Chapter Nine

Temperature Regulation, Thirst, and Hunger
Regulating Systems

• Homeostasis: Physiological equilibrium
• Epic FAIL with weight? Obesity rates 1980-2000
• Motivation: Activating and directing behavior
• Regulation of Body Temperature
  – Set point (for internal temp, that would be 98.6 degrees)
  – Mechanisms for detecting deviation
  – Internal and behavioral elements to regain set point
• Adaptations to Temperature
  – Endotherms have internal metabolic ways to adjust temps (shiver, adjust circulation, pant, perspire, etc) + behavioral
  – Ectotherms only use external (behavioral) strategies (basking, shelter away from elements, curl up, etc)
More About Temperature Regulating Systems?

• Small deviations in Human Core Temperature can be serious or even lethal
  – Fever (a reset of our set point over 106 = life threatening)
  – Heat stroke (hyperthermia) from exertion + excess clothing
  – Hypothermia – may be used by medical professionals

• Brain Mechanisms for Temperature Regulation
  – POA of the hypothalamus (hot, cold & temp insensitive types of neurons), and the anterior hypothalamus
  – Spinal cord helps, but insensitive compared to hypothalamus

• Temperature Regulation in Infancy
  – Relatively helpless in adapting to temperature
Figure 9.7 The Hypothalamus Controls Temperature Regulation
Thirst: Regulation of the Body’s Fluid

• Intracellular and Extracellular Fluids
  – Extracellular fluid (34%) includes blood (7%) and CSF (1%) and interstitial fluid surrounding cells (26%)
  – Intracellular fluid (66%)

• Osmosis Causes Water to Move
  – Water moves from an area with lower concentration of solutes to an area with higher concentration
  – Hypotonic (low solute concentration) versus hypertonic (high solute concentration)

• The Role of the Kidneys
  – Excretes excess fluids and sodium
Figure 9.8 The Body’s Fluids Are Held in Three Compartments
Figure 9.9 Osmosis Causes Water to Move

Equilibrium

Only water molecules pass through the semipermeable membrane.

Equal concentrations of solute in both containers

Add salt

Higher concentration of solute

Higher concentration of solute than before

Add water

Lower concentration of solute

Lower concentration of solute than before

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Thirst: Regulation of the Body’s Fluid

• The Sensation of Thirst
  – Occurs as a result of osmotic (drops in the intracellular fluid volume) and hypovolemic (drops in blood volume) thirst

• Mechanisms of Osmotic Thirst
  – Osmoreceptors located in the brain
  – Organum vasculosum of the lamina terminalis (OVLT)

• Mechanisms of Hypovolemic Thirst
  – Baroreceptors measure blood pressure
  – Receptors in the heart and kidneys
### Table 9.1 Sources of Typical Daily Fluid Loss and Intake in Humans

<table>
<thead>
<tr>
<th>Source</th>
<th>Typical Daily Loss</th>
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<th>Typical Daily Intake</th>
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<tr>
<td><strong>Typical Daily Loss</strong></td>
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<td><strong>Typical Daily Intake</strong></td>
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<tr>
<td>Urine</td>
<td>1.4 liters/4.928 cups *</td>
<td>Fluids from beverages</td>
<td>1.2 liters/4.224 cups</td>
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<td>Perspiration, evaporation, respiration</td>
<td>0.9 liters/3.168 cups</td>
<td>Fluids contained in food</td>
<td>1.0 liters/3.52 cups</td>
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<td>Feces</td>
<td>0.2 liters/0.704 cups</td>
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<td><strong>TOTAL LOSS</strong></td>
<td>2.5 liters/8.8 cups</td>
<td><strong>TOTAL INTAKE</strong></td>
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* 1 cup = 8 ounces
Figure 9.10 Detecting Osmotic Thirst

(a) Brain Structures Associated with Osmotic Thirst
- Organum vasculosum of the lamina terminalis (OVLT)
- Optic chiasm
- Posterior lobe of the pituitary gland

(b) Brain Structures Associated with Drinking Behavior
- Subfornical organ
- Thalamus
- Zona incerta
- Fornix
- Median preoptic nucleus of hypothalamus
- Medulla
- Nucleus of solitary tract
Thirst: Regulation of the Body’s Fluid Levels

• Hormones, Sodium, and Thirst
  – Osmotic & Hypovolemic thirst both cause the release of Antidiuretic hormone (ADH) or vasopressin
  – Low blood volume stimulates hunger for sodium

• Initiation of Drinking
  – Begins when angiotensin II acts on subfornical organ (SFO)

• Cessation of Drinking
  – Fluid receptors in mouth, throat, digestive system
  – Hyponatremia

• Thirst and Sports Drinks
  – Provides more sodium than other beverages, which helps athletes retain fluids and may prevent hyponatremia
Figure 9.11 Antidiuretic Hormone Begins a Sequence of Events Leading to Fluid Conservation

4. Conversion of angiotensinogen to angiotensin I to angiotensin II.
5. Constrict blood vessels, Message to adrenal glands: Release aldosterone.
7. Antidiuretic hormone (ADH)
Hunger

• Influences on Food Choices include
  – External factors like Learned food preferences, emotions, social setting, food characteristics, time of day, etc, AND
  – Internal factors like blood glucose levels and / or low fat supplies

• The Process of Digestion
  – Foods are broken down into usable chemicals by the digestive tract
  – During digestion fats, proteins, and carbohydrates are absorbed into the blood supply and circulated to waiting tissues
  – The brain uses glucose for energy
Figure 9.14 The Major Structures of the Digestive Tract
Hunger – What initiates it?

• The Pancreatic Hormones
  – Ghrelin short term circulating hormone stimulates hunger
  – Insulin helps store glucose as glycogen and assists in moving glucose from the blood supply into body cells
  – Glucagon converts stored glycogen back into glucose
• Fat cells release Leptin. Low levels trigger hunger
• The hypothalamus releases neuropeptides called Orexins when leptin is low, or ghrelin levels are high – stimulates eating behavior
• Simultaneously the pituitary suppresses the release of TSH and ACTH (slows metabolism)
Figure 9.15 Insulin Release is Reduced in Type 2 Diabetes
Figure 9.17 Hypothalamic Nuclei Participate in the Control of Hunger
What tells us to stop eating?

- Glucoreceptors in the duodenum react to sugar
- Fatty foods signal release of CCK – high leptin levels tell the pancreas to release TSH & ACTH
- Systems based on neuropeptides and hormones is slow (10+ minutes of added eating time)
- Many factors have contributed to our Obesity Epidemic (1/3 of adults, and ¼ of adolescents)
- As other cultures have adopted our ‘diet’ obesity rates have skyrocketed there
Obesity: An Eating Disorder?

• Defining Normal Weight
  Body mass index (BMI) seems scientific, but is hardly accurate. Body fat measurement is a better indicator.

• Obesity = 20% or higher above ideal weight

• Stress and high fat diet increase release of NPY and appetite

• Defending the Obese Weight
  • Diet reduces size of individual fat cells but not the number of fat cells
  • Genetic factors also play a significant role (50% concordance)

  – Interventions for obesity
    • Weight loss diets reduce calories consumed, however
    • They don’t reduce one’s set point, so keeping weight off is difficult
Figure 9.20 Body Mass Index Provides a Measure of Ideal Weight

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- **BMI under 18.5:** Underweight
- **BMI between 18.5–24:** Healthy weight
- **BMI between 25–29:** Overweight
- **BMI between 30–39:** Obese
- **BMI over 40:** Severely/morbidly obese

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Other Eating Disorders?

• Anorexia Nervosa
  – Maintain 85% or less of normal weight: 15% below normal

• Bulimia Nervosa
  – Cyclical pattern of binge eating and purging

• Causes for Anorexia and Bulimia
  – Media images
  – Biological factors
  – Addictive processes
  – Distorted body image

• Treatment for Eating Disorders
  – Antidepressants, cognitive behavioral therapy