine) and $T_3$
    • Play crucial roles in development and maturation
  – In mammals, thyroid hormones maintain normal blood pressure, heart rate, muscle tone, and digestive and reproductive functions
The hypothalamus acts through the anterior pituitary to direct activity of the thyroid gland

- Hypothalamus produces TRH
- TRH stimulates anterior pituitary to produce TSH
- TSH influences thyroid to release thyroxine
- Controlled by a negative-feedback mechanism
Hypothalamus

TRH

Anterior pituitary

TSH

Thyroid

Thyroxine

Inhibition

Inhibition
• Hyperthyroidism
  – Excess $T_4$ and $T_3$ in the blood
  – Most common result is Graves disease
• Hypothyroidism
  – Insufficient amounts of $T_4$ and $T_3$
  – Can result from defective thyroid gland or insufficient iodine in diet
  – Can lead to cretinism and goiter
• Negative feedback maintains homeostatic levels of $T_4$ and $T_3$
Distributional Aspects of Endemic Goiter in the United States
Joseph B. Schiel, Jr. and Anita Joan Wepfer

Fig. 2. Goiter rates of World War I recruits.
Hypothalamus

TRH

Anterior pituitary

TSH

Thyroid

Insufficient $T_4$ and $T_3$ produced

Thyroid grows to form goiter

No inhibition

No inhibition

No iodine
Pancreatic hormones regulate blood glucose levels

- The pancreas secretes two antagonistic hormones critical in regulating the body's energy supply
  - Insulin signals cells to use and store glucose
  - Glucagon causes cells to release stored glucose into the blood

- Negative feedback manages the amount of glucose circulating in blood versus amount stored as glycogen
Insulin

Beta cells of pancreas stimulated to release insulin into the blood

High blood glucose level

Blood glucose level rises to set point; stimulus for glucagon release diminishes

Liver breaks down glycogen and releases glucose to the blood

Body cells take up more glucose

Liver takes up glucose and stores it as glycogen

Blood glucose level declines to a set point; stimulus for insulin release diminishes

Body cells take up more glucose

Alpha cells of pancreas stimulated to release glucagon into the blood

Stimulus: Declining blood glucose level (e.g., after skipping a meal)

Glucagon

Homeostasis: Normal blood glucose level (about 90 mg/100 mL)

Stimulus: Rising blood glucose level (e.g., after eating a carbohydrate-rich meal)

Liver takes up glucose and stores it as glycogen

Body cells take up more glucose
Diabetes is a common endocrine disorder.

- In diabetes mellitus, body cells are unable to absorb glucose from the blood.
- Results from a lack of insulin or a failure of cells to respond to it.
- Cells burn fats or protein as fuel.
- Glucose remains in the blood, is excreted in urine.
- Can be a life-threatening disease.
– Type 1 (insulin-dependent) diabetes is an autoimmune disease
  • Usually develops in childhood
  • Pancreas does not produce enough insulin
  • Treated by injections of insulin
– Type 2 (non-insulin-dependent) diabetes is usually associated with being overweight
  • Characterized by deficiency of insulin or reduced responsiveness of target cells
  • Treated by diet and lifestyle changes
Diabetes can be detected by a glucose tolerance test
The End