Motivation and the Regulation of Internal States

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Chapter Summary

Study Resources

After reading this chapter, you will be able to:

- Summarize the psychological theories of motivation.
- Describe how temperature regulation and thirst reflect the concept of homeostasis.
- Explain the role of taste in choices of food.
- Identify the brain signals that control when we begin and end eating.
- Compare the roles of environment and heredity in risk for obesity.
- Examine how the environment and genetics impact risk for disordered eating.
- Discuss the role of neurotransmitters in eating disorders.

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When Christopher was born, it was obvious there was something wrong (Lyons, 2001). He was a "floppy baby," lying with his arms and legs splayed lifelessly on the bed, and he didn't cry. Doctors thought he might never walk or talk, but he seemed to progress all right until grade school, when he was diagnosed with Prader-Willi syndrome. The disorder occurs when a small section of the father's chromosome 15 fails to transfer during fertilization. The exact contribution of those genes is not known, but the symptoms are clearly defined, and Christopher had most of them. He stopped growing at 5 feet, 3 inches (1.6 meters), he had learning difficulties, and he had difficulty with impulse control.

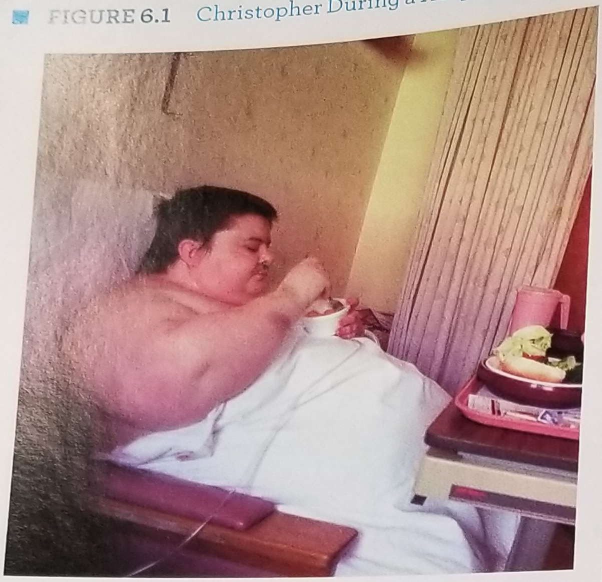
More obviously, Christopher could never seem to recognize when he had eaten enough, so he ate constantly. He even stole his brother's paper-route money to buy snacks at the corner store. At school, he would retrieve food from the cafeteria garbage can and wolf it down; his classmates would taunt him by throwing a piece of food in the trash to watch him dive for it. The only way to protect a person like Christopher is to manage his life completely, from locking the kitchen to institutionalization. State law did not permit institutionalization for Christopher, because his average-level IQ did not fit the criterion for inability to manage his affairs. He lived in a series of group homes but was thrown out of

> "
> *I can stuff my face for a long time and I won't feel full.*
>
> *—Christopher Theros*

each one for rebelliousness and violence, behaviors that are characteristic of the disorder. When he died at the age of 28, he weighed 500 pounds (227 kg; Figure 6.1).

In Chapter 5, we puzzled over why people continue to take drugs that are obviously harming them. Now we are forced to wonder why a person would be so out of control that he would literally eat himself to death. When we ask why people (and animals) do what they do, we are asking about their motivation.

FIGURE 6.1 Christopher During a Hospital Stay.



Source: Courtesy of the *San Luis Obispo County Tribune*.

Motivation and Homeostasis

Motivation, which literally means "to set in motion," refers to the set of factors that initiate, sustain, and direct behaviors. The need for the concept was prompted by psychologists' inability to explain behavior solely in terms of outside stimuli. Assuming various kinds of motivation, such as hunger or achievement need, helped make sense of differing responses to the same environmental conditions.

Keep in mind, though, that *motivation is a concept psychologists have invented and imposed on behavior*. We should not expect to find a single "motivation center" in the brain or even a network whose primary function is motivation. The fact that we sometimes cannot distinguish motivation from other aspects of behavior, like emotion, is evidence of how arbitrary the term can be. Still, it is a useful concept for organizing ideas about the sources of behavior.

After a brief overview of some of the ways psychologists have approached the problem of motivation, we will take a closer look at temperature regulation, thirst, and hunger as examples before taking up the topics of sexual behavior in Chapter 7 and emotion and aggression in Chapter 8.

Theoretical Approaches to Motivation

Greeks relied heavily on the concept of instinct in their attempts to explain human behavior. An *instinct* is a complex behavior that is automatic, unlearned, and unmodifiable, and occurs in all the members of a species (Birney & Teevan, 1961). Migration and parental behavior are good examples of instinctive behaviors in animals. According to early instinct theorists, humans were guided by instincts, too, waging war because of an aggressive instinct, caring for their young because of a parental instinct, and so on. At first blush, these explanations sound meaningful. But if we say that a person is combative because of an aggressive instinct, we know little more about what makes the person fight than we did before; if we cannot then analyze the supposed aggressive instinct, we have simply dodged the explanation. Contemporary students of behavior have used stringent requirements of evidence to identify a few instincts in animals, such as homing and flight in birds. But most psychologists believe that, in human evolution, instincts have been for the most part replaced by learned behaviors.

? What do homeostasis and drive mean?

Several theories have been proposed as a replacement to instinct. The first, drive theory, deals with motivation in terms of needs arising from physical conditions such as hunger, thirst, and body temperature. According to *drive theory*, the body maintains a condition of *homeostasis*, in which any particular system is in balance or equilibrium (C. L. Hull, 1951). Any departure from homeostasis, such as depletion of nutrients or a drop in temperature, produces an aroused condition, or *drive*, which impels the individual to engage in appropriate action such as eating, drinking, or seeking warmth. *Incentive theory* recognizes that people are motivated by external stimuli, not just internal needs (Bolles, 1975). Incentives can meet a biological need (such as food, clothing, or mates) or can be things that are valuable to the individual (such as money or good grades). According to the theory, motivation is mostly geared toward seeking and acquiring external rewards, or incentives. Then again, sometimes we do things without either an obvious drive or an incentive. The first author's wife once jumped out of an airplane for the thrill of plummeting toward the earth, only to be saved at the last minute by a flimsy parachute. Observations like this have led to the *arousal theory*, which states that people behave in ways that keep them at their preferred level of stimulation (Fiske & Maddi, 1961). Different people have different optimum levels of arousal, and some seem to have a need for varied experiences or the thrill of confronting danger (Zuckerman, 1971). This *sensation seeking* finds expression in anything from travel and unconventional dress to skydiving, drug use, risky behaviors, violence, and eating *fugu* (see Chapter 2). Both of these theories share a common neural mechanism of increased release of dopamine in the brain, which can result in addiction (see Chapter 5).

In the face of challenges to drive theory, psychologists have shifted their emphasis to drives as states of the brain rather than as conditions of the tissues (Stellar & Stellar, 1985). This approach nicely accommodates sexual behavior, which troubled drive theorists because it does not involve a tissue deficit. Even eating behavior is better understood as the result of a brain state. Hunger ordinarily occurs when a lack of nutrients in the body triggers activity in the brain. However, an incentive like the smell of a steak on the grill can also cause hunger, apparently by activating the same brain mechanisms that tissue deficits do. In addition, the person feels satisfied and stops eating long before the nutrients have reached the deficient body cells. Similarly, if the brain is not "satisfied," it little matters how much the person has eaten. In other words, if the information that reserves are excessive fails to reach the brain or to have its usual effect there, the person may, like Christopher, eat to obesity and still feel hungry. In the following pages, we will look at the regulation of body temperature, fluid levels, and energy supply from the perspective of drive and homeostasis.

Simple Homeostatic Drives

To sustain life, a number of conditions, such as body temperature, fluid levels, and energy reserves, must be held within a fairly narrow range. Accomplishing that requires a *control system.* A mechanical control system that serves as a good analogy is a home heating and cooling system. Control systems have a *set point,* which is the point of homeostasis (or equilibrium) to which the system returns. For the heating and cooling system, the set point is the temperature selected on the thermostat. The result of a departure in the room temperature from the set point is analogous to a drive; the thermostat initiates an action, turning on the furnace or the air conditioner. Larger deviations from the system's set point trigger stronger drives to return to it. When the room temperature returns to the preset range, the system is "satisfied" in the technical sense of the word; homeostasis has been achieved, so the system goes into a neutral state until there is another departure from the set point.

Temperature Regulation

Not only is the regulation of body temperature superficially similar to our thermostat analogy; it is almost as simple. All animals have to maintain internal temperature within certain limits to survive, and they operate more effectively within an even narrower range; this is their set point. How they respond to departures from homeostasis is much more variable than with the home heating and cooling system, however. *Ectothermic* animals, such as snakes and lizards, are unable to regulate their body temperature internally, so they adjust their temperature behaviorally by sunning themselves, finding shade, burrowing in the ground, and so on. *Endothermic* animals, which include mammals and birds, use some of the same strategies, such as building nests or houses, moving to warmer or cooler areas, and wearing clothing. However, endotherms are also able to use their energy reserves to maintain a nearly constant body temperature automatically. In hot weather, their temperature regulatory system reduces body heat by causing sweating, reduced metabolism, and dilation of peripheral blood vessels. In cold weather, it induces shivering, increased metabolism, and constriction of the peripheral blood vessels. To say that we make these adjustments because we *feel* hot or cold suggests that the responses are intentional behaviors, but, of course, that is not the case. So how do these behaviors occur?

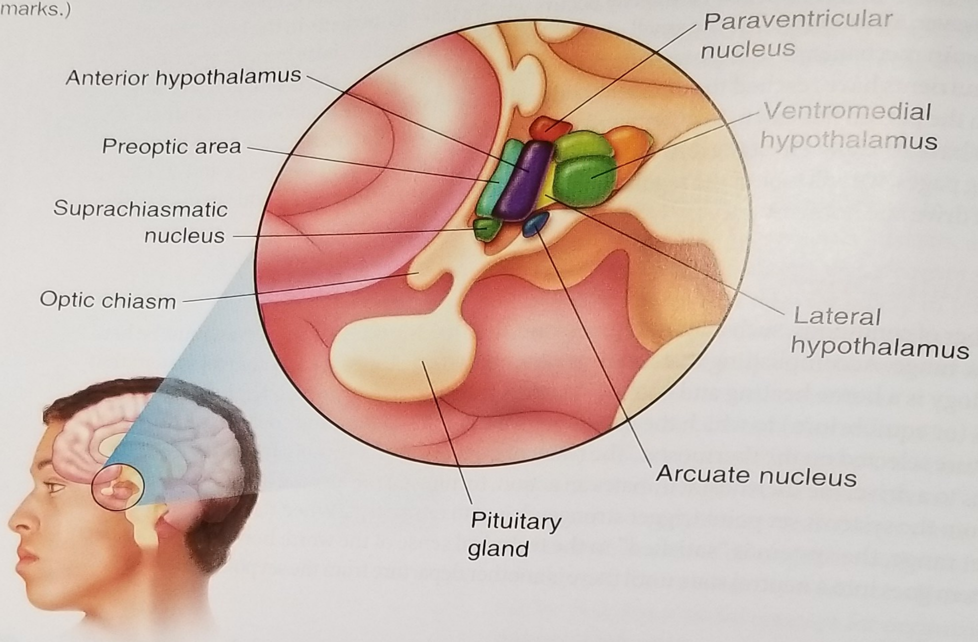
In mammals, the major "thermostat" is located in the *preoptic area* of the hypothalamus, which contains separate warmth-sensitive and cold-sensitive cells (Figure 6.2; Nakashima, Pierau, Simon, & Hori, 1987). Some of these neurons respond directly to the temperature of the blood flowing through the area; others receive input from temperature receptors in other parts of the body, including the skin. The preoptic area integrates information from these two sources and initiates temperature regulatory responses, such as panting, sweating, shivering, increasing or decreasing blood flow to the extremities, and building winter fat reserves as insulation against the cold (for a summary, see Morrison, 2016). We will be talking about several nuclei in the hypothalamus in this chapter, so you may want to refer to Figure 6.2 often.

Thirst

The body is about 70% water, so it seems obvious that maintaining water balance is critical to life. Water is needed to maintain the cells of the body, to keep the blood flowing through the veins and arteries, to transport nutrients, and to dispose of waste. You can live for weeks without eating but for only a few days without water, in part because of the constant loss through evaporation, urination, and defecation. The design of your nose, which could have been just a pair of nostrils on your face, is testimonial to the body's efforts to conserve water. As you breathe, you exhale valuable moisture; but as your breath passes through the much cooler blood-rich passages of your nose, some of the moisture condenses and is reabsorbed. The next time you get a sinus cold that interferes with water absorption, you will be surprised by how much water your runny nose isn't recycling.

FIGURE 6.2 Selected Nuclei of the Hypothalamus.

The illustration shows only the right hypothalamus. The hypothalamus is a bilaterally symmetrical structure, which means that the left and right halves (separated by the third ventricle) are duplicates of each other. (The pituitary, and optic chiasm have been identified for use as landmarks.)

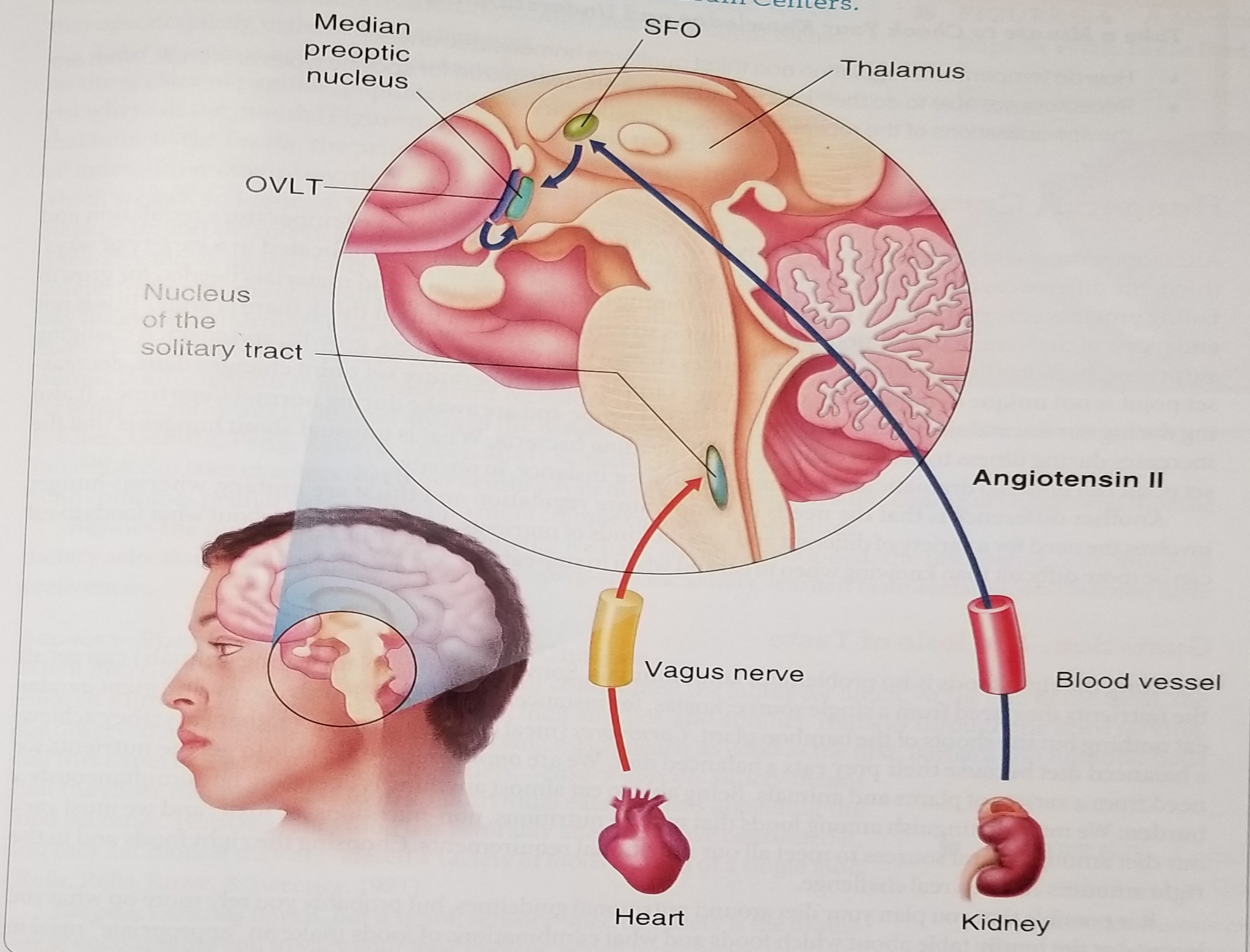


Source: Nieuwenhuys, R., Voogd, J., & vanHuijzen, C. (1988). *The human central nervous system* (3rd Rev. ed.). Berlin, Germany: Springer-Verlag.

How does the body regulate its water reserves?

It is also obvious that you drink when your mouth and throat feel dry, but at most a dry mouth and throat
determine only *when* you drink, not *how much* you drink. There are two types of thirst generated by a drop in
water content, one from inside the body's cells (*osmotic*) and the other from the blood (*hypovolemic*). Drinking
remedies both kinds of deficits, but the fluid levels in the two compartments vary independently and so the brain
manages them separately. *Osmotic thirst* occurs when the fluid content decreases inside the body's cells. If you eat
a salty meal, the excess blood solutes (salt and other dissolved substances) contrast with the lower solutes inside
the cells. Since water flows freely across cell membranes, but solutes do not, water corrects this osmotic difference
by leaving the cells and flowing into the bloodstream. *Hypovolemic thirst* occurs when the blood volume drops
due to a loss of extracellular water. This can be due to breathing, sweating, vomiting, urination, defecation, or a
loss of blood. That is why you might feel thirsty after donating blood, exercising, or spending a few hours at the
beach. (For relative amounts of water loss at rest versus exercise, see Tam & Noakes, 2013, for a review.)
The reduced water content of cells that contributes to osmotic thirst is detected primarily in areas bordering
the third ventricle, particularly in the *organum vasculosum lamina terminalis* (*OVLT*; Figure 6.3). Injecting saline
(salt solution) into the bloodstream draws water out of the cells and induces drinking, but this effect is dramati-
cally reduced when the OVLT is damaged (Thrasher & Keil, 1987). This is because the OVLT communicates the
osmotic loss to the *median preoptic nucleus* of the hypothalamus, which triggers thirst.
Hypovolemia is detected by pressure receptors (baroreceptors) located where the large veins connect to
the left and right atria of the heart; these receptors increase activity when blood pressure rises and decrease
when blood pressure falls (Fitzsimons & Moore-Gillon, 1980). Information about the reduced blood volume
that accompanies hypovolemia is conveyed by the vagus nerve to the *nucleus of the solitary tract* (*NST*) in
the medulla. From there, the signal goes to the median preoptic nucleus of the hypothalamus (Figure 6.3;
Stricker & Sved, 2000).
Lowered blood volume is also detected by kidney receptors, which trigger the release of the hormone renin.
Renin then increases production of the hormone angiotensin II in the bloodstream. *Angiotensin II* informs
the brain of the drop in blood volume. It stimulates the *subfornical organ* (*SFO*), a structure bordering the third

■ **FIGURE 6.3** Thirst Control Signals and Brain Centers.



ventricle and one of the few areas not protected by the blood-brain barrier (see Figure 6.3). Again, thirst is induced by the nearby median preoptic nucleus (Fitzsimons, 1998; Stricker & Sved, 2000). Injecting angiotensin into the SFO increases drinking; lesioning the SFO blocks this effect but has no effect on thirst in response to osmotic thirst (J. B. Simpson, Epstein, & Camardo, 1978).

So far we've been talking about what *initiates* drinking; we still must ask how we know when to *stop* drinking. Based on what you've just learned, you might think that we stop drinking when the deficit is eliminated and the initiating signals subside. However, that takes 10 to 20 minutes to occur; if we continued to drink until the cellular need was satisfied, we'd be in danger of water intoxication, which would mean headache, confusion, alterations in behavior and personality, and possibly death. So how do we explain *satiety,* the satisfaction of appetite? Like humans, dogs drink an amount of water according to their cellular need and then stop (reviewed in G. Fink, Pfaff, & Levine, 2012). They will continue to drink this way even when a tube in the stomach allows the water to drain out as quickly as it is ingested, so we can rule out the intestines as the source of the stop signal. Injecting water directly into the stomach doesn't inhibit drinking, so the stomach isn't involved, either. Researchers concluded that the act of drinking somehow signals the brain about the intake of water; recent studies with mice revealed what that neural mechanism is (Zimmerman et al., 2016). The SFO not only assesses the fluid levels of the body but also anticipates the consequences of a water meal on those water reserves. Drinking inhibits thirst-activating neurons in the SFO, with activity beginning to decline with the very first lick of water. Cool water is more effective than warm water; salty water inhibits the SFO as much as pure water, but this is reversed about a minute later as receptors detect the water's concentration.