YOUR HORMONES

ENDOCRINE SYSTEM
Endocrinology: study of **ductless glands**

- Release **secretions** (hormones): **directly** into blood
- **Hormone**: chemical messenger
- Secreted → blood → “effect” on other (**target**) cells
- **Hormone**: attaches to cell **receptor** → brings about “effect”
Nervous Impulses
1. Fast
2. Rapid effect

Hormone Action
1. Slower
2. Longer effect

Nervous Impulses ↔ Endocrine Systems
Closely linked
Mind → Body (Bad/Good effects)
Major Endocrine Glands
Types of Hormones

1. Amino-acid based: made from an amino acid
   Example: adrenaline, dopamine

2. Peptide Hormones
   Example: Growth hormone, insulin

1 & 2 bind to receptor on cell membrane → change cell activity
Hormones and Target Cells

1. Endocrine cells release hormone.

2. Hormone enters circulation.

3. Hormone is carried throughout the body.

Hormone will not bind to cells that are not target cells.

4. Binding occurs, hormonal effects take place.

receptor

target cell (skeletal muscle)
3. **Steroid Hormones**: made from **cholesterol**

Example: testosterone, estrogen
Turn **genes** on or off

Attach to DNA

Nucleus

Hormone + receptor

Bind to receptor **inside** cell

**Steroid** Hormone
How is Most Hormone Secretion Controlled?

NEGATIVE FEEDBACK
After Meal \(\uparrow\) Blood Glucose

Pancreas: Beta cells \(\rightarrow\) Insulin

\(\uparrow\) Glucose uptake-cells

Liver & Muscle glucose \(\rightarrow\) glycogen

\(\downarrow\) Blood Glucose

Return: Normal levels
Insulin receptor-cell membrane

“key” opens door:
Glucose outside cell
inside cell
energy
stored
After few hours without food……

1. ↓ Blood Glucose
2. Alpha cells-pancreas → glucagon
3. Does opposite of insulin
4. Glucagon: liver glycogen

- glucose
- blood (normal levels)
Insulin & glucagon balance each other

Insulin

Glucagon

Keep blood glucose- normal levels
Why do you need to **shut off** insulin secretion after blood glucose reaches **normal** levels?

**Answer:**

**Hypoglycemia**

(low blood sugar)

Our red blood cells, brain, and nerve cells primarily rely on glucose. This is why you get tired, irritable, and shaky when you have not eaten for a prolonged period of time.
Extreme case: Diabetic

- **Inject** self with *insulin*
- Very **little** to eat
- Exercise **actively**: muscles use glucose

Result: Rapid drop in blood glucose

Figure 4.17  Changes in blood glucose after a meal for people with hypoglycemia and without hypoglycemia (normal).
Blood Glucose Levels

• Normal glucose narrow range: 80-100 milligrams/100 ml of blood (homeostasis)

• Uncontrolled diabetic: 200 milligrams or much higher (600)
Why does your body keep blood glucose in this narrow range?

- **Kidney threshold**: 160-180 milligrams
- **Above this level**: glucose spills- urine
- **Lost energy**
Why is high blood glucose so bad?

- **Glucose- sticky**: damages small blood vessels in body
- ↑ Risk heart attack/strokes
- ↑ Risk **kidney failure**
- **Nerve** damage- feet
- Damage- blood vessels eye **retina**
  (Diabetes: leading cause **blindness**)
Damaged blood vessels - diabetic retina (left)
Infections (gangrene)/amputations: toes, feet, legs

Diabetes, soaring among New Yorkers, has already left a mark on Diane and Aniello Discala of the Bronx. She lost a leg to its complications.
Who gets diabetes? Children, teens, young, old

Because diabetes doesn’t ask how old you are.
Diabetes: uncontrolled, **high** blood glucose

**Type 1: Insulin deficiency**

- Glucose can’t get into cells
- “Starvation in the midst of plenty”
- Glucose spills - urine (wasted)

**Causes:** genetics, viral infection, toxin exposure, autoimmune disease
Type 2 Diabetes

• **Insulin** at high levels
• Trying to get glucose into cells
• Muscle & adipose tissue cells **not** responding: “insulin resistance”
• Result: ↑ blood glucose
• **Causes:** genetics, overweight/obese, at risk: African, Native, Hispanic, Asian Americans
Diabetic

Blood Sugar (glucose)

CELL

insulin

glucose

energy

nucleus
• Overstuffed fat cells: leak fat & hormones (trigger inflammation): blood

• Fat → liver (fatty)

• Fat → muscle cells
  insulin resistance

• Fat → toxic: Beta cells
Parathyroid Hormones

Behind thyroid: regulate blood calcium
Blood calcium: important: blood clotting, stabilize: nerve & muscle membranes

- ↓ Blood calcium
- ↑ Parathyroid hormone
- **Bone calcium** → blood
- ↑ Blood calcium
- ↓ Shuts off parathyroid hormone
- **Negative feedback**
Adrenal Glands: on top of kidneys

- Adrenal medulla secretes catecholamines.
- Adrenal cortex secretes steroids.
Connected to brain (**hypothalamus**)

Diagram showing the connection between the adrenal gland and the brain via the hypothalamus. The adrenal gland is connected to a sympathetic preganglionic neuron, which releases neurotransmitters and chromaffin cells, resulting in the release of epinephrine into the blood vessel.
Hypothalamus → Sympathetic nerves → Adrenal glands → Inner portion (medulla) → Adrenaline & noradrenaline → Blood: Fight or Flight response (emergencies)
Fight or Flight Response

- Liver/muscle: glycogen $\rightarrow$ glucose
- Blood glucose
- Adipose fat $\rightarrow$ blood $\rightarrow$ energy
- Heart rate/blood flow
- Pupils/respiratory passages dilate
- Blood vessels muscle dilate
Hypothalamus

• Size: lima bean
• Attached by stalk
• Surrounded- bone

Pituitary

• 2 lobes: anterior (front), posterior (back)

“master gland”

close link
Posterior: extension of hypothalamus
Posterior Pituitary

2 hormones:

1. Antidiuretic Hormone (ADH)
2. Oxytocin

Made in hypothalamus neuron (stored) posterior pituitary

3. Brain nervous impulse pituitary

blood hormones
FIGURE 7-12  Synthesis, storage, and release of posterior pituitary hormones

1. Hormone is made and packaged in cell body of neuron.
2. Vesicles are transported down the cell.
3. Vesicles containing hormone are stored in posterior pituitary.
4. Hormones are released into blood.
ADH: regulates H2O Balance:

Low H2O intake
- Concentrated blood
- ↑ ADH
- Kidneys reabsorb H2O

High H2O intake
- ↑ Blood volume
- ↓ ADH
- ↑ Urine
CHILD BIRTH
Oxytocin: Birth of baby

- Baby drops lower uterus
- Pressure - cervix
- Nerve impulses - hypothalamus
- Oxytocin - pituitary to uterus → contractions
- **Placenta** releases prostaglandins
- Cause contractions
- Baby pushes cervix harder
- More stretching
- More impulses
- Baby born
- **Positive feedback**
• Prostaglandins: Local **tissue regulators**
Stimulate **uterus**: muscle contractions
• Menstrual cramps
• Induce Abortions
Oxytocin: Milk Ejection

mammary glands

After baby born: **Positive Feedback**
• Sound: baby’s cry
• Mom’s brain:
  Impulses from higher brain to hypothalamus
• Pituitary release Oxytocin → breast
• Muscles contract:
milk squirts: baby’s mouth
Baby’s suckling

Impulses

Mom’s brain

Positive

Feedback
Oxytocin: other actions

- Males: helps with semen ejaculation
- Men & women: ↑ blood oxytocin during orgasm
Anterior Pituitary: cascade effect
1. **Hypothalamus**: neurons produce: *releasing* (+) or *inhibiting* (-) hormones: blood vessels → anterior pituitary

2. **Anterior pituitary**: +/- (release/inhibition) 6 hormones

3. **Blood** → another endocrine gland

4. **Another** hormone released

5. **Finally**: to *target cells*
Anterior Pituitary Hormones

1. ACTH
2. Thyroid Stimulating Hormone
3. Growth Hormone
4. Prolactin
5. Follicle Stimulating Hormone
6. Luteinizing Hormone
#1 ACTH

Adrenal gland cortex (outer portion)

Cortisol

Helps body cope with stress

“stress response hormone”
Cortisol actions overlap with adrenaline “fight or flight” response

Cortisol: short-term (daily) stress

- Getting ready for exams
- Cortisol gets “energy” ready for you (energy mobilization)
Glucose production: liver
Blood glucose

Energy in Blood

Adipose fat breakdown
Blood fats

Muscle protein breakdown
Amino acids
Glucose
Cortisol Release

- In bursts
- ↑ Morning  ↓ Night
- Related: Sleep/wake cycle (circadian rhythms)
- Reversed: People awake at night, sleep during day
Problem: Long-term stress & cortisol release

Side-effects

• Weakens immune system
  (↓ # immune cells)

• ↑ Chances getting sick

• ↑ Atherosclerosis (arteries): heart attacks ?

• ↓ Insulin sensitivity: diabetes ?
Stress: condition- actual or potential- challenge to **homeostasis** → stress response

**Stressors:**

**Physical:** dehydration, hemorrhage, infection, extreme temperatures, severe exercise (**marathon**)

**Psychological:** pain, fear, anxiety

**Stressor:** for 1 person, no effect on another
Stress: adrenal gland

Cortex
  - Cortisol
  - Daily/long-term

Medulla
  - Adrenaline
  - Emergency
Nervous ↔ Endocrine ↔ Immune
All **linked** together

Share
Common
Chemicals/
Hormones &
Receptors
Psychosomatic Illnesses
Mind → Body
Examples:
• People in hospital: depression, ↓ immunity
• Caregivers (husband or wife) of Alzheimer's patient: ↓ immune cell activity

Associated Press/mtvU survey-2008: 4/10 college students “stressed often”
“Broken heart syndrome”

1. Emotional trauma (sudden death of husband or wife)
2. Rapid **blast** of **stress hormones**
3. Paralyzes heart muscle/drop blood pressure/ decreased O2
4. Heart fails- some people die
5. No blockage, no heart attack
6. More common: **post-menopausal women**
Personality Type

- **Type A: Coronary prone**
Type A:
Time urgency, impatient, competitive, aggressive
Subtype: hostile, cynical, increased adrenaline stress response: ↑ heart disease risk

Type B: more relaxed, less time conscious: ↓ risk
World Health Organization 2008: 
**Night Shift**: a “probable” carcinogen

↑ Breast & prostate cancer: people working-night

Cause? Effect?

Changes- Biological clock (circadian rhythm)
Positive Outlook on Life

- 2006 Dutch “Outlook on life” study: men 64-84 followed for 15 years

  “I still expect much from life”
  “I am still full of plans”

  50% lower risk dying heart disease

- Cancer & AIDS survivors- positive outlook: improved health
• Laughter Therapy ([www.aath.org](http://www.aath.org))
   People watching funny movies:
   \[ \uparrow \text{immune cell activity} \]
• Complementary medical therapy:
   meditation (?) endorphins), yoga, hypnnosis, biofeedback
• Exercise as stress reliever
2007 study: *Exercise* almost as good as anti-depressant in reducing depression
#2 Thyroid Stimulating Hormone (TSH)

TSH from anterior pituitary

Thyroid hormones

Stable blood levels

Maintain normal metabolism
The thyroid gland is a butterfly-shaped gland, located just below the larynx.
Thyroid hormones: made from an amino acid + iodine
Iodine concentrated in thyroid

Children, radioactivity exposure, and thyroid cancer
1986: **Chernobyl** (Ukraine): nuclear reactor **meltdown**

- Plume: radioactivity (**Iodine 131**) - taken up by **thyroid**
Children: thyroid hormones important: normal growth, body, nervous system development

Deficiency: hypothyroidism = cretinism

• Mental retardation
• Growth stunted
• Brain damage
Cretinism: can be result of iodine deficiency

21 year old woman
2’ 6” tall
Thyroid Hormones: what they do

• ↑ O2 use by most tissues

• Maintain your **Basal Metabolism**: Oxygen used and heat produced at **rest**

• Heat helps maintain your **body temperature**
Basal Metabolism: energy needed - basic functions - just to keep you alive

- Breathing
- Circulating Blood
- Maintaining Body Temperature
- Making New Tissue
- Removing Waste Products
- Sending Nerve Impulses
Basal Metabolic Rate (BMR)

• Calories you burn every hour to keep you alive

• 60-70% of total calories you burn (energy needs)

• Does not include: physical activity/exercise

• Warm blooded animals: “Keep fires lit all night”
In General:

- BMR (Lean body mass) (metabolically active vs. fat tissue)
- Men vs. women (more lean mass)
- Age (less lean mass)
BMR ↑ Thyroid hormones ↑

BMR ↓ If calorie intake low (starvation) ↓

*Homeostasis:* less energy needed to maintain weight

Frustration: Trying to lose weight
Adults- **Hyperthyroidism**

- **Thyroid hormone secretion**
- **↑ Oxygen use by cells**
- **↑ Heat produced** (warm/sweaty/heat intolerant)
- **↑ Weight loss, ↑ protein catabolism**
- **Hyper excitable** nervous system
- **↑ Heart rate, irritability**

**Treatment**

Remove part thyroid, destroy with radioactive iodine, drugs: block hormone synthesis
**Exophthalmus**: bug-eyed appearance – enlarged (↑ fluid) muscles/tissue eye socket
Hypothyroidism

- Secretion thyroid hormones
- **Slow metabolism**
- ↓ O₂ use by cells
- Puffiness-skin
- **Slow** reflexes, speech, thought processes, fatigue
- **Slow** heart rate
- Treatment: **oral thyroid hormone**
Goiter: enlarged thyroid gland
One cause:
↑ TSH causes increased release thyroid hormone
Thyroid gland hypertrophies (↑ size)
Goiter: iodine deficiency

- ↓ iodine in diet
- ↑ TSH: stimulates thyroid to grow
- No iodine → thyroid hormone
- No feedback shut off TSH
- Treatment: iodine supplement
- Iodized salt
#3 Growth hormone: from anterior pituitary: affects growth & metabolism

Growth:

1. Bone

2. Soft tissue: organs- heart, lungs, kidneys, intestines, skin, muscles
Anterior pituitary: growth hormone
When major **growth** happens

- 1st 2 years of life
- **Adolescence**: **growth spurt**
  - 11 years old - girls
  - 13 years old - boys
Late teens:

**Plate** - end of bone closes

- Can’t grow taller
- Bones - only grow **wider** (circumference)
Growth Hormone levels

- High secretion in **children**
- Even higher - **teens**
- **Maximum** at puberty: testosterone & estrogen also stimulate growth hormone release
- **Adults**: lower levels: maintain bone mass/lean (muscle) body mass
- **Older adults**: still lower: ↓muscle mass ↑body fat
What growth hormone does to make people grow

- Stimulates liver: make glucose
- ↑ Blood glucose & fatty acids (energy for growth)
- ↑ Protein synthesis (muscles, tissues)
- ↑ Cell size (hypertrophy)
- ↑ Cell number (hyperplasia)
Result:

- **Bones** grow longer
- Increase **lean** Body mass (muscle)
- **Increase size:** heart, lungs, kidneys, intestines
Growth Hormone: Over & Underproduction
Growth Hormone Pathologies

Dwarfism \(\downarrow\) Growth hormone secretion or receptor defect

- \(\downarrow\) growth, \(\downarrow\) muscle development, \(\uparrow\) body fat

- Before 1985: treatment - human pituitary extracts: cadavers
- 1985: genetically engineered growth hormone: replacement therapy
Gigantism: Sometimes pituitary tumor in children
- ↑Growth hormone
- ↑Growth
- ↑Great height
- Robert Wadlow: 8’ 11” tall

*Figure 11.4 A Giant. When the anterior pituitary produces excessive growth hormone in a child, the child grows rapidly to excessive height. This caused Robert Wadlow, shown here in 1939, to attain a world-record height of 271 cm (8 ft 11 in). (From N. McWhirter, ed., Guinness Book of World Records, New York: Sterling Publishing Co., 1982, p. 6. © Sterling Publishing Co., Inc.)*
Sun Ming Ming 7’9” 387 pounds
NBA hopeful from China playing in ABA
Acromegaly: pituitary tumor adults

- ↑ Growth hormone
- ↑ **Size**: forehead, jaw, hands, feet
- ↑ Internal organs
- Problems: hypertension, diabetes, arthritis, enlarged heart, loss vision

- **Treatment**: surgery or radiation: destroy tumor
- **Drugs**: ↓ growth hormone production
Figure 11.5 Acromegaly. Excessive production of growth hormone in adults causes acromegaly. Bones broaden and other tissues enlarge, causing a progressive disfigurement. The photographs show this progression in one woman, from 16 years of age, when acromegaly had just begun, to age 33 and 52. (From W. H. Daughaday in A. I. Mendeloff and D. E. Smith, eds., Amer. J. Med. 20 [1956]:135.)
Growth hormone, anabolic steroids and athletes

Jose Canseco

Mark McGwire
(70 home runs-1998)
Roger Clemens?
Growth hormones
• Improve **muscle mass**

**Side effects**
• Insulin resistance
• Inflammation pancreas
Anabolic Steroids - performance enhancing drugs

- Banned - International Olympic Committee

- Mimic - male sex hormones (androgens)

- ↑ Protein synthesis

- ↑ Muscle development
Anabolic steroids: side effects

- Jaundice, liver failure
- Liver tumors
- Hypertension
- ↓ HDL (good cholesterol)
- Heart damage
- ↓ Sperm production, ↓ size testes
- ↓ Testosterone
- ↓ Sex drive
- Acne
Anabolic Steroids: women athletes

• ↓ Egg development & ovulation
• ↓ Breast size
• Disrupts menstrual cycle
• Deep voice
• Facial Hair
Anterior Pituitary Hormones

1. ACTH
2. Thyroid Stimulating Hormone
3. Growth Hormone
4. Prolactin *
5. Follicle Stimulating Hormone *
6. Luteinizing Hormone *
#4 Prolactin

- ↑ Mammary gland development
- Estrogen/progesterone also increase mammary development - pregnancy
- ↑ Production of milk
- Prepares breasts for lactation: secretion of milk
Baby nurses: activates nipple receptors
hypothalamus
releasing hormone
anterior pituitary
prolactin
milk formation in breasts
Positive feedback

![Diagram showing positive feedback process involving prolactin release during nursing, with a graph indicating prolactin levels over time.](image-url)
Prolactin: Milk Production

Oxytocin: Milk release
#5 Follicle Stimulating Hormone (FSH)
FSH

Egg development
ovaries: estrogen

Reproductive Tract

Female Body Characteristics

Promotes Sperm Production
(spermatogenesis)
#6 Luteinizing Hormone

**Males**

**Testes**

**Androgens**

(testosterone)

Sex organs & Male sex Characteristics

**Females**

**Ovaries**

Release egg (ovulation)

Production estrogen & progesterone
Pineal Gland: pea size in brain

The pineal gland is a pea-sized structure buried deep in the brain of humans. Nearly 2000 years ago, this "seat of the soul" was thought to act as a valve that regulated the flow of vital spirits and knowledge into the brain. By 1950, however, scientists had decided that it was a vestigial structure with no known function.
Releases: **Melatonin “Darkness Hormone”**

- Establishes **24** hour day/night cycle (internal biological clock)
- **Circadian rhythm**: daily rhythm coordinates body activities
Melatonin ↑ night ↓ day

- Potent sleep inducing agent

Melatonin is the “darkness hormone,” secreted at night as we sleep. It is the chemical messenger that transmits information about light-dark cycles to the brain center that governs the body's biological clock.
Jet lag: day sleepy, decreased energy

• Lasts few days after flying across many time zones

• Changes in circadian rhythm

• Melatonin/light exposure may help
Pheromones: “communicative odors”

- External hormones found in many animals: cause physiological response in same species
- Cause changes behavior: ants tell other ants about food source
- Sexual attractants—monkeys
- Female monkeys volatile acids from vagina during ovulation
Do humans have pheromones?
Human Pheromones?

- Arm pit secretions: volatile steroids related to sex hormones
- Women: ↑ vaginal acids during ovulation
- **Synchronization**- menstrual cycles: women living together
- Musklike odors: perfumes/after shaves
- Difference humans vs. other animals
- Humans: ↓ sense of smell